A Measurement tool on Food losses and Waste

Applied in a tomato value chain in Nigeria

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Acronyms and abbreviations

DRS	Data Recording Sheet
FLW	Food Loss and Waste
IFDC	International Fertilizer Development Centre
IFPRI	International Food Policy Research Institute
MDTD-SL	Multi-Donor Trust Fund for Sustainable Logistics
MP	Measuring Points
PHL	Post-Harvest Loss
VC	Value Chain
WFBR	Wageningen Food and Biobased Research

Summary

Consuming vegetables in Africa have recently received considerable attention for their contribution to food and nutrition security and opportunities for enhancing smallholder livelihoods. The most important market vegetables in quantity and value in Africa are tomatoes, onions and hot peppers due to their daily consumption. In 2013 Nigeria produced almost 1.6 million metric tonnes of tomatoes which is almost 58% of West Africa and 9% of Africa's total production. Nigerian producers lack critical inputs including lack of improved technology that result in low yield and productivity. Furthermore high Post-harvest losses (PHLs) due to high transportation distances, and lack of processing and marketing infrastructure are challenges that restrain an efficient tomato value chain and pose a great threat in the quest to attain the health benefits of tomato consumption.

Therefore the scope of this research is to measure the current PHLs in the tomato value chain in Nigeria and to test and introduce a new packaging of tomatoes as intervention to reduce these losses. This project has been conducted in cooperation of Agrofair, N-N-Solutions and the International Fertilizer Development Centre (IFDC). The performance has been evaluated in terms of loss in product volume as well as in loss in product quality.

The research team collected primary data on food losses and waste (FLW) amounts through on-site measurements, observations and interviews in selected value chains in Nigeria. In total three different pilots were conducted; two pilots in the southern part of Nigeria and one pilot in the northern part of Nigeria. The two pilots in the South were organized in low season and high season respectively (pilot 1 and pilot 3). These pilots were implemented in five different supply chains supplying to five different markets consisting of farmer, transporter, trader and retailer. The pilot in the North was implemented in their production period at the end of the dry season. This pilot was implemented in three different supply chains consisting of farmer, transporter, collection point, agent and retailer (pilot 2).

Final results revealed that the innovation in the form of the plastic crates showed better results compared to the traditional raffia baskets in the last pilot (pilot 3). Although food losses were still present when using these reusable plastic crates, they resulted in reduced losses and less quality decay compared to the traditional raffia baskets. Pilot 1 did not reveal any difference between the performance of raffia baskets and plastic crates, while pilot 2 showed less quality decay of grade A tomatoes in plastic crates compared to raffia baskets but no difference in the overall PHLs. Furthermore a likely connection was found between the percentage of quality grade A tomatoes filled in the baskets and crates at farmer level and the percentage of loss at retailer level, for total loss and loss in quality grade A tomatoes respectively. This founding suggests that increasing the quality of tomato at farmer level will decrease the percentage of loss in the value chain. However this was independent from the use of raffia baskets or plastic crates.

For these pilots only a small sample of value chains (VCs) were selected compared to the total number of VCs that can be identified in Nigeria. Especially in the south, the variation of the results between the VCs was high. This high variation in data collection identifies the difficulty in upscaling these data for the whole of Nigeria. Every batch of tomatoes has another transportation time due to police controls, broken vehicles, closed roads or distances to the market. Furthermore the production circumstances are different between the farms in a region; like different varieties, use of sheds or use of fertiliser. These can have influence on the tomato losses further in the VC. To exploit the data for Nigeria as a whole, more VCs should be included of which several with equal production circumstances.

1 Introduction

1.1 The tomato supply chain in Nigeria

1.1.1 Consumption in Nigeria

Traditionally fruits and vegetables are essential in the African cuisines but between countries and regions the consumption of different fruits and vegetables differ (Grubben et al, 2014). This variation in consumption is due to differences in historical backgrounds and agro-ecological conditions (Njogu et al, 2010). According to Grubben et al. (2014), the most important market for vegetables in quantity and value in Africa are tomatoes, onions, and hot peppers due to their daily consumption. Okra, African eggplant, cabbage, eggplant, pumpkins, and carrots are also important products (Raaijmakers et al., 2017).

Nigeria is the most crowded country in Africa with a population growth of 30% between 2007 and 2017. Total population has risen over 190 mln in 2017. Urban population had a growth rate of almost 60% in the same period (over 95 mln in 2017) (World bank, 2017). The combination of population growth, rising incomes and urbanisation result in an increasing total vegetable consumption. This makes Nigeria interesting for further research regarding agricultural optimization.

As described above many different vegetables are consumed in Africa, but tomato is a major food component which is consumed in every household. It accounts for about 18% of the average consumption of vegetables in Nigerian daily diets. Besides, tomato constitutes the national food security programme (Babalola et al., 2010). This combination of factors makes it an important food crop. A study conducted in Ibadan (2016) showed that 93.3% of 150 consumers interviewed purchase tomatoes on the urban market and they mostly prefer the fresh tomato varieties UC82B (62% of respondents) and Roma (32%), as well as large tomatoes (56%) and medium sized tomatoes (42%). Tomatoes were bought in all seasons, but the expenditure on tomatoes was higher during low season (Adeoye et al. 2016).

1.1.2 Production of tomatoes

The production of tomatoes serves as an important source of income for most rural and peri-urban farmers in most developing countries. Consequently, tomato has become an important cash and industrial crop in many parts of the world (Ayandiji et al., 2011). Not only because of its economic importance, but also due to its nutritional value to human diets and subsequent importance in human health (Willcox et al., 2003). Tomatoes and tomato-based foods provide a wide variety of nutrients and many health-related benefits to the body. They provide a relatively good nutritional value compared to many other vegetables and is rich in lycopene vitamins, minerals, sugars, essential amino acids, iron, dietary fibres and phosphorus which may have beneficial health effects (Ayandiji et al., 2011).

Many challenges are making its production unprofitable in most African countries. The challenges faced by producers are seen either in production, post-harvest, marketing or a combination of any of them. Nigerian producers lack critical inputs including lack of improved technology that result in low yield and productivity. Furthermore high postharvest losses and lack of processing and marketing infrastructure are challenges that restrain an efficient tomato value chain (Ugonna et al., 2015). In 2013 Nigeria produced almost 1.6 million metric tonnes which is almost 13% less compared to 2010. However Nigeria still accounts for almost 58% of West Africa and 9% of Africa’s total production (FAOSTAT, 2013).

Tomatoes are grown in the South-western part of the country in small holdings under rain-fed conditions and in the northern regions under irrigation systems (Ayandiji et al., 2011). Since tomato production fields are partly in the northern states in the savannah agro-ecologies and the consumption regions are located in the South, huge distances have to be crossed to transport the tomatoes (Seck,1997; Coffey, 2013). The estimates of the Post-Harvest losses in the tomato supply chain in Nigeria are high, and this can pose a great threat in the quest to attain the health benefits of tomato consumption (Ugonna et al. 2015).

1.1.3 Post-harvest losses

Post-harvest losses (PHLs) refer to the losses of crops after the harvest and at all stages of the onward supply of produce to markets (the post-harvest chain) (Hodges et al., 2010; Buzby and Hyman, 2012). The PHL is often used as reference to the quantitative loss of food that was originally intended for human consumption, particularly in the context of food security in developing countries (Kader, 2005). Nevertheless also qualitative losses occur in crops between harvest and consumption (Tyler and Gilman, 1979). Reducing PHLs could increase income for 470 million smallholder farms world-wide, representing a big step forward in global efforts to end poverty and contribute to food security and sustainability (Schuster and Torero, 2016).

Beyond careful measurement of crop loss, understanding its root causes is important for any policy aimed at loss reduction (IFPRI, 2017). Measuring food loss and waste, identifying where in the food system it occurs, and developing effective policies along the value chain are essential first steps toward addressing the problem (Schuster and Torero, 2016). The methodologies for analysing PHLs mostly focus on measuring quantitative losses because measuring the qualitative losses such as loss in edibility, nutritional quality, caloric value, and consumer acceptability of the products, is much more difficult to assess (Kader, 2005).

Studies conducted on PHLs in vegetable chains in Nigeria revealed some of the losses ‘guestimates’, typically showing a wide range between 30 to 60% (Bolarin and Bosa, 2015). The policy and strategy document of Nigeria’s Federal Ministry of Agriculture and Rural Development reported post-harvest loss rates up to 60% for all perishable crops (FMARD, 2016). Ugonna et al. (2015) estimated the annual losses of tomatoes in Nigeria at 45% of the total production. However a differentiation between low season and high season is often not considered. It is expected that due to a exposure to various diseases the PHLs are even more in the high (wet) season. In addition, losses are often caused by mechanical injuries, inadequate storage, unsuitable handling, faulty system of transport and delayed transportation in the retail market (Prigojin et al, 2005).

1.1.4 Scope

It is obvious that the PHLs are generally high and leave ample incentive for intervention to reduce these losses. From a PHL viewpoint, tomatoes are an interesting vegetable to select due to the high transportation distances and high losses. Therefore the scope of this research is to measure the current PHLs in the tomato value chain in Nigeria and to test and introduce a new packaging of tomatoes as intervention to reduce these losses.

1.2 Food loss and waste measuring

In this study, we cooperated with a project run by Agrofair, N-N-Solutions and the International Fertilizer Development Centre (IFDC), which was funded by the Multi-Donor Trust Fund for Sustainable Logistics (MDTD-SL) administrated by the World Bank. The combined project aimed to facilitate a reduction in the PHLs in the tomato value chain by means of improved packaging of tomatoes during transport from farm to market to retailer. In cooperation with actual value chain (VC) actors (farmers, transporters, traders and retailers), replacement of the traditional raffia baskets by reusable plastic crates was selected as a high potential intervention.

The purpose of the Food Loss and Waste (FLW) measurement is to assess the performance of VCs when using traditional product packaging, the raffia baskets, in comparison with the intervention with plastic crates. These packaging materials are used to transport tomatoes from farmers to markets to retailers. These crates are expected to lower the weight loss during transport of tomatoes consignments compared to the raffia baskets used now. Furthermore, it is expected that with crates

less tomatoes will be bruised, squashed or physically harmed in another way during transport, resulting in less loss of the high quality grade tomatoes.
This performance will be evaluated in terms of loss in product volume as well as in loss in product quality. By assessing the changes in product quality it will be possible to evaluate the loss of revenues as a result of the degrading quality. Wageningen University and Research collected (primary) data on FLW amounts through on-site measurements in selected value chains in Nigeria.

1.3 FLW Measurement Tool

Wageningen Food and Biobased Research (WFBR) developed a Food Loss and Waste (FLW) measurement tool. The objective of this FLW measurement tool is to define the scope and select and/or develop the appropriate method for measuring losses. It is intended to help identify the *what*, and *how* related to measurement volumes in the value chain in order to assess the associated product losses. For this study this FLW measurement tool is implemented and tested for further improvements.

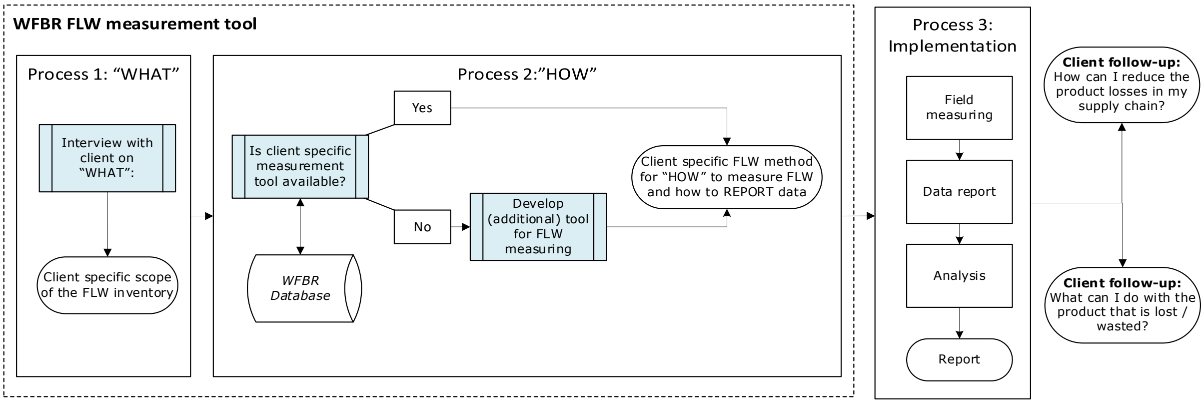


Figure 1: WFBR FLW measurement tool (Source WFBR)

The tool consists out of 2 processes that facilitate the pilot implementation of the FLW measurement study.

1. Process 1 leads to a user-specific scope of the FLW inventory: *What* to measure.
2. Process 2 results in a user-specific FLW method for *how* to measure FLW and how to report this data.

Process 3 is the implementation of the PLW measurement study itself and is not part of the developed tool.

Process 1: "WHAT"
Purpose: To obtain insight into the goals and intentions concerning the measurement of loss and waste. The answers of the contractor-client will give insight in the scope and level of detail of the information that is desired by the contractor-client. The level of desired detail has a direct effect on the method of measuring (process 2) and whether or not data can be retrieved from primary (company) or secondary sources (sector statistics), or that data are not available and have to be explored by means of measuring. The answers to these questions will give input for the selection and/or development of a measurement tool, based on the WFBR database, that is tailored to the contractor-client's specific value chain and/or need for information.

Process 2: "HOW"
The purpose of the tool is to select, describe and present the methodology for measuring food losses for a specific contractor-client based on the client specific scope as the result of process 1: "How". The tool will provide a planned approach to implement the measurements, including (if relevant) instructions and weighing methods, as well as a description of alternative data collection through interviews. In order to facilitate the implementation of this tool a set of sub-tools are provided to facilitate the collection of information and the recording and processing of the retrieved data.

Based on the applied FLW measurement study, a supply chain strategy to reduce postharvest losses or to improve valorisation of losses can be setup.

2 Methodology

The FLW measurement tool was used to provide a measurement tool for this specific project. In this chapter the set-up of this study is explained.

2.1 Project set up

2.1.1 Selected value chains and pilots

In total three different pilots were conducted. Two pilots were conducted in the southern part of Nigeria and one pilot in the northern part of Nigeria. The two pilots in the southern value chains were conducted in low season and high season respectively. The first pilot in the southern value chains was organised during low season in December 2017 (pilot 1) and the second pilot in high season in August 2018 (pilot 3). The study was implemented in five different supply chains supplying to five different markets consisting of farmer, transporter, trader and retailer. The value chains that were selected for this research are located in Ogun, Osun, and Oyo state, centred around the markets in Lagos, Ibadan and Ogbomose. Annex 1 shows these five supply chains. These five supply chains have in total 24 participants, of which eight farmers, five hauliers, six traders and seven retailers.

The pilot in the northern value chains (pilot 2) was implemented in March 2018 in the production period at the end of the dry season. Due to irrigation this region is home to the largest number of dry season producers in Nigeria. For pilot 2, three value chains were measured with production areas in Kano and Kaduna. The chosen wholesale- and retailer markets were located in Lagos. The supply chains consisted of a farmer, transporter, collection point, agent and retailer. Table 2.1 shows an overview of the three pilots.

Table 2.1: The pilots

	What	When
Pilot 1	Low season southern value chain	December 2017
Pilot 2	Northern value chain	March 2018
Pilot 3	High season southern value chain	August 2018

2.1.2 Load tracking

To quantify FLW across multiple stages, load tracking was used in this study. Load tracking is the evaluation of the weight and visual observations of the product quality of a sample of the crop as it moves through a supply chain under conditions that are comparable with usual circumstances (e.g. regions, season, transport distances and conditions (type of vehicle)). By tracking of the load the research-team was able to follow the product batch and to observe the specific conditions and circumstances in which the product was handled, packed, transported, etc. The initial procedure for load tracking is described in Annex 2. However small changes were made before and during the pilots.

As a baseline every selected individual farmer harvested their produce as usual and packed them in the traditional raffia baskets (scenario A) and provided plastic crates (scenario B). Per packaging (raffia baskets and plastic crates) a product sample was taken from the entire batch at each selected farmer. The sample size selected per packing at the individual selected farmer varied between the pilots. It was decided to select a sample of maximum three baskets and three plastic crates per value chain as result of the limited produce during low season and workload. In addition, sorting more than six baskets and crates was not feasibly without hampering the normal business procedures. The samples were labelled for tracking through the entire VC. The samples were labelled by means of coloured ribbons, whereby each product sample that was supplied by a specific farmer was marked with a colour by attaching a ribbon to the farmer’s basket and plastic crate. The advantage of using coloured ribbons is that there is minimal risk of wear and tear as may happen when using paper labels.

Picture 2.1: Packing of tomatoes in traditional raffia baskets and provided plastic crates (left) and an example for a used coloured ribbon for labelling (right)

To quantify FLW across multiple stages, the first step was to create the baseline. This is the weight of the selected sample at farm level that will be followed. Data retrieval on product losses was done by weighing of tomatoes at different points in the VC by means of a scale. The main advantage of weighing is its accuracy, provided that the weighing device is calibrated and used properly. Furthermore the data retrieval per value chain was done by the trained local research team who followed the produce in the value chains. As the research included the simultaneous implementation of the use of the traditional raffia baskets and the use of reusable plastic crates, both were transported simultaneously in the same transport modality. This means that a farmer shipped both in traditional baskets and in plastic crates. The measuring of FLW in the traditional situation and the FLW during the intervention was measured simultaneously as a result.

2.1.3 Local research team

A team of five enumerators was contracted and trained to monitor the tomatoes from farm to retail. Every enumerator was appointed to each supply chain and trained during the kick-off meeting on the measurement techniques. The enumerators were responsible for the load tracking, weighing and grading of the tomatoes, and to make observations that are relevant for the evaluation of the specific conditions and circumstances during the pilots.

2.1.4 Quality classification

As sorting and grading takes place in the tomato value chain in Nigeria, a classification of the quality was needed. Classification of product qualities in the VCs and in Nigeria in general is not transparent. Workshops including the research team and selected stakeholders concluded that in the southern value chains tomatoes were graded into three different grades with economic value (grade A, grade B and grade C) while the northern value chains use four different grades with economic value (grade A, grade B, grade C and grade D). The tomatoes are graded on colour, firmness and damage. Grade A are red, firm and undamaged tomatoes. The grading during the pilots was done by the enumerators, since this guaranteed an equal grading system needed to determine the quality decay within the chain.

2.2 Data collection

2.2.1 Direct measurements

During load tracking data was collected from five or six measuring points (MP) in the value chain (see Table 2.2). Measuring points were farmer (2 MP), collection point (1 MP when applicable), wholesaler/agent (1 MP) and retailer (2 MP). As shown in Table 2.2, sorting and grading take place at farm level and at retailer level.

Table 2.2: Points in the value chain for measuring

Stakeholder:	VC-link:	Measurement:
1. Farmer [1)]	after sorting & grading	baseline measurement 0: quantity + grades
2. Farmer [2)]	Just before loading of vehicle	measurement +1: quantity
3. (Collection point) [3)]	(Before loading)	measurement + 2: quantity
4. Agent/Wholesaler [4)]	upon arrival at the wholesaler	measurement +3: quantity
5. Outlet / retailer [5)]	At picking up at wholesaler	measurement +4: quantity
6. Outlet / retailer [6)]	At arrival after sorting & grading	measurement +5: quantity + grades

[1)] After harvesting and packing tomatoes in baskets and crates by the farmer, tomatoes were graded directly by the enumerators. After grading the tomatoes were placed back in the original packed packing material (basket or plastic crate).

[2)] The purpose of this measurement is to observe any possible product loss that may occur during the time period between harvesting / sorting & grading and the moment of loading of the product for transport.

[3)] The northern value chains (pilot 2) made use of a collection point. When applicable food loss measurement was done before loading.

[4)] The purpose is to measure food loss due to transportation. Sorting and grading was not possible at the wholesaler.

[5)] The purpose is to measure food loss derived at the wholesaler.

[6)] The measurement stops at sorting and grading at retail level. Measurement of product waste by the consumer is not included in the measurement.

Recording of data during load tracking was done on a FLW Data Recording Sheet (DRS) that was provided together with the FLW measurement tool. A sample of this DRS is shown in Figure 2.1. The format of the DRS was adjusted slightly over time based on the feedback during the pilots.

2.2.2 Surveys and observations

Furthermore the FLW measurement tool included observation and a survey. Surveys are a cost-effective way of gathering information on FLW related aspects or other information from the individual stakeholders in the research. One of the issues is information on product prices. The research-team collected data of product spot prices from the respective stakeholders (farmer, wholesaler/dealer and retailer) on site, specified by product grades at retail level. The sales prices per class category gave insight in the effects of the change in product quality on the product revenues and the economic viability of the intervention measure (plastic crates). Furthermore the research team retrieved information from the VC stakeholders that provided insight in the specific reasons and causes for produce being lost or quality being degraded. This information gave insight in the analyses of the data and in the discussion how losses in the VC could be prevented.

Additional information was acquired through observations and impressions by the research-team (photographs and short film-clips taken on site) to assess the appearance and performance of the product and the specific conditions and circumstances in which the product moved through the VC (e.g. transport means, roads, facilities). Observations included, amongst others, type of vehicle, dimensions of the cargo bin of the vehicle, road conditions and facilities. Also the registration of ambient temperatures on the basis of local weather statistics were included.

2.3 Data analysis

Data analysis was done based on the filled data recording sheet (see Figure 2.1), interview data and observations by the research team. For the analysis descriptive statistics is used and the t-test to calculate significance. Significance is tested as $P < 0.05$. In the next chapter the results of the food loss analysis for raffia baskets and plastic crates in the tomato value chain in Nigeria are presented.

VALUE CHAIN nr.:		**NAME FARMER :**		**VILLAGE or CITY:**		**NAME of ENUMERATOR:**	
ROUND nr.:		**NAME COLLECTOR:**		**VILLAGE or CITY:**			
DATE:		**NAME WHOLESALER:**		**VILLAGE or CITY:**			
COLOUR LABEL:		**NAME RETAILER:**		**MARKET:**			

BASKET sample#1	**0: BASELINE: FARMER**		**1: FARMER** (before loading)	**2: WHOLESALER** (at arrival)		**3: RETAILER** (at picking up the tomatoes)		**4: RETAILER** (before sales)		
	QUALITY	WEIGHT (kg):	WEIGHT (kg):	WEIGHT (kg):	Trader pays farmer (NAIRA):	WEIGHT (kg):	Retailer pays wholesaler (NAIRA):	QUALITY	WEIGHT (kg):	Buyer pays retailer (NAIRA):
	A1							A4		
	B1							B4		
	C1							C4		
				unsold -		unsold -		unsold	-	
	TOTAL	-	-	-		-			-	

PLASTIC CRATE sample#1	**0: BASELINE: FARMER**		**1: FARMER** (before loading)	**2: WHOLESALER** (at arrival)		**3: RETAILER** (at picking up the tomatoes)		**4: RETAILER** (before sales)		
	QUALITY	WEIGHT (kg):	WEIGHT (kg):	WEIGHT (kg):	Trader pays farmer (NAIRA):	WEIGHT (kg):	Retailer pays wholesaler (NAIRA):	QUALITY	WEIGHT (kg):	Buyer pays retailer (NAIRA):
	A1							A4		
	B1							B4		
	C1							C4		
				unsold -		unsold -		unsold		
	TOTAL	-	-	-		-			-	

Observations research-team:	**at FARMER**	**at WHOLESALER**
Tomato **VARIETY**		
Time of **HARVESTING** of the product		
Presence of a **SHED** or **COVER** at loading point		
Way of product **HANDLING** of the product		
Duration time of **LOADING** of the product		
Way of **STACKING** product in vehicle		
ambient (air) **TEMPERATURE** (°C)		
WEATHER at time of measurement		

Observations research-team DURING TRANSPO	**FARMER to TRADER**	**WHOLESALER to RETAILER**
VEHICLE type		
Current vehicle **LOADING CAPACITY**		
TEMPERATURE CONTROLLED compartment		
transport **DISTANCE**		
WAITING TIME between harvest & loading		
WAITING TIME between arrival & loading		
Time of **DEPARTURE** of transport		
Time of **ARRIVAL** of transport		
Transport **DELAY**		

Figure 2.1: FLW data recording sheet

3 Results

As described in the methodology in total three pilots were conducted. Below the results are showed based on these three pilots. The five value chains measured in the southern value chain in pilot 1 were equal to the five value chains measured in the value chain in pilot 3. In the northern value chain three different value chains were observed (pilot 2).

3.1 Quantitative data analysis

3.1.1 Loss in quantity

The producers located in the South of Nigeria filled the plastic crates up to an average weight of 21.3 kg with a variation between 16.1 and 23.8 kg. On the other hand, the total volume of tomatoes in the raffia baskets was dependent on the raffia baskets used. Some value chains used smaller raffia baskets compared to others. The weight of tomatoes in the baskets varied between 5.7 and 30.3 kg. In the northern value chain, the crates were filled on average with 25.4 kg while the tomatoes in the raffia baskets had an average weight of 63.0 kg with a variation between 60 and 66.8 kg. Picture 3.1 presents examples of used raffia baskets.

Picture 3.1: Different sizes of raffia baskets used in the southern and northern value chains

The tomatoes were transported from farmer to the intermediary (on the market) and finally to the retailer. During this process losses occurred in the raffia baskets and plastic crates. Figure 3.1 shows the percentage of loss in raffia baskets and plastic crates for the different value chains in low season (pilot 1). In this pilot the average loss of tomatoes in baskets was 12% and for crates 5%. The losses for baskets varied between 2% and 35% and for crates between almost 0% and 12%. These results did not significantly differ, so on average the plastic crates did not perform better based on the overall losses. In value chain 3 and value chain 4 the highest losses occurred, with maximum up to 35% for baskets and 12% for plastic crates.

Compared to the results in the low season, the average losses were lower for baskets and crates in high season (pilot 3), while the plastic crates performed significantly better compared to the baskets. The average losses in high season were 7% for raffia baskets and 2% for plastic crates with a variation between 2% and 16% for baskets and between 0% and 5% for plastic crates. Again, VC3 and VC4 reported the highest losses in high season as well (see Figure 3.2).

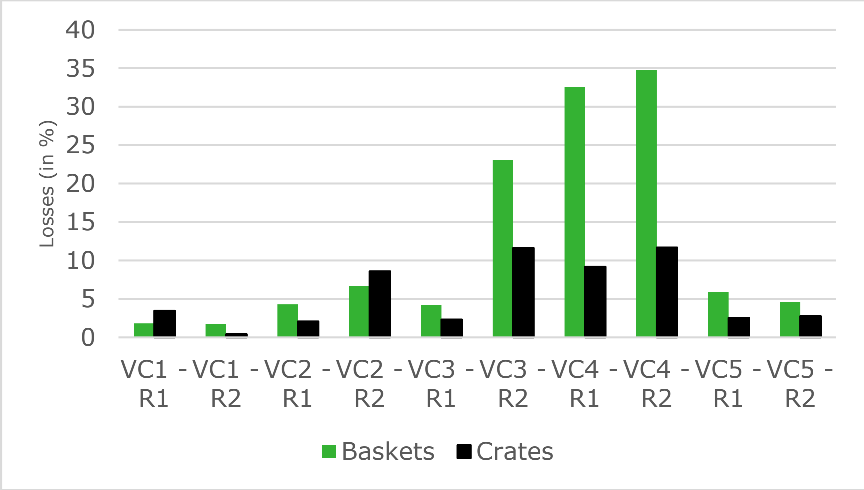


Figure 3.1: Percentage of loss in baskets and crates for the different value chains in pilot 1

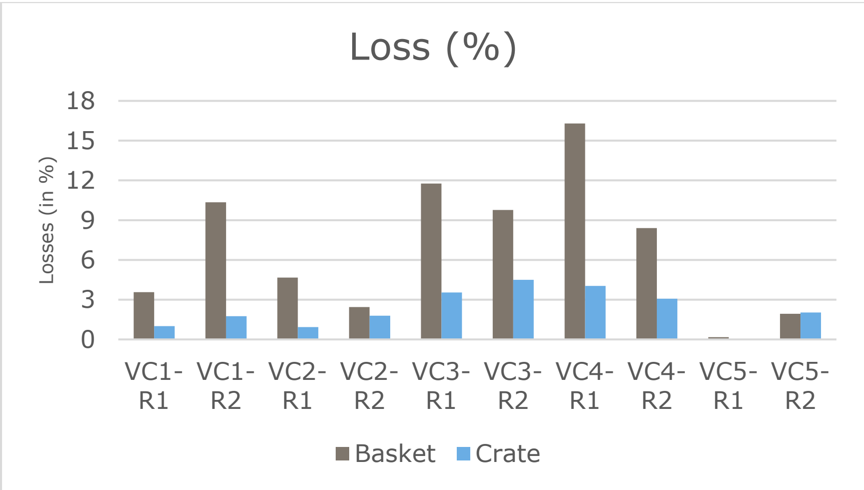


Figure 3.2: Percentage of loss in baskets and crates for the different value chains in pilot 3

The analysis of the northern value chain shows no significant difference in the performance of baskets and crates. Both baskets and crates show an average loss of 7%. For baskets the losses varied between 0% and 12% and for crates between 4% and 13% (see Figure 3.3).

Table 3.1 shows an overview for the overall losses of tomatoes for the raffia baskets and plastic crates in the three pilots. Overall the loss between baskets and crates did only significantly differ in pilot 3.

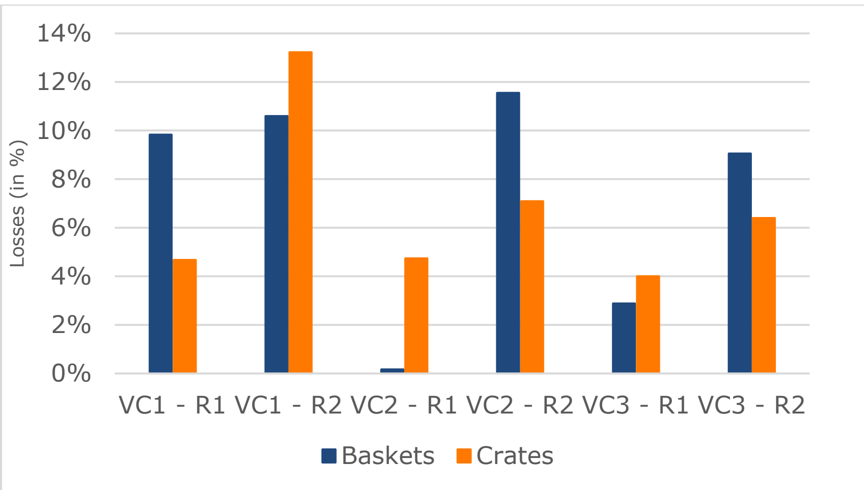


Figure 3.3: Percentage of loss in baskets and crates for the different value chains in pilot 2

Table 3.1: Overall loss of tomatoes for baskets and crates

	Loss in baskets	Loss in crates	P-value
Pilot 1	12%	5%	0.16
Pilot 2	7%	7%	0.79
Pilot 3	7%	2%	0.02

3.1.2 Loss in quality

At farmer level, tomatoes were filled at random in every basket and crate. In the southern value chain, during low season (pilot 1), the baskets were filled on average with 75% tomatoes of grade A and the crates with 69% tomatoes of grade A (see Figure 3.4). In high season (pilot 3), this percentage was higher with 84% grade A tomatoes in baskets and 80% grade A tomatoes in crates (see Figure 3.5). In the Northern value chain (pilot 2) both baskets and plastic crates were filled with 82% grade A tomatoes (see Figure 3.6).

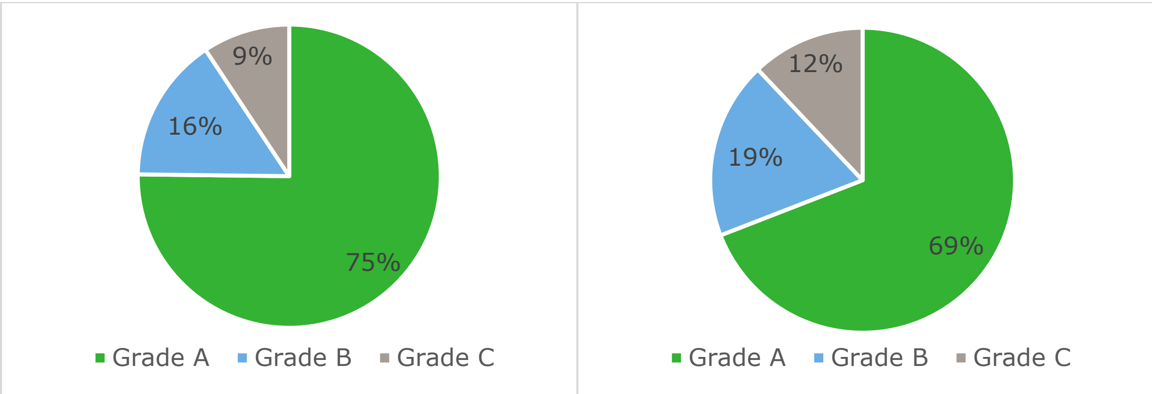


Figure 3.4: Input in baskets (L) and input in crates (R) in pilot 1

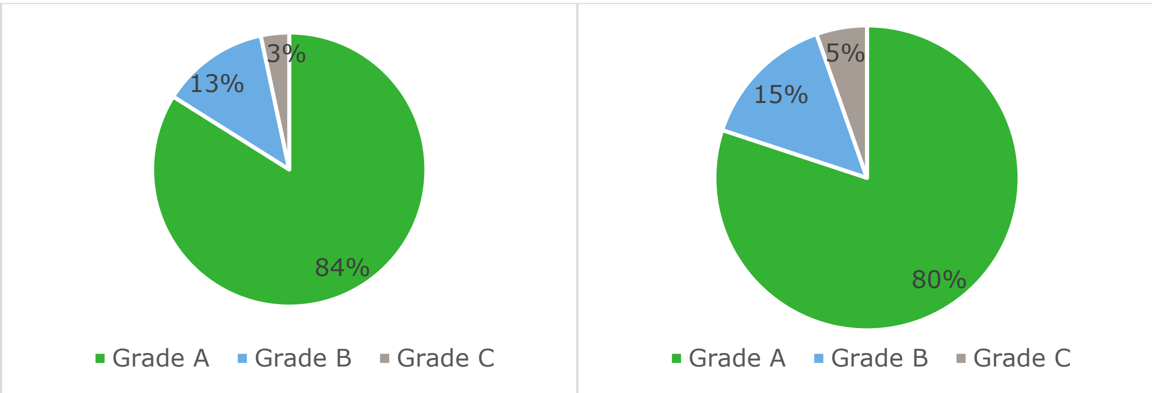


Figure 3.5: Input in baskets (L) and input in crates (R) in pilot 3

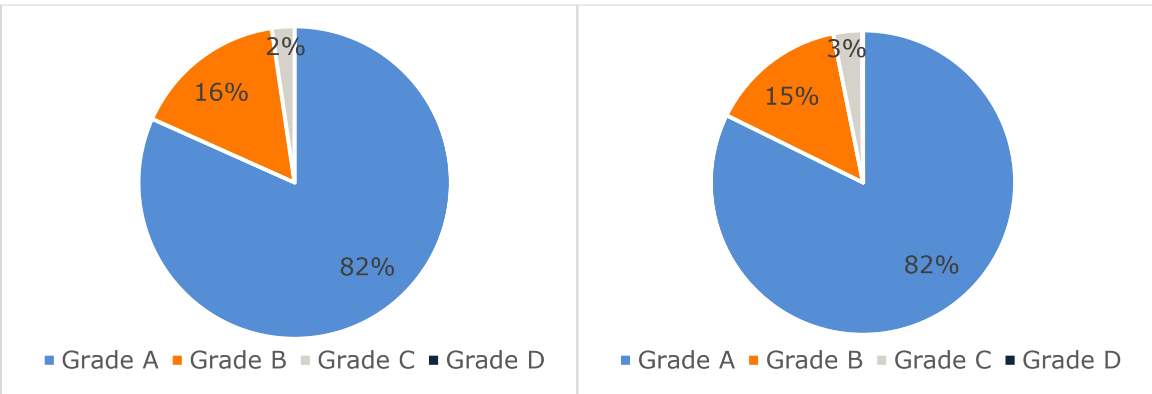


Figure 3.6: Input in baskets (L) and input in crates (R) in pilot 2

At arrival at the retailer the baskets and crates were sorted again and showed a different distribution compared to farm level. The average quality loss of grade A tomatoes in pilot 1 for baskets was 37%, with a variation between 4% and 78%, and for plastic cates 15% with a variation between 0% and 31% (see Figure 3.7). As the P-value is 0.07>0.05 the performance did not significantly differ for quality A tomatoes between baskets and crates.

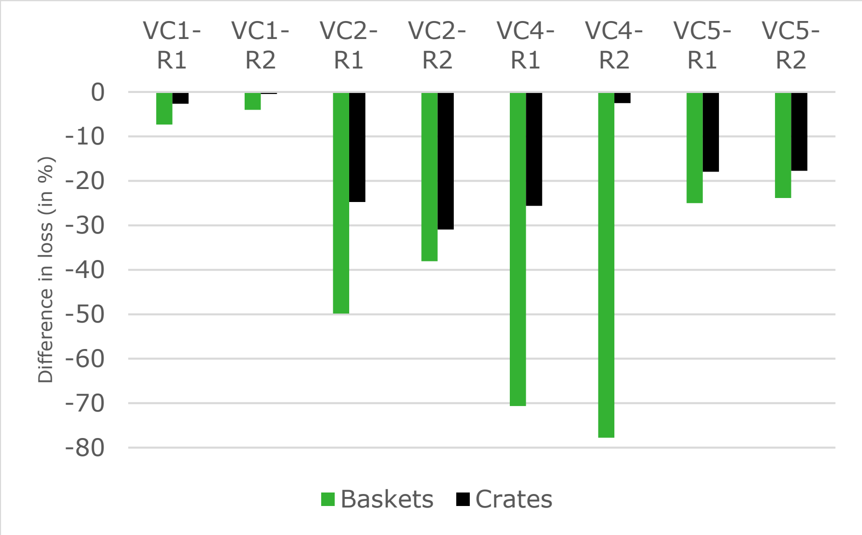


Figure 3.7: Difference in amount of quality A tomatoes between farm level and retail level in pilot 1 (in %)

The differences in amount of quality A tomatoes between farm level and retail level in pilot 3 are presented in Figure 3.8. The average quality loss of grade A tomatoes was 27% for baskets, with a variation between 9% and 69%, and 2% for crates. The loss of quality grade A tomatoes was significantly lower for plastic crates compared to the raffia baskets. As shown in the figure the difference of quality A tomatoes is higher in baskets compared to crates for all value chains.

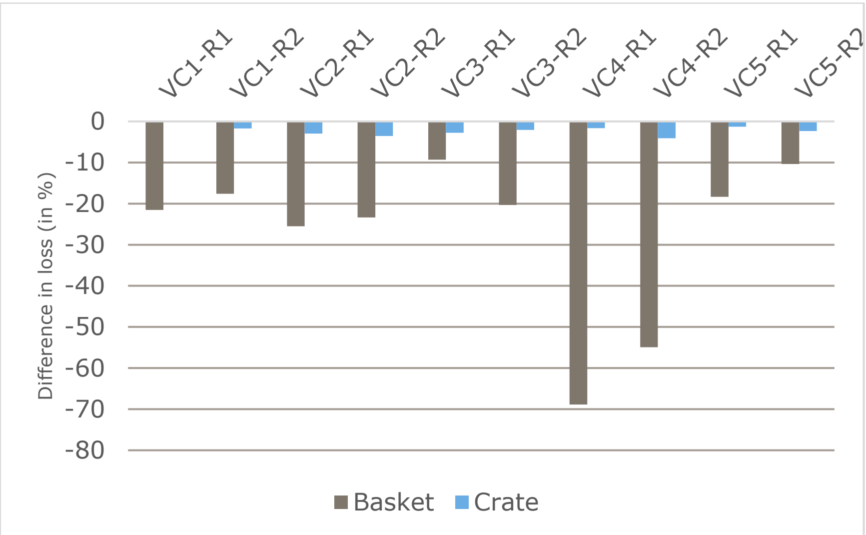


Figure 3.8: Difference in amount of quality between farm level and retail level of grade A tomatoes in pilot 3 (in %)

For pilot 2 the difference in quality loss of grade A tomatoes was significantly different between baskets and crates. The average quality loss of grade A tomatoes for baskets was 28%, with a variation between 10% and 44%, and for plastic crates 12% with a variation between 2% and 26% (see Figure 3.9). This figure shows that the quality decay of grade A tomatoes is not higher for baskets in every value chain.
Table 3.2 shows the average quality loss of grade A tomatoes in the different pilots. Overall the quality decay of quality A tomatoes is the higher for baskets compared to crates.

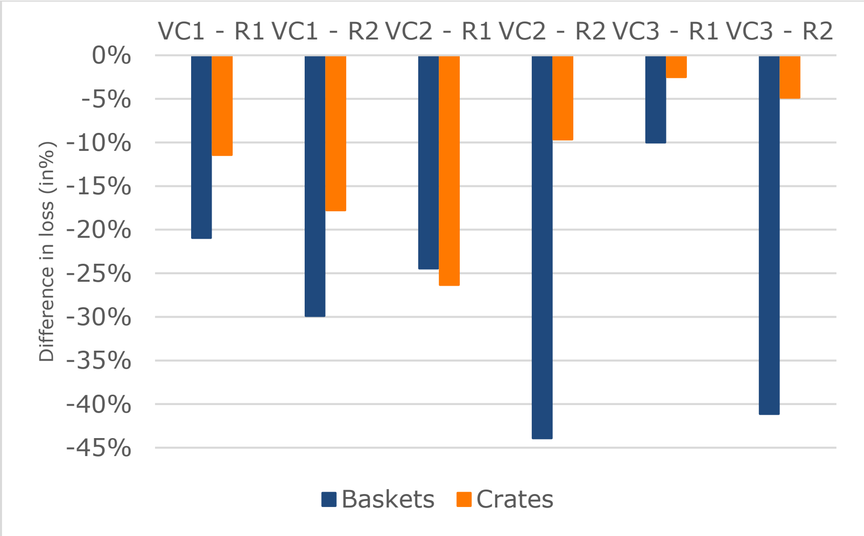


Figure 3.9: Difference in amount of quality between farm level and retail level of grade A tomatoes in pilot 2

Table 3.2: Quality loss of grade A tomatoes on average

	Δ Quality A in baskets	**Δ Quality A in crates**	**P-value**
Pilot 1	-37%	-15%	0.07
Pilot 2	-28%	-12%	0.03
Pilot 3	-27%	-2%	0.003

3.1.3 Economic value

At retail level the tomatoes are sorted and sold to consumers for different prices. Figure 3.10 shows the average price of different grades of tomatoes in baskets and crates. Overall the prices for grade A tomatoes are the highest (in Naira per kg), followed by grade B, grade C and grade D tomatoes (when applicable) respectively. In pilot 1 the prices for grade A and grade B tomatoes sold from the traditional raffia baskets were higher compared to the prices for these tomatoes sold from the plastic crates. In pilot 3 the price of grade A and grade B tomatoes sold from basket and crates were almost equal. An explanation of this difference in price is probably that buyers were less familiar with the plastic crates at the start of the project. The crates were introduced to the markets so the demand for tomatoes from the plastic crates was probably lower. Furthermore this figure shows that the prices for tomatoes were slightly higher in off-season compared to high season. Difficulties in comparing the prices are due to the high price fluctuations during seasons, days and even hours. From personal communication it was said that the prices at the start of the day are higher compared to the end of the market day. It is influenced by the number of tomatoes entering the market.

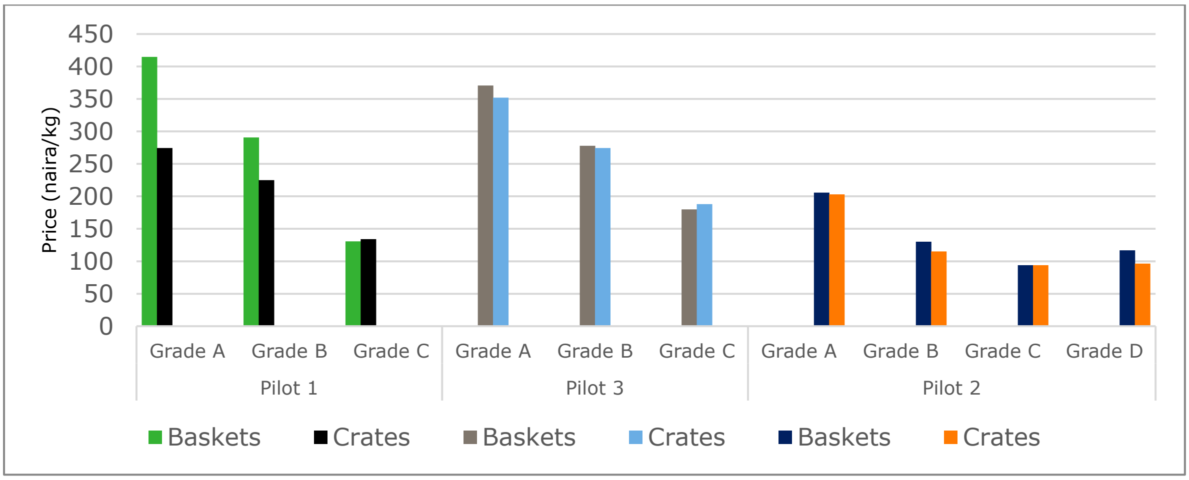
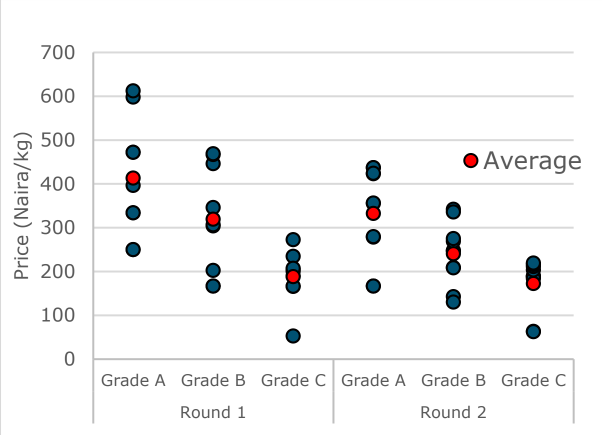


Figure 3.10: Price of different grades of tomatoes in baskets and crates in pilot 1, pilot 3 and pilot 2 respectively

Additionally the prices between the value chains differ, since every value chain handle their own prices. In Figure 3.11 the retail prices per round and grade are shown for pilot 3. Every blue dot shows an individual basket or crate in a value chain. The red dot shows the average of all individual cases.

The price per kg of tomatoes originated from the North (pilot 2) were lower compared to the tomatoes derived from the South. The average price for grade A tomatoes sold from baskets was 225 Naira/kg, for grade B 151 Naira/kg and for grade C and grade D 91 Naira/kg and 92 Naira/kg respectively.



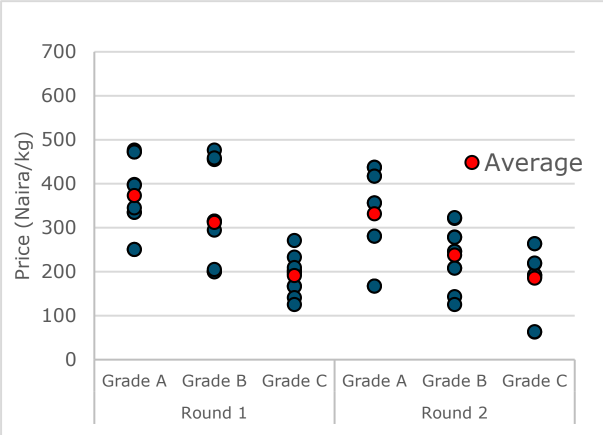


Figure 3.11: Retail prices per round and grade for baskets (left) and retail prices per round and grade for crates (right) in pilot 3

3.2 Differences between individual VCs

The results in the South (pilot 1 and pilot 3) show that VC3 and VC4 performed less regarding post-harvest losses compared to the other value chains. In practice several reasons can influence these differences. Below are several reasons explained.

3.2.1 Size of baskets

As described in chapter 3.1 the size of the baskets differ between the value chains. In Table 3.3 the average weight (in kg) for filled baskets and crates at farmer level are presented. Pilot 1 shows a similar average weight of the baskets and crates as pilot 3 since the same value chains were used. However no influence can be found between the size of the raffia baskets and the percentage of loss in the value chain. Also no connection can be found between the filling degree of the crates and the percentage of loss.

Table 3.3: Average weight (in kg) for filled baskets and crates at farmer level in the different pilots

Pilot 2	VC 1	VC 2	VC 3
Average weight Baskets (total all qualities)	66.8	60.0	62.3
Average weight Crates (total all qualities)	26.8	24.5	25.0

Pilot 1	VC 1	VC 2	VC 3	VC 4	VC 5
Average weight Baskets (total all qualities)	5.7	25.0	6.1	7.5	23.3
Average weight Crates (total all qualities)	20.8	22.5	20.0	22.9	22.5

Pilot 3	VC1	VC2	VC3	VC4	VC5
Average weight Baskets (total all qualities)	5.7	22.9	10.5	6.7	30.3
Average weight Crates (total all qualities)	16.1	22.0	21.1	20.9	23.8

3.2.2 Distance

The transportation distance and transportation time can have influence on the percentage of loss. Since drivers get paid per basket or crate, most tried to squeeze the baskets to include an extra basket. It was impossible to squeeze the plastic crates. Table 3.4 shows the average distance between the different actors in the value chains in pilot 2, pilot 1 and pilot 3 respectively. As for the weight in the baskets and crates, pilot 1 is almost similar to pilot 3. Linking travel distance and time to losses in the 3 pilots cannot be proven since losses that occur at the end of the value chain are not automatically linked with processes at that part of the chain. Those losses can express at the end of the chain, but product degradation can already take place at the start of the value chain. Therefore losses at retailer level are not automatically connected to, for example, transport distances or -time.

Table 3.4: Distance between the different actors in the value chain in the different pilots

Pilot 2	VC 1	VC 2	VC 3
Average waiting time harvest - truck arrival at farm (hours)	15.7	2.0	4.7
Distance Farmer-Collection point (km)	0	3	3
Distance Collection point-Agent (km)	1,040	1,260	1,220
Distance Agent-Retailer (km)	45	20	20

Pilot 1	VC 1	VC 2	VC 3	VC 4	VC 5
Average waiting time harvest - truck arrival at farm (hours)	16.3	1.5	5.5	0.6	3.7
Distance Farmer-Wholesaler (km)	140	80	300	5	210
Distance Wholesaler-Retailer	0.5	15	5	245	33

Pilot 3	VC1	VC2	VC3	VC4	VC5
Average waiting time harvest - truck arrival at farm (hours)	8.5	4.0	12.4	3.5	4.3
Distance Farmer-Wholesaler (km)	140	87	153	8	210
Distance Wholesaler-Retailer (km)	5	15	3	45	18

3.2.3 Connection between other qualitative data and PHLs

Other results that were found due to the observations could not be connected to an increase or decrease in loss in the tomato value chain, like variety produced, vehicle used, product handling, time of harvest, etc. For example, in the South at the start of the project (pilot 1), only one farmer in one value chain used a shed (VC2), while at the end (pilot 3) sheds were used in VC1, VC2, VC4 and VC5. However no connection was found between the use of these sheds and the difference in loss.

3.2.4 Quality at farmer level

A likely connection was found between the percentage of quality grade A tomatoes filled in the baskets and crates at farmer level and the percentage of loss at retailer level, for total loss and loss in quality grade A tomatoes respectively. This founding suggests that increasing the quality of tomato at farmer level will decrease the percentage of loss in the value chain. This was independent from the use of raffia baskets or plastic crates.

4 Discussion

4.1 Adaptations of the measurement tool

The FLW measurement tool was tested during these pilots. Several changes and improvements were made during and after conducting the pilots:

- First the data recording sheet had to be updated before starting the first pilot. Instead of five different grades of tomatoes, the chosen value chains in the South only gave value to three different grades; grade A, grade B and grade C. After the first pilot the data recording sheet needed an update since for the second pilot a different production zone was selected. In that production zone other type of grading was applied; grade A, grade B, grade C and grade D.

- Secondly, during the first pilot it became clear that sorting and grading at the wholesale level was not possible. This was not possible in practice since the tomatoes arrived within the night. There was a lack of light at the market in the night and a problem with safety. Sorting and grading the next morning was also not possible due to the lack of space and the number of people at the market that made it crowded. Therefore sorting and grading took only place at the start, at farmer level, and at the end of the value chain at retailer level. Furthermore the analysis of the data from the first pilot (pilot 1) showed that the amount of quality grade A tomatoes increased from farm level to retail level for VC3 round 1. This is not possible unless the quality classification was done differently at both stakeholders. Classification of product qualities in the VCs and in Nigeria in general is not transparent. Because it was expected that stakeholders in the VC will have a more subjective interpretation of quality and quality classes, local enumerators performed the grading of the tomatoes at the farm gate, while grading at the retailer VC-link was done by enumerators and the local shopkeeper together. Hence the conclusion was that the absence of a standardized classification system probably undermined the positive effect of crates on quality. Therefore the grading of tomatoes both at farm level and retail level was executed by the enumerator in pilot 2 and pilot 3. This guaranteed a standardized classification system.

- Last was the change in notation of the observation sheet. In the first pilot, several fields were not filled in correctly so this showed that the observation list was not applicable enough. Although changes were made in consultation with the enumerators to made the observation sheet more clear, the information collected was equal between the pilots.

- The enumerators collected the data during the pilots. They were trained by the research team in advance. Although the training took place, the data recording sheet was not always filled in correctly, especially for pilot 1. For example some observations were missing or the wrong unit was used during recording, the prices for the different grade tomatoes at retail level were absent, or grading was done differently at retail level compared to farmer level. The enumerators of pilot 1 were also included in pilot 3. The data collection improved significantly in time, since less errors and missing data were found in pilot 3. This reveals that repetition and training influences the quality of the data collected. In addition the use of local enumerators also benefit the pilots, since they speak the local language what improves the communication with the local stakeholders. Furthermore this guaranteed that five value chains could be tracked at the same time without influencing the harvest activities.

4.2 Errors during measurements

Although the measurement tool was updated after every pilot, still some errors occurred during data collection.

For the second pilot (pilot 2) three product samples were taken for each packing type from the entire batch from a specific individual farmer which were labelled for tracking it through the entire VC. The samples were labelled by means of coloured ribbons, whereby each product sample that was supplied by the participating farmer was marked with various coloured ribbons attached to its baskets and plastic crates. The advantage of using coloured ribbons is that there is minimal risk of wear and tear as compared to paper labels. Unfortunately in one VC case the ribbons from two baskets were removed, or became detached from the baskets, in which cases the samples could not be tracked anymore. In these cases the corrupted measurement data were taken out from the datasets. This affected the results, since two out of three basket samples in VC2 round 1 were removed from the dataset. The comparison of data from three sampled crates with one sampled basket is therefore inconclusive. The results of this sample also deviated from the results from the other value chains and rounds.

Another example of the restriction in sample size was shown in the third pilot (pilot 3). In this pilot two samples were taken for each packing type. In VC2 round 1 the total weight of one basket increased from 19.1 kg at farm level to 19.3 kg at retail level. This should not be possible and therefore was considered as error and removed from the dataset. The reason for the slight increase in weight for this basket was that the baskets of tomato were transported from the wholesale market to the retail store by a driver who also transported other retailers' produce. In doing this, the driver had to squeeze the baskets and stalked them on each other in the small space. In the process of doing so, since the enumerator was not allowed to intervene in the process, one or two pieces of tomato might have fallen from one basket into another basket, or at the bottom of the car. This difference in weight might have occurred during the driving, during offloading by the driver, or because the driver dropped the tomatoes at the bottom of the car in any of the baskets. In case of the crates this did not happen because creates were neatly stalked on top of each other and even during turbulence of movement on the road, it was unlikely for one or two tomatoes to fall into another.

The number of packaging samples varied between and within the pilot. For example in pilot 2, VC1 round 1 contained two samples of raffia baskets instead of three samples used in this pilot. In VC2 round 2 only two sample baskets were available (instead of three) because of insufficient product from the farmer at that time. This had no effect on the dataset other than that a third sample would have enlarged the dataset. In pilot 3 only two packaging samples were used for the measurement. This sample was therefore really small. These examples show the significance of having sufficient and equal number of samples per type of packaging. An equal number of completely measured samples for both packaging types will enable better comparison of the results.

In a few value chains two farmers were used, one used in round 1 and the other for round 2. For example VC1 and VC3 used in pilot 2 contained two measurement rounds that were performed in VCs that were identical. For VC2 the two rounds were not exactly identical because of the limited availability of product at the farmer of the 1st round. Therefore a 2^{nd} farmer in the vicinity of Kano was approached for the 2^{nd} round. This different composition makes the data less suitable for comparison.

A problem derived from the first pilot (pilot 1) was that the season was coming to an end. This resulted in a small amount of tomatoes. This low amount of tomatoes also resulted in different transportation practices. In low season the vehicles were not fully loaded and therefore the drivers did not need to squeeze the baskets and crates as done during high season (see Picture 4.1). This could have influenced the results.

Picture 4.1: Transportation of baskets and crates in an 'empty' vehicle in pilot 1 (left), and baskets transported in a fully loaded vehicle in pilot 3 (right)

4.3 Literature comparison of the measured PHLs

The results of the southern value chain (pilot 1 and pilot 3) show a total loss of 12% during low season and 5% during high season for the raffia baskets. These post-harvest losses are lower compared to the post-harvest losses estimated by FAOSTAT. They estimated the post-harvest losses of tomato at 15.0% in 2013 (FAOSTAT, 2013). However the data of FAOSTAT is based on the data available in the whole country while this study did a measurement of five value chains. Furthermore the data of FAOSTAT was derived five years ago and in these five years the production of tomatoes improved. As this current conducted research concluded that the quality of the tomatoes provided in the baskets at farm level probably influenced the losses in the value chain, this can explain the different results.

Three years ago Abubakar and El-Okene (2015) conducted a research about the transportation losses of tomatoes in Nigeria. For this research in total twenty traditional raffia baskets and twenty rectangular baskets were selected randomly for the loss assessment. The loss assessment was based on weight and the tomatoes were graded to damaged and undamaged tomatoes. The traditional baskets had an average loading capacity of 40 kg, the rectangular baskets of 25 kg. They found an average weight loss of 6.85% and 13.22% was damaged or lost in the traditional baskets for a total transportation distance of 877 km from Katsina State to Ibadan. The rectangular baskets showed an average weight loss of 1.91% and 3.58% was damaged or lost. The results from the production area in the North (pilot 2) showed a similar result for the traditional raffia baskets. The total weight loss was 7% for raffia baskets from farm level to retailer level. However the plastic crates showed an average weight loss of 7% as well. However this difference between raffia baskets and crates was visible in the southern value chain (pilot 1 and pilot 3).
Nevertheless these results are not fully comparable. This current research included the complete value chain from harvest till retailer instead of only the transportation part. Furthermore the cultivar of the tomatoes is different and different stakeholders and activities were included in this current research, like unloading and loading at the agent or collection centre.
The results about the weight loss of quality A tomatoes of this current research cannot be compared with the study of Abubakar and El-Okene (2015) since grading was not done equally. In the research of Abubakar and El-Okene (2015) grading was done based on damaging while in this study grading was based on colour and firmness of the tomatoes. A study of Idah et al. (2007) showed the same result as Abubakar and El-Okene (2015). It showed that 13,89% of fresh tomatoes were damaged during transport in the traditional baskets. The weight of these baskets varied between 20 kg and 55.07 kg.

In total five different VCs were used in pilot 1 and 3, and three different VCs in pilot 2. This is only a small sample of the total number of VCs that can be identified. Especially in the southern value chains the variation of data was high. The loss of tomatoes in baskets varied between 2% and 35% in pilot 1. This high variation in data collected identifies the difficulty in upscaling these data for all value chains. Every batch of tomatoes has another transportation time due to police controls, broken vehicles, closed roads or distances to the market. Furthermore the production circumstances are different between the farms in a region; like different varieties, use of sheds or use of fertiliser. These can have influence on the tomato losses further in the VC. To exploit the data for Nigeria as a whole, more VCs should be included of which several with equal production circumstances.

5 Conclusion

Although the sample sizes were small, it can be assured that the measurement tool was successfully applied. In between the pilots the measuring tool was fine tuned to tackle the errors that occurred. Therefore it can be concluded that the results of the third pilot give the best insights in the performance of the traditional raffia baskets in comparison with the use of reusable plastic crates. Therefore, the results give an insight into the performance of the reusable plastic crates when introducing them to the value chain.

To conclude, the innovation in the form of the plastic crates showed better results compared to the traditional raffia baskets in the last pilot (pilot 3). Although food losses were still present when using these crates, they resulted in reduced losses and less quality decay compared to the baskets. The current system with the use of tradition raffia baskets showed an overall loss of 12%, 7% and 7% for pilot 1, pilot 2 and pilot 3 respectively. The innovation in the form of plastic crates showed an overall loss of 5%, 2% and 7% respectively (see Table 5.1).

Table 5.1: Overall loss of tomatoes for baskets and crates

	Loss in baskets	Loss in crates	P-value
Pilot 1	12%	5%	0.16
Pilot 2	7%	7%	0.79
Pilot 3	7%	2%	0.02

Furthermore the quality decay of grade A tomatoes was lower in the plastic crates compared to the raffia baskets in pilot 2 and pilot 3. The results in pilot 1 did not show any significant differences between the performance of raffia baskets and plastic crates. The use of raffia baskets resulted in quality loss of grade A tomatoes of 37%, 28% and 27% for pilot 1, pilot 2 and pilot 3 respectively while crates showed a quality loss of grade A tomatoes of 15%, 12% and 2% respectively (see Table 5.2).

A likely connection was found between the percentage of quality grade A tomatoes filled in the baskets and crates at farmer level and the percentage of loss at retailer level, for total loss and loss in quality grade A tomatoes respectively. This founding suggests that increasing the quality of tomato at farmer level will decrease the percentage of loss in the value chain. However this was independent from the use of raffia baskets or plastic crates.

Table 5.2: Quality loss of grade A tomatoes on average

	Δ Quality A in baskets	Δ Quality A in crates	P-value
Pilot 1	-37%	-15%	0.07
Pilot 2	-28%	-12%	0.03
Pilot 3	-27%	-2%	0.003

For these pilots only a small sample of VCs were selected compared to the total number of VCs that can be identified in Nigeria. Especially in the southern value chains the variation of the results between the VCs was high. This high variation in data collected identifies the difficulty in upscaling these data for whole Nigeria. Every batch of tomatoes has another transportation time due to police controls, broken vehicles, closed roads or distances to the market. Furthermore the production circumstances are different between the farms in a region; like different varieties, use of sheds or use of fertiliser. These can have influence on the tomato losses further in the VC. To exploit the data for Nigeria as a whole, more VCs should be included of which several with equal production circumstances.

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Annex 1 Selected value chains and stakeholders

The value chains and stakeholders have been derived from IFDC/Agrofair/Taste tomato value chain pilot project workshop - list of invited participants.

Table 4: Selected value chains & stakeholders

S/N	ACTOR IN THE VALUE CHAIN	LOCATION
CHAIN ONE (1)		
1	Wholesaler/Dealer	Oja-Oba, Ibadan
2	Farmer	Oloka, Oyo state
3	Farmer	Oloka, Oyo state
4	Driver	Onila, Oyo state
5	Retailer	Ayegun, Oyo state
6	Retailer	Ayegun, Oyo state
7	Farmer	Idiroko Ibadan, Oyo state
CHAIN TWO (2)		
8	Wholesaler/Dealer	Shasha-Ibadan, Oyo state
9	Farmer	Ipapo-Iseyin, Oyo state
10	Farmer	Ipapo-Iseyin, Oyo State
11	Driver	Ipapo-Iseyin, Oyo State
12	Retailer	Gbagi – Ibadan
13	Retailer	Ibadan
CHAIN THREE (3)		
14	Wholesaler/Dealer	Abule-Egba, Ileepo market, Lagos
15	Wholesaler/Dealer	Abule-Egba, Ileepo market, Lagos
16	Retailer	Abule-Egba, Ileepo market, Lagos
CHAIN FOUR (4)		
17	Dealer/Wholesaler	Ogbomoso, Oyo state
18	Farmer	Ajegunle-Oba, Ogbomoso
19	Farmer	Ajegunle-Oba, Ogbomoso
20	Driver	Ogbomoso, Oyo state
21	Dealer/Wholesaler (Plastic crate)	Mile 12, Lagos
CHAIN FIVE (5)		
22	Dealer/Wholesaler	Lagos
23	Farmer	Iseyin
24	Farmer	Iseyin
25	Driver	Iseyin
26	Wholesaler	Mile 12 Lagos
27	Retailer	Okokomaiko, Lagos
28	Retailer	Okokomaiko, Lagos

Annex 2 Procedure load tracking

Baseline measurement.

When: Farmer: after harvest, or after sorting & grading

1. Label sample packaging: attach coloured ribbon to each sample baskets and plastic crate, with a different ribbon colour for each farmer. Condition: tomatoes of that specific farmer will remain in this packaging and will not be mixed with product from other farmers.
2. Weighing of product per class; weighing of packaging
3. Observations of product (heterogeneity/homogeneity of the product, colour/ripeness of the product (use of colour charts?), how product is handled, a.s.o.)
4. Observations of the reasons/causes of FLW
5. Fill out the DATA RECORDING SHEET for the 1st measurement point

Measurement +1

When: FARMER: just before loading of the vehicle

1. Measure dimensions of the vehicle's cargo bin (length, width, height)
2. Weighing of product per class
3. Observations of product (heterogeneity/homogeneity of the product, how product is handled, packed into the vehicle a.s.o.)
4. Observations of the reasons/causes of FLW
5. Fill out the DATA RECORDING SHEET for the 2nd measurement point

Measurement +2

When: WHOLESALER/DEALER: after sorting/grading, after arrival / off-loading of the product from the vehicle

1. Weighing of product per class after sorting/grading
2. Weighing of product loss after sorting/grading
3. Observations of product (heterogeneity/homogeneity of the product, how product is handled, a.s.o.)
4. Observations of the reasons/causes of FLW

Fill out the DATA RECORDING SHEET for the 3rd measurement point

Measurement +3

When: Retailer: after sorting/grading

1. Weighing of product class after sorting/grading
2. Weighing of product loss after sorting/grading
3. Labelling of retailer display baskets with the appropriate farmer coloured ribbon
4. Observations of product (heterogeneity/homogeneity of the product, colour/ripeness of the product (use of colour charts?), visible damage, how product is handled, a.s.o.)
5. Observations of the reasons/causes of FLW
6. Fill out the DATA RECORDING SHEET for the 4th measurement point

Measurement +4

When: Retailer: after sales

1. End-of-market-day survey of retailer: inventory of product sold, product unsold, product loss, and sales price (for the baskets that correspond with the farmers in the research).
2. Observations of the reasons/causes of FLW

Fill out the DATA RECORDING SHEET for the 5th measurement point

To explore the potential of nature to improve the quality of life

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