

PRODUCTION TO MARKET: IMPROVING THE QUALITY REQUIREMENTS FOR EXPORT MARKET.
(Case Study of passion fruit in Rwamagana District; Rwanda)





Improving the Quality of Passion Fruit in the Value Chain for Export Market in Rwamagana District;
Rwanda

A research project submitted to Van Hall Larenstein University of Applied Sciences in partial fulfillment
of the requirements for the degree of MSc in Agricultural Production Chain management,
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DEDICATION

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List of abbreviations

COMESA	The Common Market for Eastern and Southern Africa
DAP	Diammonium phosphate
DDT	Dichloordifenyltrichloorethaan
EAC	East African Community
EU	European Market
FAO	Food Agriculture Organization
GDP	Gross Domestic Product
HCH	Hexachlorocyclohexane
IDPRS	Economic Development and Poverty Reduction Strategy
Kgs	Kilograms
LDCs	Low Developing Counties
MINAGRI	Ministry of Agriculture and Animal Resources
MRLs	Maximum Residue Levels
NAEB	National Agricultural Export Development Board
NARI	National Agricultural Research Institute
NGO's	Non-government organizations
NISR	National Institute of Statistics of Rwanda
NPK	Nitrogen, Phosphorus, and Potassium
PHLs	Postharvest Losses
UK	United Kingdom
USAID	United States Agency for International Development
WHO	World Health Organization
AFR	Access to Finance Rwanda,

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ABSTRACT

Rwandan passion fruit has become one of the sources of income for producers and the country at large. However, the passion fruit sub-sector development is hindered by insufficient quantity for export due to the poor quality of produced passion fruits. The study aims to identify causes that affect the quality of passion fruit value chain (production to the market) in Rwamagana district to provide recommendations to NAEB to address the problem of poor quality that results in high rejection on the international market.

Quantitative and qualitative methods were used to gather data from field surveys for passion fruit producers in Rwamagana district and in-depth online interviews with key informants. The sample size was 40 for field survey respondents in which 21 were farmers randomly selected from cooperative Ejoheza members by picking names from the list of cooperative members and 19 were obtained by the snowball method where one farmer was leading to another. The key informants for online interviewees were purposively selected. Literature was used to collect secondary data. The research was conducted during the corona pandemic and the researcher was not able to travel due to restriction to movement put by both The Netherlands and Rwandan government. A research assistant was hired to collect field data on behalf of the researcher.

The study shows that 45% of the planting materials were sourced from farmer's farms, 20% were from cooperative Ejoheza and only nearly 3 percent were from agro-dealers. Nearly 53% of the passion fruit farmers work with the export market and 47 percent do not work with the export market. Among the respondents (farmers) 62 percent practice organic farming and others 37 percent do both conventional and organic farming. Based on the study results, almost (58%) of farmers who work with the export market harvest their fruits less than a week after pesticide spray, while others harvest immediately or a week after spraying. Therefore, there is no difference in the waiting time between pesticide application and harvesting time between farmers who sell passion fruits to exporters and those who sell on the local market. Both farmers who work with the export market and farmers who do not work with export (30%) harvest their fruits when fully ripe and half-ripe fruits. Furthermore, during harvesting, almost all (90%) of farmers use their experience to determine the harvesting time. The study results showed that 55 percent of passion fruit growers do sorting while 67 percent grade their fruits before supplying them to exporters.

Farmers in Rwamagana district do farming practices that are in line with the export market quality requirements but they still lack knowledge and skills about good agricultural practices. As a result, they receive low prices for their produce. Moreover, passion fruit farmers recognize the export market as an opportunity for their farming business which can enhance their livelihood. However, there are still few stakeholders in the passion fruit value chain; consequently, their supporting services to farmers are insufficient.

To meet export market quality requirements, passion fruits farmers in Rwamagana district should be capacitated in pests and disease control, proper harvesting techniques, postharvest handling (sorting and grading). These practices will contribute to the quality improvement of the passion fruits exported to the international market. Finally, to strengthen the passion fruit value NAEB in partnership with Rwamagana district should coordinate all stakeholders (farmers, input suppliers, exporters, NGOs, etc.) involved in the passion fruit value chain.

Key Words; Quality, Export market, Passion fruit, Pre-harvest, Postharvest handling, Value chain

CHAPTER ONE INTRODUCTION

The passion fruit is an important fruit crop grown in the world due to its economic value. It belongs to the family *Passifloraceae* (Deshmukh, et al., 2017). The majority of *Passiflora* species are indigenous to the tropical and subtropical regions of South America. Brazil is considered the centre of the origin of approximately 139 known species and the world's top producer of this genus of which 89 are widespread (Nerdy & Ritarwan, 2019). According to Maciel, et al., (2018) the most cultivated species in Brazil is the yellow passion fruit (*Passiflora edulis Sims*) that accounts for 95% of the total planted areal whereas the purple passion fruit (*P. edulis Sims*) and the sweet passion fruit (*P. alataCurtis*) are grown in smaller areas for the consumption and are present in restricted markets.

Brazil, South Africa, New Zealand, Taiwan, and Kenya together account for 80-90% of the world's passion fruit production. Altendorf (2017), points out that it is estimated that the global production of passion fruit has reached 1.5 million tonnes in 2017, mainly due to strong harvests in Brazil, Colombia, and Indonesia. Passion fruit is highly appreciated for fresh consumption and industrial purposes because of its nutritiousness, attractiveness, and its diverse uses for juice, jelly, and ice cream products (Thokchom & Mandal, 2017). The commercial production of purple passion fruit begun in Kenya in 1933 and expanded in 1960. The purple passion fruit is adapted to the cooler subtropics or at high altitudes in the tropics, while the golden passion fruit (*P. edulis var. flavicarpa*) is more suited to the tropical low land conditions (Deshmukh, et al., 2017). In Kenya, passion fruit has become part of the solution in staving- off hunger and malnourishment (Lagat, et al., 2018). On the other hand, passion fruit is underutilized because of the significant amounts that go into waste during peak production (Lagat, et al.,2018).

Furthermore, Kenya is considered the largest supplier of fresh purple passion fruits to the European markets like the UK, The Netherlands, France, Germany, and Belgium. Kenya competes with Brazil, Columbia, Nigeria, Zambia, Zimbabwe, and Uganda on the market. Thus, the volumes of passion fruits exported had not been a stable trend (Kormelinck & Janssen, 2012). There has been an increase and decrease in the trend of passion fruit export over the years and the decrease can be attributed to stringent market requirements especially the Maximum Residual Limits (MRLs) (Tridge, 2020). Additionally, Lagat, et al., (2018), state that important considerations for the quality of passion fruits include consistent and fresh appearance, acceptable texture, characteristic flavor, and sufficient shelf-life to survive the distribution system.

In Rwanda, passion fruit started to be grown as a commercial crop largely after 1994. Rwanda grows both yellow and purple passion fruit but exports purple passion fruit to the international and regional market. Rwandan passion fruit is well received on the marketplace due to its superior flavor (RDB, 2020). Rwanda's relative advantages in horticulture include diversified agro-climatic conditions such as high, medium, and low altitude, productive soils, enough water resources, and available labor that can be used to produce quality and competitive horticulture products for sale in regional and international markets (NAEB, 2020). Additionally, the Government of Rwanda is putting effort into investing in the production of clean planting material and an expansion program of passion fruit.

Despite the agriculture competitive natural environment, and available labor, Rwanda is not among the main passion fruit exporters. This is possibly due to pre and post-harvest handling practices, thus resulting in loss of the large quantity of the harvested produce and deterioration in the quality of the produce (MINAGRI, 2017). It was emphasized on by Gasasira (2020), in charge of export at National Export Development Board that "demand for fresh passion fruit is still high, however, there is still a challenge of inadequate supply of quality product on the export market due to local farmers limited knowledge of good agriculture practices (GAP), lack of basic processing skills (sorting, and grading) which results in the limited supply of the passion fruits on the export market". Furthermore, one of the most common mistakes growers make is to harvest fruit crops with mixed maturity either too early or too late, when fruits are under-ripe or over-mature which reduces the fruit shelf life (Kader & Kitinoja, 2003).

1.1 Problem statement and Problem Owner

Rwandan passion fruit has become one of the sources of income for the families who produce it for mainly the local and export market (Wamucii, 2020). However, the passion fruit sub-sector development is hindered by insufficient quantity due to the poor quality of produced passion fruits. Data from NAEB (2018), shows that passion fruit export has remarkably decreased in quantity due to failure to meet the export quality standards. This means that in the agricultural season (2017-2018) only 42,081 kgs were sold out of 42,857 kgs of passion fruits received at NAEB packhouse and the rejects of passion fruit resulted in a shortage of supply of passion fruits on the export market. Furthermore, in its strategic plan of 2019, NAEB has set a goal of reaching 1 billion USD in agri-exports revenue per annum by 2024 through investing in the export of horticulture crop but the area of improvement in the passion fruit subsector remains uncertain. There is a knowledge gap about factors affecting the quality of passion fruit in Rwanda. Therefore, the study will suggest interventions that can be used by NAEB to address the causes of poor quality of produced passion fruit in Rwamagana district.

Problem Owner: NAEB has commissioned this research to find out factors that affect the postharvest quality of passion fruits grown for the export to support the passion fruit value chain (from production to market) to meet international market requirements. The passion fruit producers and exporters are also affected by losses because they gain less income compared to the cost of production incurred.

1.2 Research Objective

The study aims to identify causes that affect the quality of passion fruit value chain (production to the market) in Rwamagana district to provide recommendations to NAEB to address the problem of poor quality that results in high rejection on the international market.

1.3 Research questions

1. *What are the current agricultural practices that affect the quality of passion fruit in Rwanda?*

Sub-research questions

- 1a. What are the existing pre-harvest practices that affect the quality of passion fruit in Rwanda?
- 1b. What are the observed harvesting maturity parameters by passion fruit producers in Rwanda?
- 1c. What are the existing post-harvest practices that affect the quality of passion in Rwanda?
2. *What are the main challenges farmers face to comply with the international market quality standards in Rwanda?*

Sub- research questions

- 2a. What are the farmers' perceptions regarding export market requirements?
- 2b. What are the current quality standards practiced by passion fruit producers to meet the export market requirement?
- 2c. What are the opportunities and constraints for improving passion fruit for the export market?
- 2d. Who are the stakeholders and their roles in the value chain of passion fruits in Rwanda?

1.4 Conceptual framework

The core concept of the study is quality features, which is approached in three dimensions. The first two dimensions are looking at the effect of current existing agricultural practices on the quality of passion fruit while the third dimension looks at the stakeholders and their roles in the value chain of passion fruit in Rwanda.

Figure 1 indicates the core concept, dimensions, and aspects the research is focused on, and the outcomes of which are related to research questions and sub-questions.

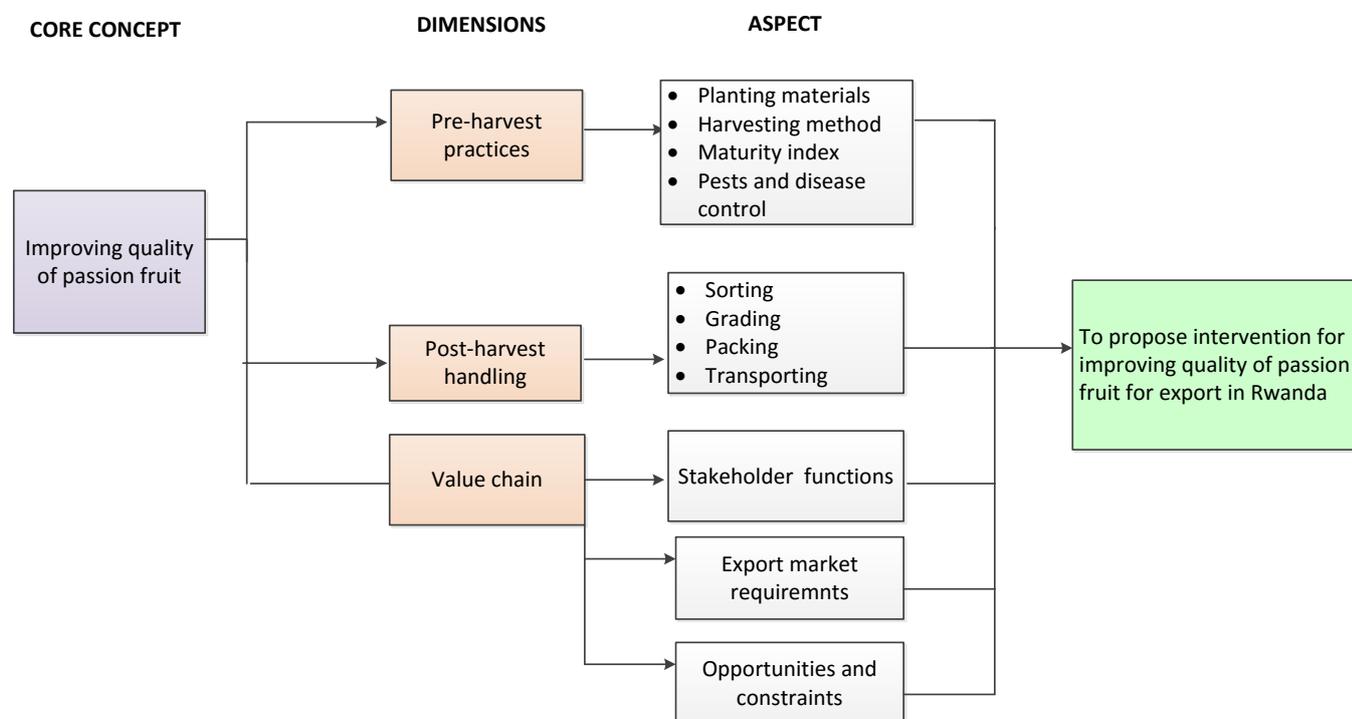


Figure 1. Improving the quality of passion fruit framework; Researcher (2020)

1.5 Definition of concepts

The main concepts in this research are; Pre-harvest practices, Post-harvest handling, Quality, Passion fruit, and value chain.

- **Quality** is defined as the desired extrinsic and intrinsic attributes of products being marketed and match the expectations of a purchaser who may be expected to pay a premium price and/or provide repeat purchases of the product if the quality criteria are consistently maintained (Ron & Golding, 2016).
- **Pre-harvest practices** are a range of activities done including; cultivar, and varieties selection, maturity indices, pest & disease control, irrigation, and pre-harvest interval (PHI) which affects the quality of passion fruit (El-Ramady, et al., 2014).
- **Postharvest handling** is a set of post-production practices that include: cleaning, sorting, grading, packing, and temperature management. The postharvest quality of fresh horticultural commodities markedly depends upon the quality attained at the time of harvest (El-Ramady, et al., 2014).
- **Passion fruit (*Passiflora edulis*)** also known as Maracuja, is defined as an exotic perennial flower plant, spherical-shaped fruit with a central cavity filled with a pleasant aromatic juicy pulp. It is a fruit that has several different varieties that differ in shape and color such as yellow, sweet granadilla, purple, and banana passion fruit which is sold both as fresh fruit and/or as processed concentrates in supermarkets (Maniwara, 2015).

- **Value chain** Ferranti (2019) defined Food Value Chain (FVC) as the network of stakeholders involved in the various steps of the life of food, ‘production to ready for market’. This definition includes producers, processing industry; sellers (both wholesalers and retailers); consumers; governments, and regulatory agencies that rule the entire process.

In the book *Competitive advantage; Creating and Sustaining Superior Performance* (Porter 1985) cited by Dilip & Rajeev (2016), the idea of the value chain is a representation of a firm’s value-adding activities which is based on the idea of seeing inputs, and outputs involve the acquisition and consumption of resources such as money, labor, materials, land, administration, and management.

CHAPTER TWO LITERATURE REVIEW

This chapter provides readers a brief description of the global situation of postharvest losses of fruits and vegetables, an overview of agriculture in Rwanda and horticulture in Rwanda, and actors and stakeholders, in the value chain of passion fruit in Rwamagana district, Rwanda. Also, this section provides a summary of EU market requirements for passion fruit.

2.1 Importance of Postharvest Losses in Global Context

Post-harvest loss is one of the concerns of food security and global hunger in many countries. According to Elik, et al., (2019), the total vegetable and fruit production in the world is over 1,07 billion tons produced on 57 million hectares of land. However, the extent of fruit and vegetable loss reaches up to 50 %. Therefore, reducing fruit and vegetable loss is one of the leading issues for providing sustainable food supply to the world's population in the future. According to Elik, et al., (2019), the major causes of post-harvest losses in fruit and vegetable occur during harvesting, post-harvest handling and storage, distribution, and consumption. Galford, et al., (2019) emphasize that worldwide, the majority of food loss occurs during early stages of the value chain, including at production, postharvest storage, transportation, and processing, while food waste takes place towards the end of the food supply chain including retail and consumption. Losses vary by product and the value chain stages the product goes through. Losses at each stage impact the next stage, cumulatively reducing the food accessibility to retail and consumption (figure 2), which should be a motivation for all stakeholders to minimize Food loss.

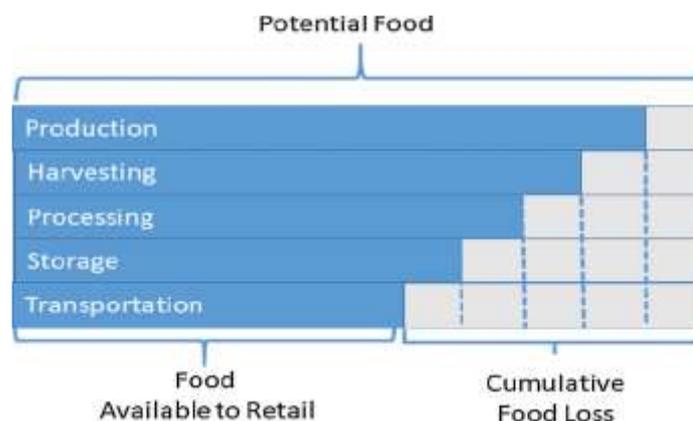


Figure 2. Cumulative effects of food loss in the food value chain; Galford, et al., (2019)

According to Singh, et al., (2014), it is estimated that 30-40% of total production in developing countries is spoiled due to lack of postharvest handling which fails to meet consumers' demand due to the low-quality food while in developed countries, a large amount of the food produced is discarded possibly due to expiring date or getting spoiled on the shelves of the supermarket. The majority of both quantitative and qualitative losses occur from harvesting, through post-harvest handling, storage, processing, and marketing to the final delivery (Kader,2005). In other words, postharvest food loss translates not only into human hunger and financial loss to farmers but also into remarkable environmental waste. Reducing food losses could, therefore, have an immediate and significant impact on livelihoods and food security (Prusky, 2011).

2.2 Agriculture Sector Overview in Rwanda

The World Bank in partnership with the Ministry of Agriculture and Animal Resources (MINAGRI), conducted an assessment on Agriculture Finance Diagnostic in Rwanda in 2018 which indicated that Agriculture is critical to Rwanda's economy. Agriculture contributes to more than half of the country's export revenues. Therefore, it is considered as one of the priority areas for future economic growth and economic inclusion in the current National Strategy for Transformation (NSIR, 2019). The National Institute of Statistics of Rwanda (2019) reports that the annual average yield for fruits and vegetables in Rwanda was 10.39 t/ha for vegetables and 6.37 t/ha for fruits among others.

2.3 Importance of Horticulture Export in Rwanda

According to NAEB (2019), horticulture export increased 24% in volume and 169% in value during the last 5 years (2018-2014). The cumulative revenues generated from Agricultural export products for the Fiscal Year (FY) 2017-2018 were \$515.9 million compared to \$ 356.5 million of the previous years (2016-2017) indicating an increase of 45%. During the Fiscal year 2017-2018, the share of tea, coffee, and pyrethrum exported were 31% of the total agricultural exports while fruit and vegetables were 69%. The Horticulture products occupied 6% of the total export. The horticulture crops exported abroad include; Passion fruits, Chili, Snow peas, Flowers, Broccoli, Macadamia, and Avocado (MINAGRI, 2019). Rwandan horticultural sector shows a potential growth by offering employment and business opportunities to smallholder farmers and is, therefore, a crucial sector for economic development at the local level, providing income security for workers in rural and urban areas (Dijkxhoorn, et al., 2016).

The Government of Rwanda has put much effort to maintain and increase horticultural production and at the same time supporting the development of the export market (MINAGRI, 2019). Nevertheless, the passion fruit subsector is characterized by low production and poor quality, possibly due to small-scale farming and persistent pests and diseases. The key to successfully accessing markets, either regional or international, is being able to respond to market quality and quantity demand with reliable consistency according Parkouda, et al., (2016).

2.4 Factors involved in the quality of passion Fruits

The word "quality" means property, or basic nature of a product and level of excellence in terms of appearance, taste, nutritional value, and safety, among others (Fischer, 2018). The set of all the qualitative parameters (such as color, size, and shape) and quantitative (physiological, mechanical, or pathological deterioration) factors indicates the rate of deterioration. The lack of control of these factors leads to post-harvest losses on a large scale (Prusky, 2011). According to Kader & Kitinoja (2003), the most common causes of poor quality of passion fruit in developing countries continue to be pre-harvest practices such as not respecting recommended harvesting time, mechanical damage during harvesting, and postharvest practices such as lack of sorting, grading, transportation. The use of inadequate packaging materials further adds to the problem.

2.4.1 Pre-harvest practices

Generally, the quality and condition of fresh produce cannot be improved after harvest. Pre-harvest production practices may seriously affect the post-harvest of fruits which results in the rejection or low price of produce at the market place (Singh, et al., 2014). The following pre-harvest practices influence quality.

❖ Planting materials

The choice of planting materials can significantly impact the postharvest quality of fruit. It is recommended to plant cultivars that produce high yields under a wide range of growing conditions and they should be resistant to environmental stress, pest, and disease because of the consumer's perception towards pesticide residues in the fruit (Prusky, 2011). Passion fruit is propagated by seeds, cuttings, and grafting whereby seedlings and grafted plants are more vigorous than cuttings. Sowed seeds should be vigorous, healthy (free of disease), and from a trusted source (Santos, et al., 2016). In Rwanda imported planting materials are first certified by Rwanda Agriculture and Livestock Inspection and Certification Services to prevent the introduction, spread, and establishment of alien pests, diseases, and weeds into the country (MINAGRI, 2020).

❖ Irrigation

Growing plants need a continuous supply of water to enable fruits to mature to marketable size and to be able to harvest at the proper time in a good physiological condition (Prusky, 2011). Although, too much rain or irrigation can lead to brittle and easily damaged the passion fruit leave and increased tendency to decay. Meanwhile, lack of rain or irrigation can lead to low juice content and the thick skin of passion fruit or small fruit for which there is no market demand. Management practices can also affect postharvest quality, for

example, through stress caused by too much or too little water. Water is highly required when fruits are approaching maturity, and if the soil is dry, fruits may shrivel and fall prematurely (Deshmukh, et al., 2017).

❖ Use of fertilizers

Lack of nutrients in the soil can seriously affect the quality of fresh produce at harvest. On the other hand, too much fertilizer can harm the growth and development of fruits (Prusky, 2011). Passionfruit requires an adequate nutrient uptake at all stages of growth and production and this requires a fertilization plan to permit the maintenance of adequate nutrition for a crop (Joy & Divya, 2016). From the start of the fruit formation, there is a great demand for energy by the plant and a strong distribution of nutrients from the leave to the development of the fruits. This reduces the vegetative growth of the plant. Phosphorus (P) is among the essential plant nutrients because in its absence fruit growth is reduced, affecting the quantity of dry matter, root growth, and fruit production. Potassium (K) deficiency reduces the size of the plant and the production of fruits, which can cause fruits to prematurely fall or shrivel. The application of larger amounts of Potassium was observed to increase the length and diameter of the fruit (Prusky, 2011).

❖ Pests and Diseases

According to Olango, et al., (2014), in Uganda and Kenya passion fruit is an important crop targeted towards enabling small fruit farmers to gain a source of income. However, viral diseases are a major limiting factor to passion fruit production worldwide. These viruses threaten passion fruit production whereby 40-100% of yield loss (Uganda) and total crop loss of 50-100% in Kenya has been reported due to biotic stresses (Robinah, et al., 2018). According to Olango, et al., (2014), several methods have been used to manage these diseases including pesticides, biological control agents, cultural methods, use of resistant varieties, and use of disease-free planting material. However, there has been little or no success. While these chemicals reportedly yield beneficial results in management, their effect in managing diseases vectored by pests such as aphids is not clear. When the diseases are widely spread in all passion fruit farms, they reduce fruit yield and quality. Coreid bugs, Flies (*Anastrepha* spp), and Mealybugs are amongst pests that affect the quality of passion fruits by often causing misshaping or dropping of young fruits, Fusarium Wilt is also a soil-borne disease-causing yellowing of leaves, after which vines wilt followed by a complete collapse of the plant (SHEP PLUS, 2013).

❖ Pesticide residues

Production and quality of passion fruit are strongly affected by pests and diseases, causing yield losses of up to 65% (Robinah, et al., 2018). Every year higher amounts and new chemical compounds are used to protect crops, causing undesired side effects, and raising the costs of food production due to pests development and adaption to chemicals (Carvalho, 2006). Agrochemicals were introduced in passion fruit aiming at enhancing crop yields and at protecting crops from pests. However, the World Health Organization (2020) highlights that pesticides are potentially toxic to humans and can have both acute and chronic health effects, depending on the quantity and ways in which a person is exposed. Some of the older and cheaper pesticides can remain for years in soil and water. This has led to a ban on cheap chemicals, such as DDT, HCH, and lindane from agricultural use in developed countries, but they are still used in many developing countries. According to Juraske, et al. (2012), Colombia and other developing countries were reported to have exceeded the Maximum Residue Limits (MRLs) in passion fruits due to the labor-intensive nature of the cultivation system. Passion fruit production lies mainly in the hands of small-scale farmers, who are attracted by the relatively high profitability and tangible market potential of the crop. Consequently, due to little or no formal training, farmers often use inappropriate pest management practices resulting in overreliance on pesticides (Robinah, et al., 2018).

2.4.2 Harvest maturity indices

Maturity and ripening are the major factors that determine postharvest- life and final quality (appearance, texture, flavor, the nutritive value of fruit) of a product and its shelf life (El-Ramady, et al., 2014). However, some farmers harvest immature crops due to economic reasons. yet un-ripened fruits are more susceptible to mechanical damage and deterioration. When fruits are harvested over-ripe, they have a low shelf life. In both cases (over-ripening and under ripening), fruits are more susceptible to physiological disorders. According to

Elik, et al., (2019), the maturity of passion fruit can be determined by different indices including the length of time after transplanting, after flowering, sight-color, size, and shape, and use of a maturity chart or refractometer.

Kader & Kitinoja (2003) state that the common index of maturity is skin color. The color of the fruit turns from green to either yellow or purple as it matures depending on the type of fruit. Fruit with limited color is considered not mature and should not be harvested. Most of the time mature fruit falls off the plant and drops on the ground. Immature fruit affects the intrinsic quality of fruit because it contains a lot of acids, which lower the flavor and aromatic compounds, and may not develop a full color after harvest (Ghosh, et al., 2017). Therefore, it is highly recommended to allow the fruit to turn color at least 50% of its surface on parent plants (Kader & Kitinoja, 2003).

❖ **Harvesting Methods**

The quality of fruit and vegetable also depends on the harvesting method. Poor harvesting practices can lead to damage to horticultural produce. Pickers should be careful in harvesting, by gentle cutting, picking, or pulling the fruit from the plant to minimize damage. Passion fruits are harvested manually by cutting, handpicking, and/ or clipping the fruit from the vine. During harvesting, the knives must be kept sharp and clean to prevent the spread of virus diseases from plant to plant. Fruits should be picked at the structure in the stem and not close to the shoulder of fruit (Joy, 2016).

Kader (2002), mentioned that the vine should be reachable for fruit should not be pulled from the plant. Fruit should be handled carefully by not throwing or putting in a rough container to avoid bruising of fruits. The field container should be stacked without damaging the fruit and fruit should be put in the shade while waiting to be transported to the packhouse or market. Pre-sorting should take place on the field to remove damaged, and over-ripe fruits to reduce losses (Prusky, 2011).

2.4.3 Post-harvest handling practices

All crops are naturally subjected to biological and physiological deterioration, but the rate of deterioration differs depending on a range of factors; starting from individual farming practices and continuing through the chain of interdependent activities between harvest and delivery of food to consumers (National Agricultural Research Institute, 2004). It is important to have in mind that fresh produce is still alive even after harvesting. This means that the handler has to handle with extra care at each stage from the farm to the market (Barman, et al., 2015). Main operations done to prevent postharvest losses include but are not limited to;

✓ **Sorting/ Grading**

According to RON (2016), pre-sorting of fruit should be carried out in the field, and grading should be performed at the packing area to remove fruit that does not meet market requirements. Passion fruits must be sorted and graded according to various external quality characteristics before packing. Export quality fruit must be firm, uniformly colored and shaped, and free of insect damage, physical injury, disease, brown discoloration, and other surface blemishes. The skin color should be at least 50% yellow or purple, depending on the market final destination and the fruit should have a smooth, shiny external appearance, and should be either round or egg-shaped. Passion fruit should be separated into 3 different size categories (small, medium, large) (NARI, 2004).

✓ **Packing**

Passion fruit should be packed in strong, well-ventilated containers capable of being stacked without damaging the fruit. The fruit surface should be free of moisture before packing and a single-layer fiberboard carton containing either 2 or 3.5 kgs of fruit is preferred for an export package for passion fruit (CBI, 2019). The cartons should be strong and self-locking so they can be stacked. Ventilation holes are needed for air movement and efficient cooling (Joy & Divya, 2016). The only fruit of the same size category and stage of ripeness should be packed in the same carton because product uniformity is crucial according to NARI (2014). The carton should have a plastic liner molded with individual cells to protect and separate the fruit.

✓ **Temperature Management**

Temperature is the most important environmental factor that influences the deterioration of harvested commodities so its management is essential in reducing water loss (Kader, 2013). Passion fruit held at temperatures above optimum will ripen more quickly and lose more weight whereas those kept below the optimum storage temperature will suffer from low temperature chilling injury. At the ideal storage temperature, partially ripe yellow passion fruit will have an average market life of 2 to 3 weeks and purple passion fruit will have a 4 to 5-week market life. Passion fruit picked fully ripe will have only about a 7 to 10-day market life (Joy & Divya, 2016). Harvested fruits should be kept under the shade to prevent water loss and sunburn which causes poor quality fruits. The sooner the optimum storage temperature is obtained, the longer fruit quality can be maintained and water loss can be minimized.

✓ **Provisions Concerning Quality for passion fruit**

Passion fruit is one of the fresh exotic tropical fruits which are mostly grown in developing countries. They are still considered niche products in Europe, due to the interest in new flavors and special varieties which is increasing (CBI, 2020). According to Codex Alimentarius standards (2014), fresh passion fruit (*Passiflora edulis Sims forma edulis*), should meet minimum quality requirements to be able to enter the international market. Passion fruits ready for export should be in good condition such that they can reach to the final destination when they are still fresh. Therefore, below are the minimum criteria that are recommended by WHO (2014) for passion fruit to meet market international market;

- The fruit should be whole
- They should look fresh
- Firm
- Fruit should be sound free from rotting or deterioration
- Fruits should be clean and free of any visible foreign matter.
- Essentially free of pests and damage caused
- Free of abnormal external moisture
- Fruits should be free of any foreign smell and/or taste
- Fruit should not be damaged or bruised to withstand transport and handling; and
- To arrive in satisfactory condition at the place of destination.

✓ **Classification/Grading**

Passion fruits are classified into three classes as defined below. Defects must not, in any case, affect the flesh of the fruit.

“Extra” Class

Passion fruits in this class must be of superior quality. They must be free of defects, except for very slight defects, provided these do not affect the general appearance of the product and keeping quality and presentation in the package.

Class I

Passion fruits in this class must be of good quality. They can have slight defects in shape, coloring, and skin such as scratches, not exceeding more than 10% of the total surface area of the fruit.

Class II

This class includes passion fruits which do not qualify for inclusion in the higher classes but satisfy the minimum requirements specified above. The following defects, however, may be allowed, provided the passion fruits retain their essential characteristics as regards the quality, and presentation;

- Defects in shape including an extension in the zone of the stalk
- Defects of the skin such as scratches or rough skin, not exceeding more than 20% of the total surface area of the fruit
- Defects in coloring.

2.5 Overview of passion fruit value chain in Rwanda

Rwanda's Agriculture consists of small scale farming under traditional agricultural practices that mainly rely on rain-fed seasonality (Giertz, 2015). According to NISR (2011) survey, the main passion fruit producing in Rwamagana district are classified into the following categories; very small farm (under 0.3 ha), small farm (0.3 to 0.9 ha), medium farm (0.9 to 3 ha), and large farm (more than 3 ha). The purple passion variety is more exported to the UK than yellow passion fruit. Extra class grade is only accepted on the export market whereas other grades (I&II) are traded on the domestic market. The value chain of passion fruit is characterized by local input suppliers, passion fruit farmers, exporters, local wholesalers in Kigali, and local retailers. The leading supporters in the value chain of passion fruit are the MINAGRI and NAEB.

2.5.1 Actors and their functions

- ✚ **Input suppliers** – Most of the time producers buy inputs such as chemical fertilizers, pesticides, and farm implements from individual shops, and source seeds from their agro-dealers and their farms.
- ✚ **Passion fruit producers** - The passion fruit subsector is considered as smallholder farmers with small farmland size. They plant passion fruits, do crop management such as pruning, pest and disease, and soil and water management throughout the planting period.
- ✚ **Exporters** - Two firms (Garden fresh and Proxifresh Rwanda Ltd) are consistent exporters who buy from farmers and do sorting, grading and packing at the NAEB pack house before export. The three distinguished functions of exporters in the passion fruit value chain are; to connect small-scale producers to international markets, they sometimes finance the production and transport process (NAEB, 2018).
- ✚ **Local wholesalers** – local wholesalers buy passion fruits from farmers or producers supply passion fruits to wholesalers in Kigali. Rejected fruit (2nd grade) from the export market is also sold on to the wholesale market.
- ✚ **Local retailers** –retailers are small traders, moving traders, supermarkets, and restaurants in Rwamagana and Kigali.
- ✚ **Local consumers** - The end consumers of passion fruit are hotels, restaurants, local consumers, regional markets, and international consumers (NAEB, 2020).

2.5.2 Key Supporters and their functions

- ✚ **Ministry of Agriculture and Animal Resources (MINAGRI)**– has established a department to inspect and certify imported planting materials. Rwanda Agriculture and Livestock Inspection and Certification Services (RALIS) are responsible for the enforcement of the Rwanda plant health law and regulations for phytosanitary measures necessary for trade, plant pest/disease monitoring, surveillance and diagnosis, conducting Pest Risk Analysis, and conduct inspection and certification (MINAGRI, 2020).
- ✚ **Rwanda Agriculture Board (RAB)** – Provide training to passion fruit producers on how to control pests and diseases using Integrated Pest Management, pesticides use in the management of pests and disease, and to provide them disease-resistant varieties (RAB, 2018).
- ✚ **National Agricultural Export Board (NAEB)** –Guide private companies and individuals who are willing and interested to export or improving their export operations by providing information on the most essential topics one needs to consider when exporting (NAEB, 2018).
- ✚ **Financial Institutions-** Micro financial institutions such as (Umutanguha finance company Ltd), provide savings, loan services to farmers but their main challenge in Rwanda is lack of data on farmers' operations, and lack of agricultural insurance (AFR, 2017).

2.6 Opportunities and constraints for improving quality of Passion fruit

✓ Opportunities

Passion fruit was introduced in Rwanda for commercial juice processing but the sector has improved to produce for both the local and export markets. Besides being a source of income to smallholder producers, it also generates foreign exchange for the country. The fruits have potential opportunities on the market due to their nutritional values. Passion fruits can be consumed raw when ripe and they can be processed into passion fruit juice and/or concentrates that are mixed with other juices (Muhaise, 2016).

✓ Constraints

According to Muhaise (2016), the passion fruit subsector faces several challenges including an insufficient supply of quality products on the market, persistent pests and diseases that destroy plants, high costs of pesticides, local farmers lack knowledge of modern passion fruit farming and farmers cannot add value to their produce. The author also mentioned that passion fruit prices repeatedly fluctuate as a result of the instability in the supply side.

CHAPTER THREE METHODOLOGY

This study was carried out to identify current agricultural practices (pre and postharvest handling) that affect the quality of passion fruit in Rwamagana district. The required quality criteria for passion fruit to meet the export market and producers' perception toward the export market requirement were also studied. Furthermore, the study aimed to analyze stakeholders and their functions in the passion fruit value chain. A semi-structured questionnaire and online interviews were administered to the respondents and key informants to answer the research questions.

3.1 Description of the Research Area

The study was conducted in 5 sectors of Rwamagana district, Eastern Province, Rwanda namely: Kigabiro, Munyaga, Mwulire, Karenge, and Munyiginya in Rwanda. It is located approximately 50 km from Kigali. Rwamagana district has a population of 313,461, an area of 87 square kilometers (34 sq mi), and a population density of 460 inhabitants/Km². Rwamagana district is a bit sunny and warm with a temperature range between 19°C and 21°C. It has adequate water sources, the soil type is light to heavy sandy loams, and there is an average rainfall of about 900mm-1800mm (REMA, 2009). The district is one of the main growing areas of passion fruit destined for the export market in Rwanda.

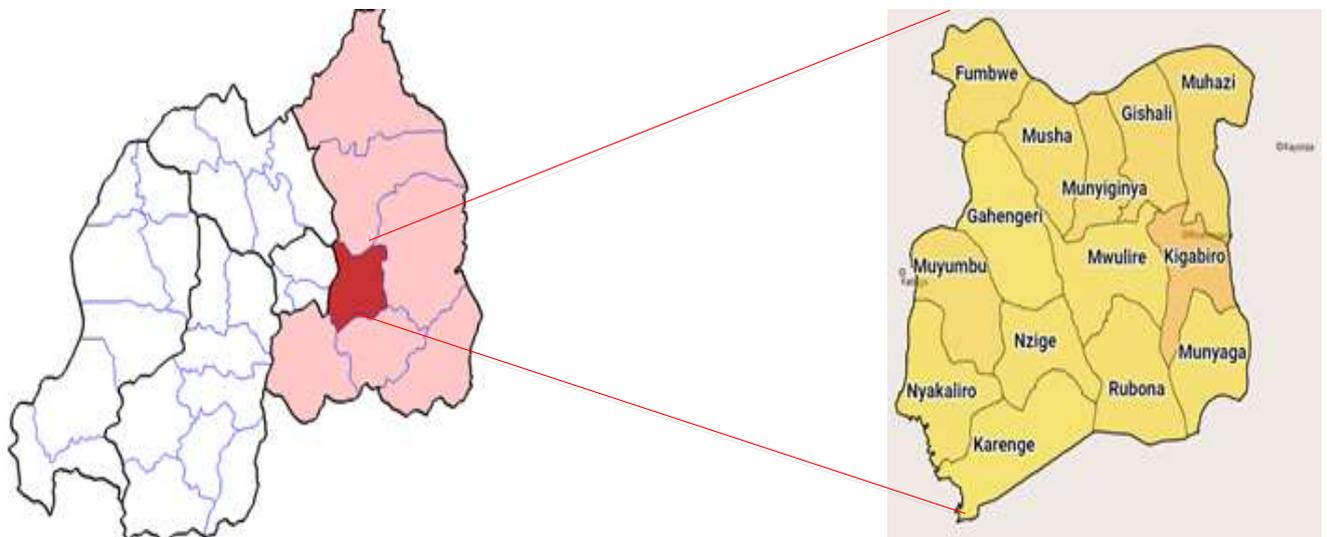


Figure 3. Map of Rwamagana district, Rwanda; NISR (2012)

3.2 Research Strategy

During this study, both qualitative and quantitative approaches were used to gain in-depth information about causes that affect the quality of passion fruits in Rwamagana district. Primary data was obtained from passion fruit producers using a questionnaire and additional information was obtained from key informants through online in-depth interviews while journal articles, books, and official organization reports were used to obtain secondary data. The research was conducted during the COVID-19 pandemic, thus both the Dutch and Rwandan Governments put in place restrictions to movement from one country to another. Therefore a questionnaire was sent to the research assistant to collect data on the behalf of the researcher while Interviews with key informants were conducted via phone calls and skype calls by the researcher.

3.2.1 Research Framework

The research framework was designed based on the research problem and research objective. It is the road map followed during the study (figure 4).

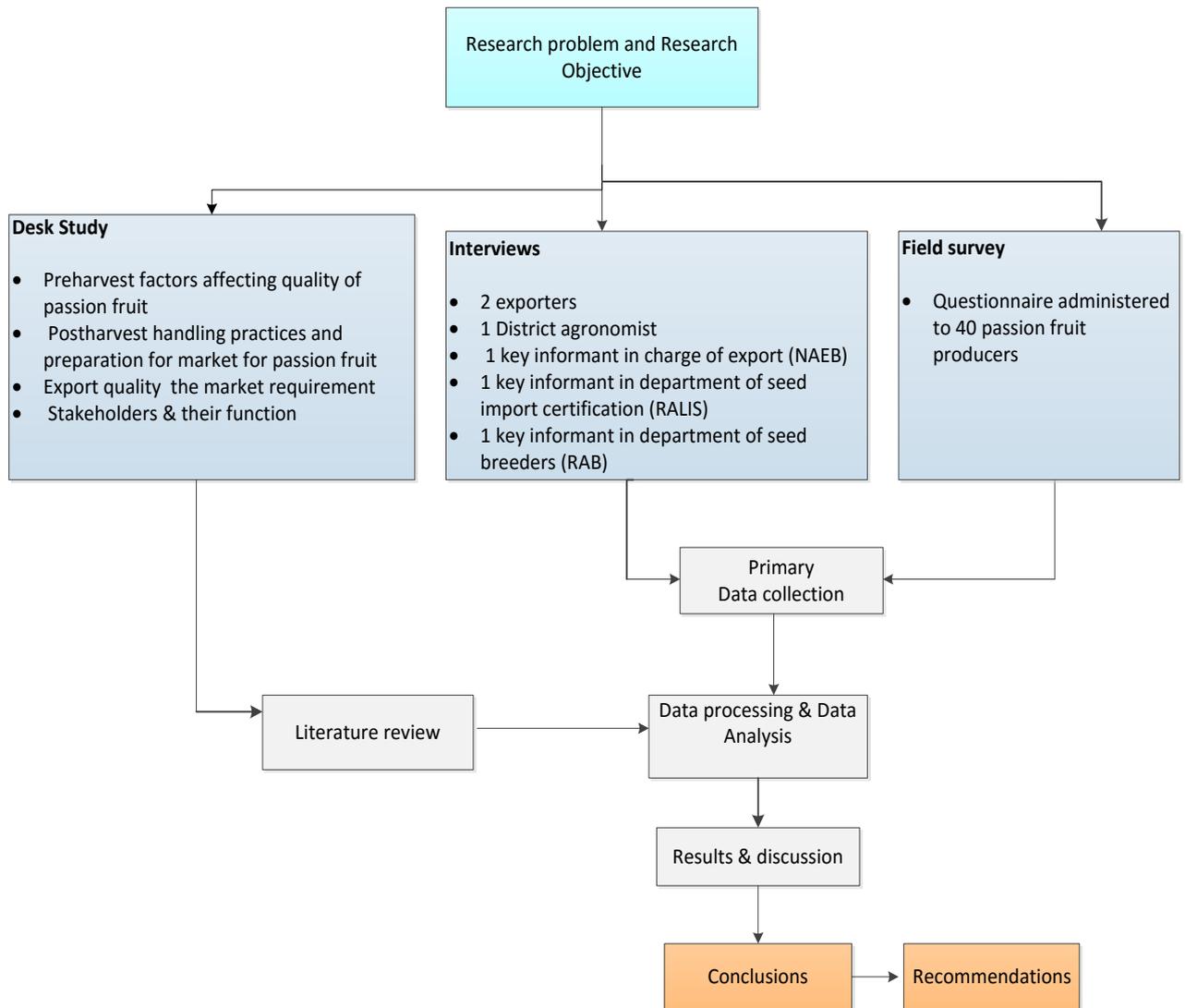


Figure 4. Research framework; Researcher (2020)

3.2.2 Data collection

Primary data was collected using a semi-structured questionnaire (Appendix 2) and a semi-structured interview checklist to get information answering the research questions (Appendices 3,4,5,6). Figure 5 shows a photo of the research assistant with a farmer after one- on- one interview during a field survey in Rwamagana district, Rwanda, and a photo passion fruit farm. Appendix (12) shows some of the field photos taken during the survey.



Figure 5. Photos were taken during the data collection; Field survey (2020)

▪ Survey

During the study, a sample of 40 passion fruit producers responded to the online semi-structured questionnaire. The questionnaire was piloted before the beginning of data collection on 6 people for further improvement. The respondents were from 5 sectors (19 from Kigabiro, 9 from Karengye, 6 from Munyiginya, 4 from Munyaga, and 2 respondents were from Mwulire) of Rwamagana district. Initially, the survey was planned to be conducted with 20 farmers from cooperative Ejoheza and 20 individual farmers in the same area. However, there was a small change in the number of respondents from both cooperative and individual farmers because it was found on the field that there was a limited number of individual farmers in the area of the study. This means that 21 respondents were randomly selected from members of cooperative Ejoheza and 19 individuals were obtained using the snowball method. The big number of respondents from Kigabiro sector is because this is a sector where most farmers who sell passion fruit on the export market are located. The research assistant asked questions to individual producers in the local language (Kinyarwanda) and collected responses were immediately electronically submitted to the researcher. The used questionnaire was designed in Microsoft forms. During the survey, the researcher was in contact with the assistant to follow up on the data collection process

▪ Interview

In-depth online interviews were conducted with key informants to obtain additional information on factors that affect the quality of passion fruit and what is being done to improve the quality of passion fruit for export. The interviewed key informants who were purposively selected included; 2 exporters, 1 district agronomist, 1 staff from MINAGRI in the department of seed import certification, 1 NAEB staff in charge of export, and 1 from RAB department of horticulture. The researcher herself carried out the online (skype and phone call) interviews using different checklists as see (Appendices 3,4,5,6). The interviews were scheduled according to the availability of respondents and they were all recorded for further data processing.

3.2.3 Data processing

Quantitative data- The researcher extracted raw data from Microsoft form to Microsoft excel and transferred to IBM SPSS version 25 for further analysis.

Qualitative data- recorded data from online interviews were transcribed in Microsoft Word, and then each interview was coded, and categorized for analysis.

3.2.4 Data Analysis

Quantitative data- Raw data were imported from an excel sheet to SPSS software where they were classified into different types of variables such as nominal, ordinal, and scale. Labels and values were assigned to responses. Descriptive analysis was done for nominal data, and Pie and/or Bar were produced. For ordinal data, a descriptive mean was calculated and the bar chart was plotted. Mean and standard deviation was descriptively calculated for scale/ratio variables such as age and a histogram graph was produced to answer research questions. A chi-square test was done to find out if there is a difference in agriculture practices between farmers who sell passion fruits on the export market and those who sell on the local market. For further analysis, Null and Alternative hypotheses were formulated for the research question for the statistical test. The right statistical test and relevant chart or graph were chosen and alpha of 0.05% was used to conclude the tested hypothesis.

Qualitative data- Qualitative data from both surveys and online interviews were summarized, categorized, and analyzed in the word document. After the analysis, the results were used for further discussion, conclusions, and recommendations.

The overview of the research approach including; research questions, data collection method, source of data tools used during analysis are attached in appendix 1.

3.2.5 Limitation of the study

While conducting the study, it was not easy to get the respondent's availability. Firstly, the survey took place during the passion fruit harvest offseason, so it was not easy to find producers on the field nor to get their time. Most of the passion fruit producers were found to be farming but also with other businesses aside, so it was difficult to reach on them. Secondly, some producers were hesitating to provide information, especially about where they source planting materials and when they apply pesticides, etc. Initially, the study was planned to be conducted in only one sector (Kigabiro) but during research, it was found that the cooperative members grow passion fruit in other sectors besides the Kigabiro sector. Therefore, the research proposal schedule was changed and the research was conducted in 5 sectors of Rwamagana district.

Also, due to the corona pandemic interviews were conducted online with the researcher. The online interviews were challenging because it was difficult to get key informants to answer the researcher's phone call from abroad. The researcher had to get a recommendation from the head of the institution. One exporter also was a bit cautious about answering questions like their contribution to improving passion fruit quality to meet the export market. Then the researcher had to ask the production manager instead of the available exporter. Lastly, the means of communication was a bit challenging as the internet connection was not good, it was connecting and disconnecting which could disturb the interview. On the other hand, using a normal phone call was costly and the voice recording was not so clear.

CHAPTER FOUR RESULTS

This chapter comprises the results processed from the survey conducted with passion fruit producers, online interviews with exporters, government institutions, and extension officer on current agricultural practices and their perception about export market requirements. General information on survey respondents is presented, current pre and postharvest practices are indicated, passion fruit producers' perceptions regarding export market requirements, opportunities and constraints on the export market, and stakeholder roles in the passion fruit value chain.

4.1 Characteristics of online respondents

4.1.1 Farmers who work with export market vs not working with export

Figure 6 represents the number of farmers who responded to the survey (N=40). The field survey shows that nearly 53% of the survey respondents work with the export market while others 47% do not work with the export market.

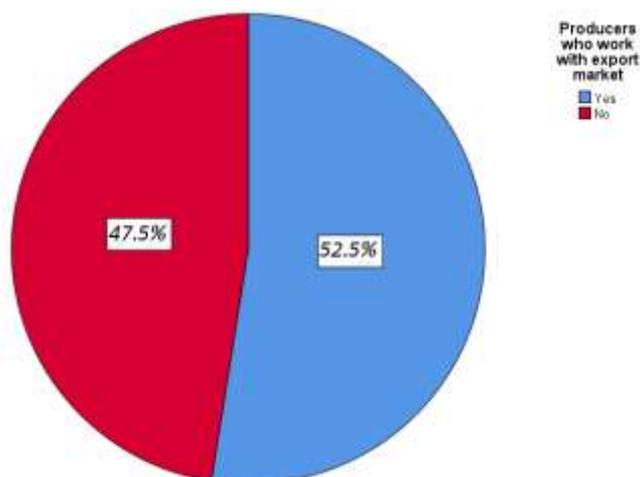


Figure 6. Passion fruit survey respondents in Rwamagana district; Field survey (2020)

4.1.2 Gender and age of the survey respondents

In this study out of 40 survey respondents, 32 respondents (80%) were male, and 8 respondents (20%) were female as presented in figure 7. Furthermore, the average age of survey respondents is 42 years, whereby the minimum and maximum age were 26 and 59 respectively (figure 8).

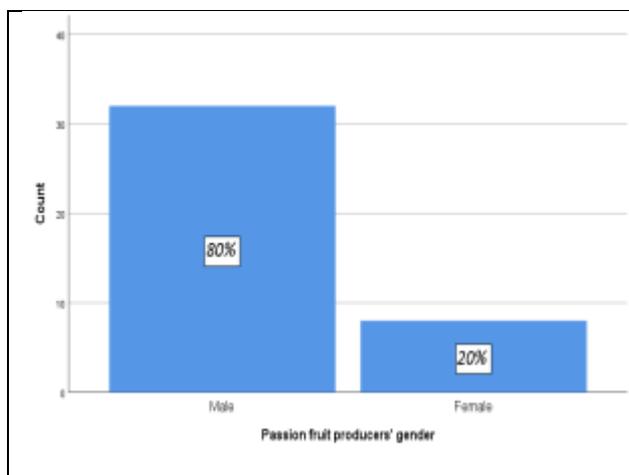


Figure 7. Passion Fruit Producer's gender

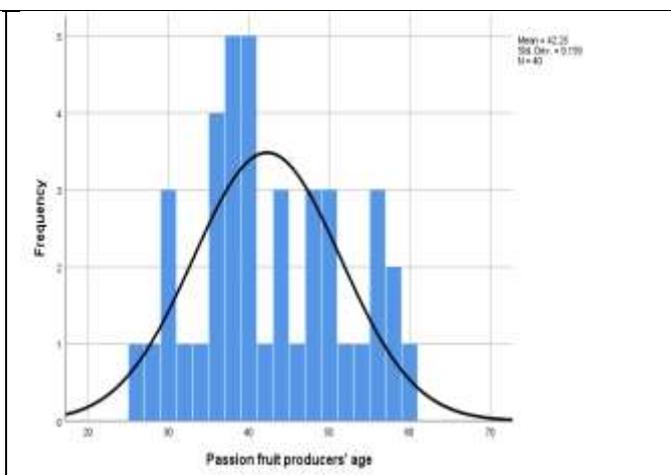


Figure 8. The age range of respondents

4.2 Current pre-harvest practices

This part of the report indicates the results on pre-harvest practices applied by farmers in Rwamagana district which are planting materials sourcing, adopted type of farming, determination on the preharvest interval, harvesting tools used, and harvesting maturity parameters.

4.2.1 Source of planting materials

Source of planting materials for the farmer respondents of the survey was categorized as own farm, agrodealers, and private nursery operators. 45% of the respondents (both farmers who work with exporters and those who do not work with exporters) mentioned that source their planting materials from their farms. While nearly 3% of the respondents source the planting materials from Agrodealers (figure 9). Additional information from one of the exporters revealed that: **“poor quality of planting materials (seeds) is a national is a matter, there are no quality seedlings in this region. So what we help farmers with is to guide them on seed selection of what they have”**.

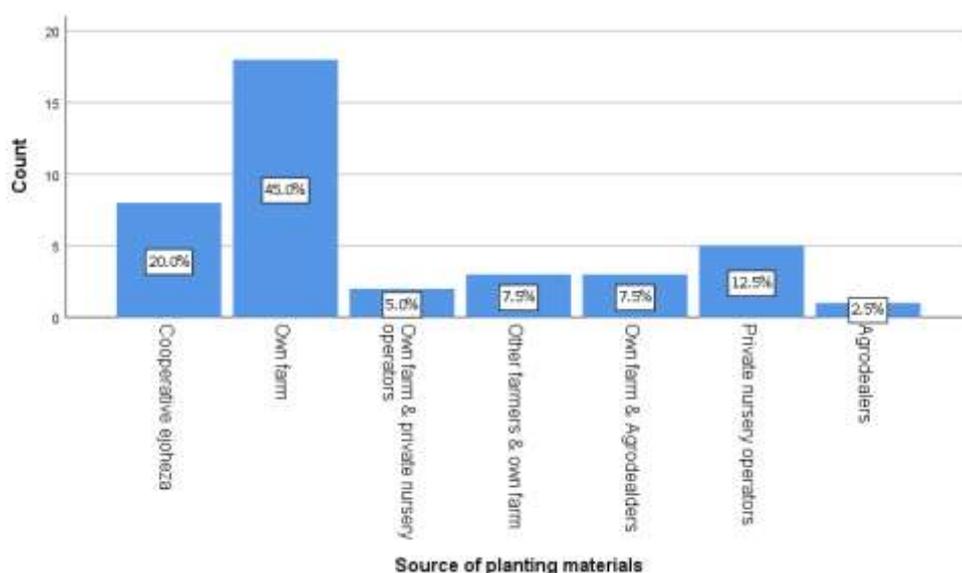


Figure 9. Source of planting material; Field survey (2020)

4.2.2 Variety of Passion fruit grown

Almost 98% of the survey respondents mentioned that they grow purple passion fruit, especially for the export market because of the export market preferences (figure 10).

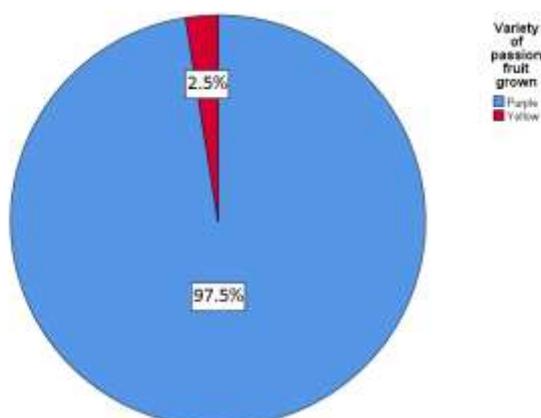


Figure 10. Type of passion fruit grown for both export and local market; Field survey (2020)

4.2.3 Type of farming

The study indicates that almost (63%) of the survey respondents grow their passion fruit organically whereas other farmers do conventional farming to grow their fruits (figure 11). Besides, it was found that farmers that work with exporters do not differ from farmers who do not work with exporters in their methods of farming ($P=0.613$) see (Appendix 7). Also, the interviewed exporters pointed out that: ***“some of their clients require passion fruits which are grown organically and GlobalGAP certified whereas others do not exert specific requirements on them”***.

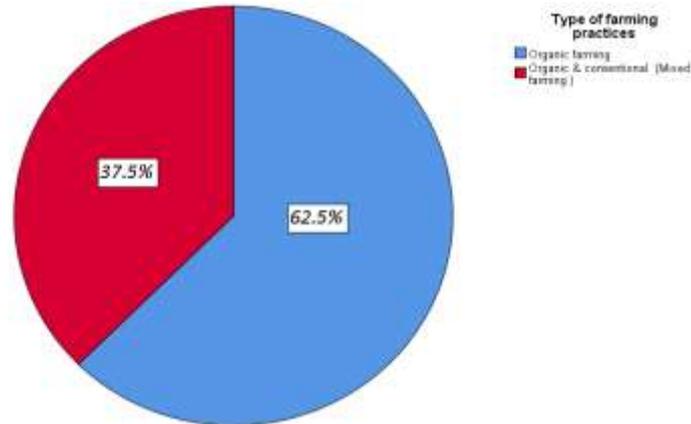


Figure 11. Type of farming applied; Field survey (2020)

4.2.4 Fertilizer application and irrigation practice

All farmer respondents mentioned that they use fertilizers and they do irrigation to grow their passion fruits. The survey result shows that DAP, NPK are the most (42%) industrial fertilizers applied (figure 12).

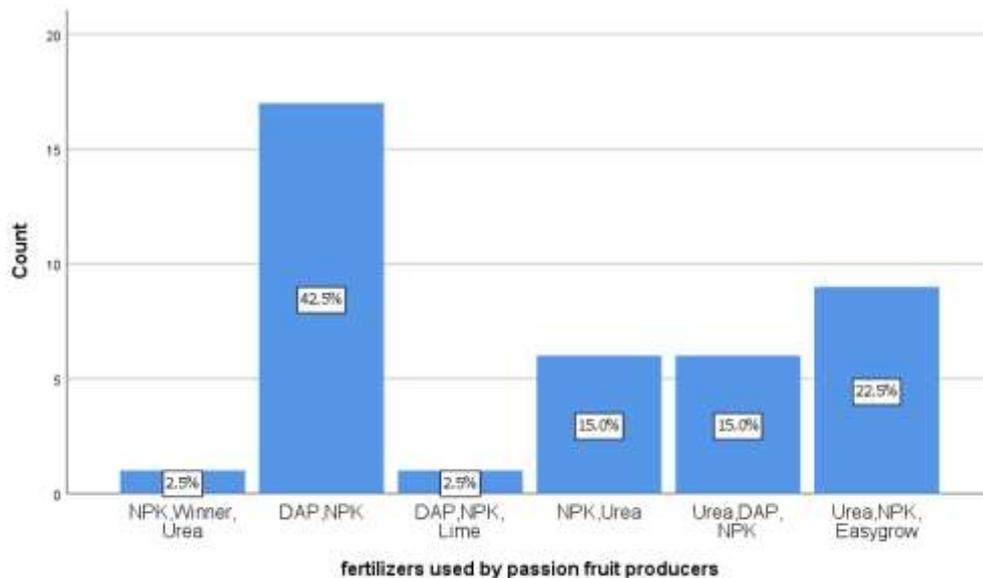


Figure 12. Fertilizers commonly used by farmers respondents; Field survey (2020)

4.2.5 Pesticide application

Figure 13 shows that almost 28% of farmers who work with exporters use mixed-method (pesticide spray, mulching, and pruning) to control pests and diseases compared to 35% of farmer respondents who do not work with exporters.

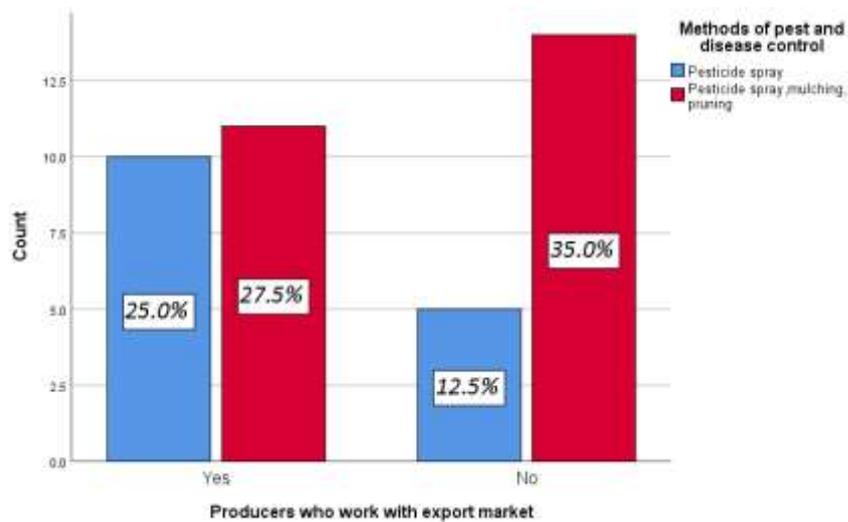


Figure 13. Pesticides application of farmers respondents; Field survey (2020)

4.2.6 Preharvest interval (PHI)

PHI is the waiting time between pesticide application and when a crop can be harvested. Figure 14 shows that nearly 57% of farmers harvest less than a week after pesticide spray, the other 12% harvest immediately after spraying, and only 30% wait for a week to harvest after spraying (figure 15). On the other hand, farmers who work with exporters do not differ from farmers who do not work with exporters in preharvest waiting time after pesticide application ($P=0.832$) see (Appendix 8).

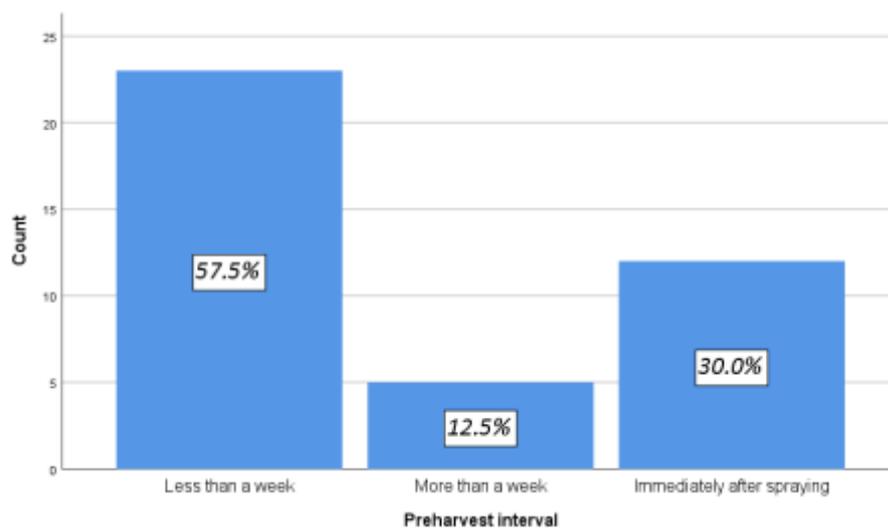


Figure 14. Preharvest interval in Rwamagana district; Field survey (2020)

4.4.7 Harvesting options

The survey results show that the majority (60%) of the respondents use hands during harvesting of passion fruits while other respondents use both hands and harvesting tools such as the sharp knife, and scissors to harvest passion fruit (Figure. 16).

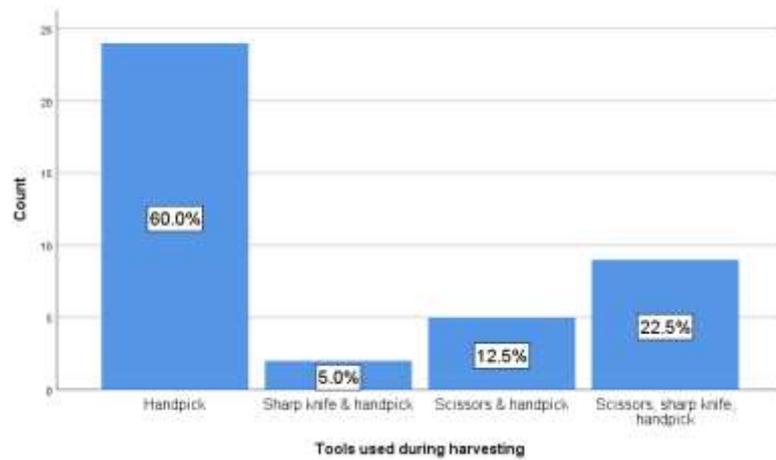


Figure 15. Tools used during harvesting; Field survey (2020)

Figure 17 shows that half of the respondents (50%) use woven sacs during harvesting while a small number of the respondents use crates during harvesting.

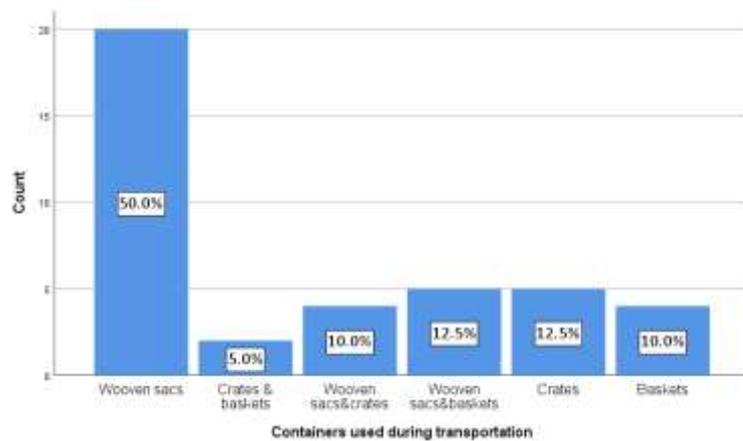


Figure 16. The container used during harvesting; Field survey (2020)

4.3 Harvesting maturity parameters

The study results indicate that both farmers who work with exporters and farmers who do not work with exporters harvest their passion fruits when they are fully ripe (30%) respectively (figure 18). Likewise, one exporter who was interviewed said that ***“they buy all harvest from farmers and sorting and grading is done at NAEB packhouse”***.

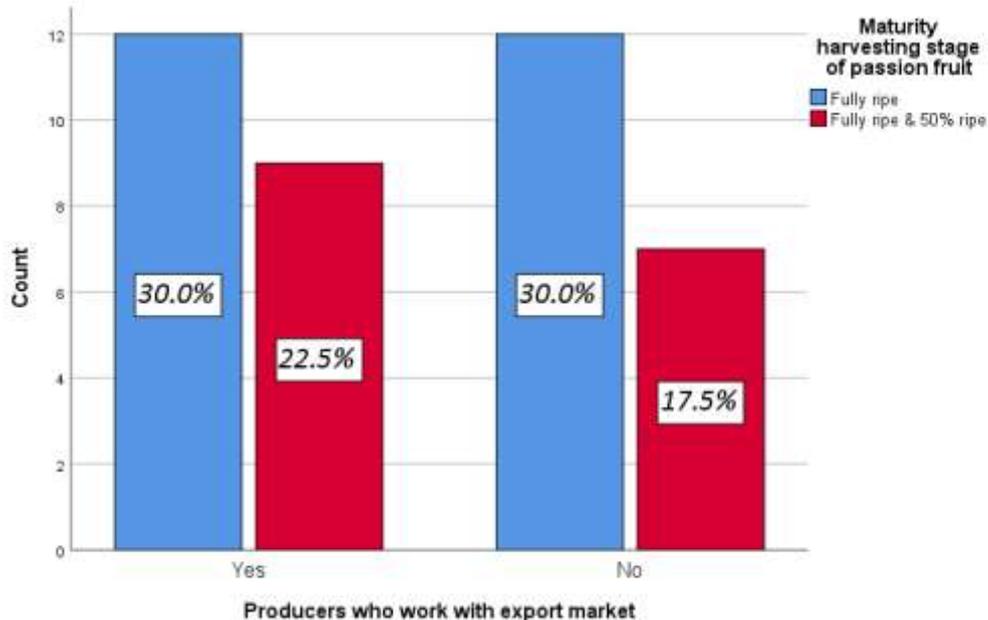


Figure 17. Harvesting maturity determination; Field survey (2020)

4.4 Current post-harvest practices

4.3.1 Sorting practice

Figure 19 indicates that both farmers who work with exporters almost (33%) and farmers who do not work with exporters approximately (23%) do pre-sorting before they sell their produce. Besides, one exporter interviewed stated that: *“Pre-sorting is done on-farm and farmers are paid by exporters based on what they have sorted and unsorted fruits are sold on the local market”*.

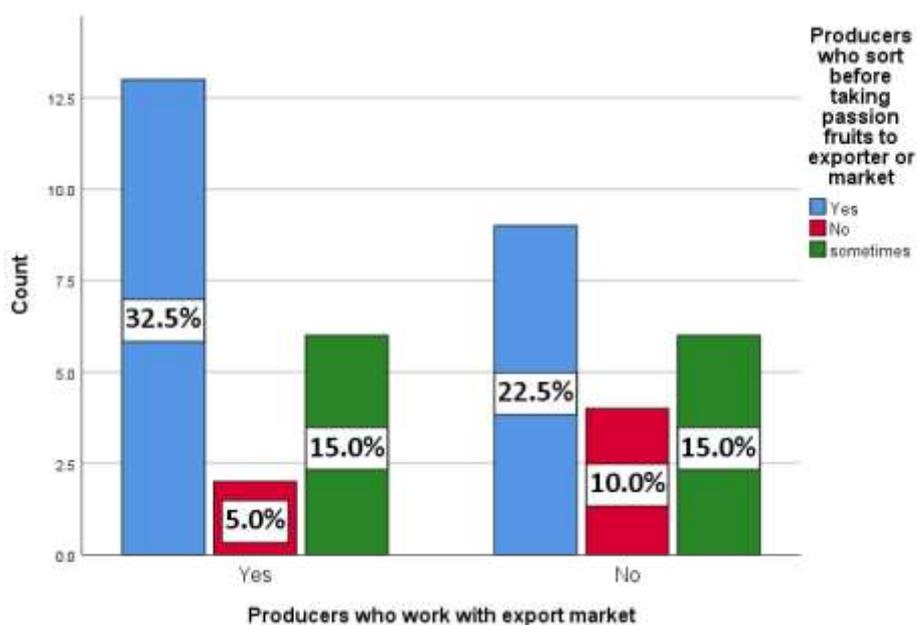


Figure 18. producers who sort; Field survey (2020)

4.3.2 Grading practice

Figure 20 shows that among farmer respondents who work with exporters 40% do grading before they sell their produce, 10 % do not grade and nearly 3% sometime grade their fruits at the farm level. It was found that there is no difference in grading practices between farmers who sell their produce to the exporters and farmers who do not ($P= 0.126$) see (Appendix 9). Nonetheless, exporters who were interviewed said that: **“grading takes place at NAEB packhouse”**. Another interviewee from NAEB mentioned that: **“grades (size) counts the highest rejection on the export market”**.

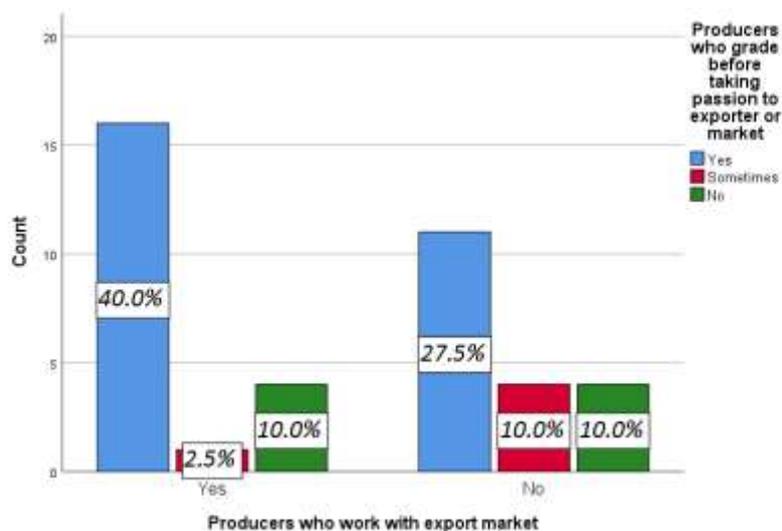


Figure 19. Grading practices; Field Survey (2020)

4.3.3 Type of containers and transporting time

During the transportation of passion fruits, woven sacs are mostly used (50%) by the survey respondents while others use more than one type of containers such as crates, baskets as detailed in figure 21.

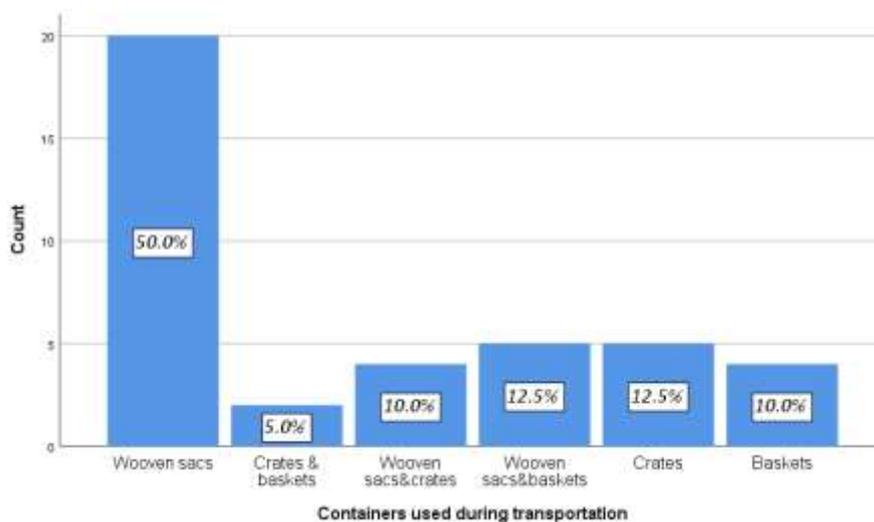


Figure 20. Packing materials used during transportation; Field survey (2020).

Furthermore, the study results indicate that the majority (55%) of passion fruit producers transport passion fruit early in the morning, followed by those who transport fruits during the day and some producers transport their produce at any time they get a buyer (figure 22).

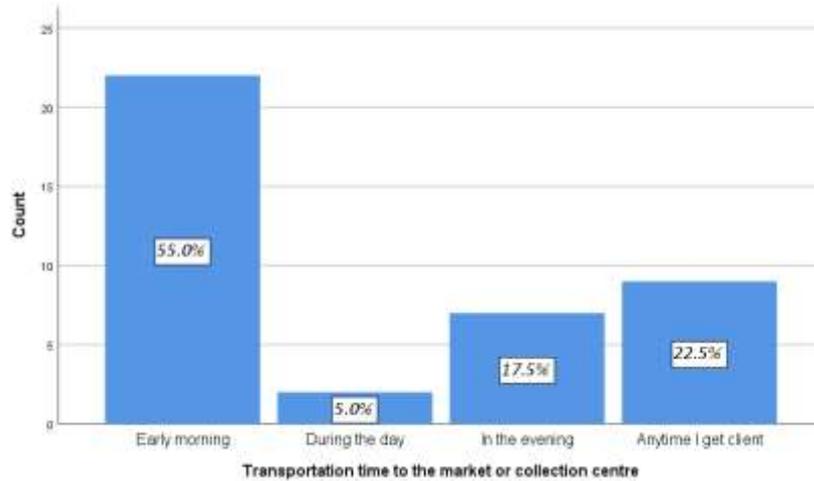


Figure 21. Time of transportation; Field survey (2020)

4.3.4 Effect of defects on the selling price

Farmers were asked to rank (not important, less important, important, and very important) which of the defects amongst misshapen, sunburn, diseased, and bruised affect their selling price. The result from the farmer's survey shows that bruising affect their selling price the most nearly with 13% (figure 23), deformed defect is the following defect affecting their selling price with almost 8% figure 23. On the contrary, exporters who were interviewed mentioned that: *“deformed fruits followed by diseased and bruised are the main causes of rejects at the packhouse”*.

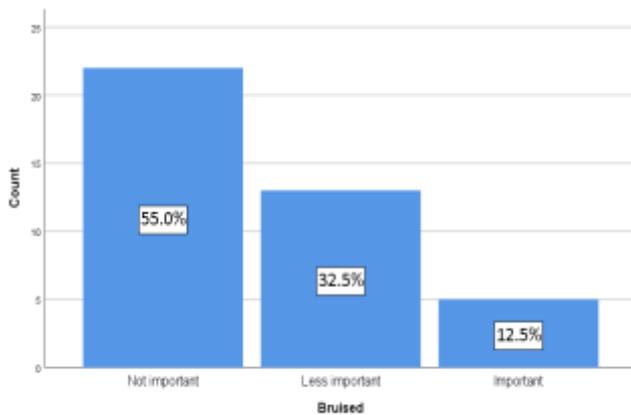


Figure 22. Bruised defect

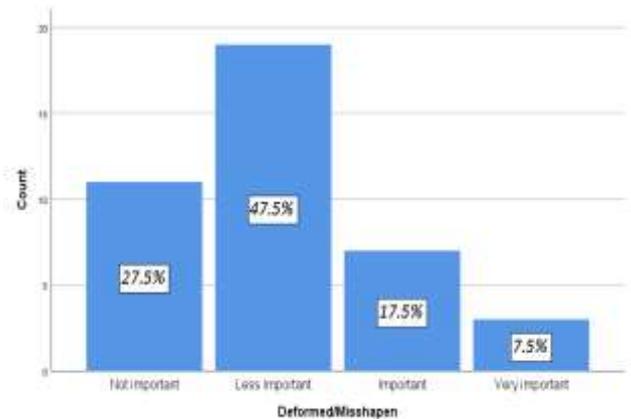


Figure 23. Misshapen/Deformed

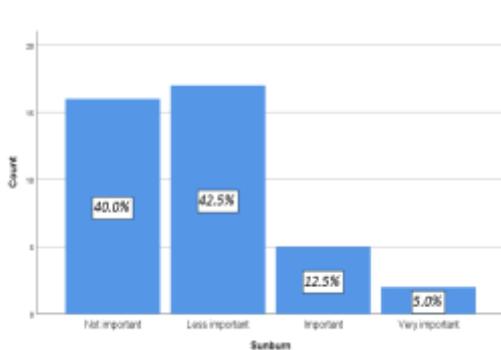


Figure 24. Sunburn defect

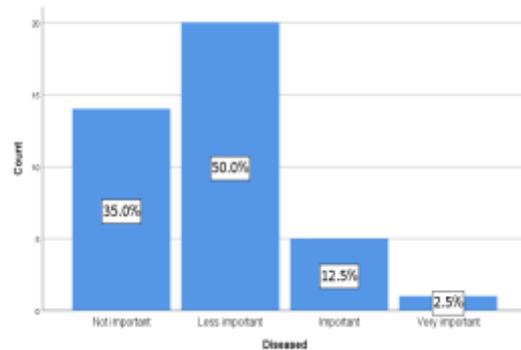


Figure 25. Diseased defect

Field survey (2020)

4.4 Producers' perceptions regarding the export market

The survey respondents showed that passion fruit farmers who sell their produce to exporters receive a good price compared to those who sell on the local market. Lack of awareness about the export market, limited knowledge and skills about growing for the export market, and high investment required to produce export market. Consequently, nearly 48% of the survey respondents do not work with the export market. Moreover, farmers' respondents mentioned that working with the export market has helped them to secure the market, get a constant price, and payments are done on time. Also, some respondents working with the export market mentioned that it is easy to get training from NGOs, and exporters about GAP, and agricultural support (e.g pesticide sprayer).

4.5 Quality requirements to meet the export market

As far as the export market is concerned, there are some quality requirements to be practiced by crop growers. The results from the survey conducted on farmers in Rwamagana district shows that 25 farmers do not use good agricultural practices to produce good quality passion fruits. Only 8 farmers use compost manure, 6 farmers harvest fully mature, big size fruits and non-deformed fruits, 5 use natural pest control (mulching, pruning), in their farms, 4 use quality planting materials (seeds), 2 apply fertilizer on time, irrigate, and they carefully handle their fruits during harvesting to avoid bruises. Besides, 15 replied that they do not practice good agricultural activities precisely for the export market.

Furthermore, staff from NAEB said that ***“there is a checklist that was developed to be used by quality officers to check if a farm meets the export market requirements”***. The quality standards required by buyers are; fruits should be free of disease, bruises/damages free, they should be of uniform in size, oval shape, and they should be of the same grade.

4.6 Opportunities and constraints for working with the export market

❖ Opportunities

More than 50% of the survey farmer respondents mentioned that their farming practices have been improved compared to the time before working with the export market. Some individual farmers mentioned they learn passion fruit farming techniques and experience from their fellow cooperative members. Additionally, the district agronomist emphasized that ***“the main opportunity for the passion fruit sub-sector is the development of interest of government by encouraging Private-Public Sector partnerships in the horticulture sector” and involvement of NGOs***. The Government has created an investor ready environment by actively earmarking sites for horticultural crops and provide facilities (packhouse) to develop export for horticulture produce. Besides, Rwanda is a member of The Common Market for Eastern and Southern Africa (COMESA) and The East African Community (EAC) which facilitates producers to have free access to the regional market.

❖ Constraints

On the other hand, the field survey responses from farmers show that there are some constraints to meet the export market requirements. Some of the constraints mentioned were limited capital, the small farmland, difficulty and expensive to get organic manure, expensive agricultural inputs (e.g. seeds, pesticide, fertilizers), irrigation is costly, limited access to disease-resistant seeds, limited knowledge about export requirements, lack of storage facilities (cold room), and difficulty procedures (collaterals, production record) to get a loan from the bank.

Information from the key informants emphasized on other constraints hindering meeting export market requirements. One of the key informants interviewed from the district agronomist said that ***“in general horticulture, farming is expensive (i.e quality seeds) when one wants to produce good quality fruits, and farming is still done on small farmland which makes it difficult to satisfy market demand”***. Generally, lack of suitable disease-resistant seeds (some imported from Kenya), limited knowledge about good agriculture

practices, lack of cold chain facilities, and some time do not respect the signed contract between producers and exporter are some of the challenges which affect the production and quality of fruits.

Furthermore, the key informant interviewed from NAEB mentioned that **“exporters do not provide in advance quality criteria of passion fruit for the export market to farmers and they do not provide clear detailed information on farmers they work with for traceability”**. The same key informant said that **“farmers do not trust exporters because some of them do not comply with the contract signed with farmers”**.

Another challenge was that the answers that were given by farmers about ‘supporting functions’ of government were sometimes contradicting from answers given by key informants. Most farmers said that government support on technical sharing is inadequate. Some farmers also mentioned that they are not provided with capacity building such as training about good agricultural practices from the government. However, the district agronomist interviewed said that: **“they provide training on GAP and farm management practices but the main challenge is that the extension staffs are few and extension services started improving recently, and training is mostly on general guidelines not specific to a crop and are mostly offered for those in the cooperative”**.

4.7 Stakeholders and their roles

The roles and functions of key stakeholders in the passion fruit value chain are summarized according to the information from the survey, online interviews with informants, and literature.

- ❖ **Passion fruit producers-** respondents from the survey with farmers mentioned that farming is their main activity, they manage the farm by applying fertilizers, pest, and weed control and harvest when fruits are mature. They sell passion fruit to both export agents and local traders. When fruits are ready to be harvested, producers wait for buyers at the farm. For producers who work with cooperative, they sell their produce to cooperative and cooperative sales to the exporter and they are paid through the cooperative.
- ❖ **Exporters-** Farmers mentioned that working with exporters (Garden fresh and Proxifresh Rwanda Ltd) has provided them with a secure market for their produce. Farmers also said that exporters offer a good price compared to local traders but they impose tough quality standards on producers. Exporters interviewed mentioned that they sometimes offer training about export market requirements (harvest mature fruits, use of compost manure) to producers.
- ❖ **Middlemen-** The survey results with farmers show that middlemen sometimes buy passion fruits from the farm gate at a low price. Mostly they buy fruits from producers who are not members of the cooperative.
- ❖ **Wholesalers and Retailers-** Farmers mentioned that wholesalers go to the farm when fruits are ready to be harvested and negotiate with producers at what price they pay of which is low because of it is passion fruit seasonality. This means that if the producer denies the price, the trader can go to another farmer. Yet farmers have no storage facilities for the ripe fallen fruits. Retailers often buy what is not sold on the export market at a lower price. For instance, according to the farmer's retailers pay 600-700 Rwf instead of 800-1000Rwf that exporter pay.
- ❖ **National Agricultural Export Development Board (NAEB)-** One of the key informants interviewed from NAEB, said that NAEB develops guidelineS for local entrepreneurs that want to start the export procedure to the international market. He also mentioned that NAEB facilitates exporters to get in touch with producers anywhere in the country and provide facilities to exporters such as cold rooms and other procedures required to export. This was confirmed by interviewed exporters who mentioned that they use NAEB facilities (e.g. packhouse, logistics) during export. NAEB has also

established a coding system where each producer working for export will be given code for traceability and quality management. A random farmer from survey respondents mentioned that he has been trained by NAEB about GlobalGAP.

- ❖ **Rwanda Agriculture Board (RAB)**- On of the key informants interviewed from RAB said that RAB department of seed breeding provides hybrid seeds resistant to pests & diseases to passion fruit producers but they have piloted them in 3 provinces including; Northern, Western, Southern but not fully successful. Eastern province is on the list of the planned districts to be piloted on where Rwamagana district is located. This confirms what farmer survey respondents said that they have not received improved seeds from RAB.
- ❖ **Non-Government Organizations (NGO's)**- The survey results from farmers showed that all farmers in cooperative Ejoheza were trained by NGO's (USAID, FAO, and Hinga Weze) on good agricultural practices, and how to use mobile phones to agricultural market information from MINAGRI in Rwanda.
- ❖ **The private sector (FAME Africa)**- The survey results show that all farmers in cooperative Ejoheza farmers show that passion fruit farmers have received good quality seeds from the private company (FAME) which they used as parent seeds to produce other seeds they used in the next season.
- ❖ **Financial Institution** – Additional information from farmer respondents mentioned that financial institutions have loan services for farmers but farmers are hesitant to work with them because of a long and complicated procedure to get loans.

Figure 27 summarizes the information from both surveys, online interviews with key informants, and the previous literature.

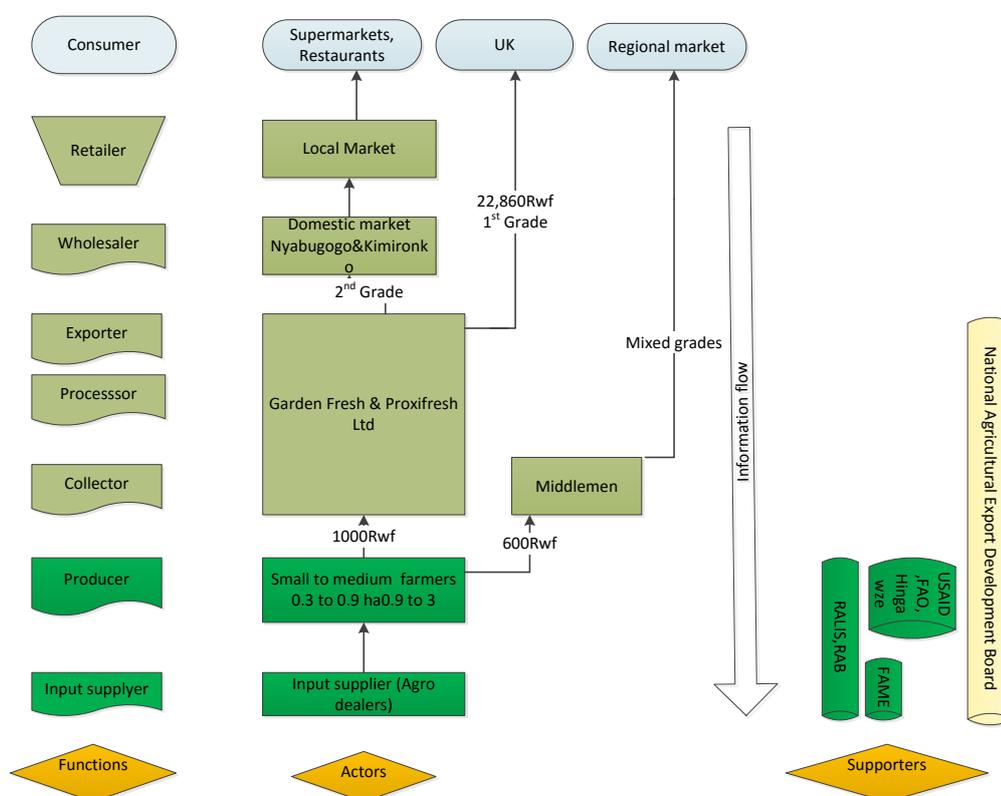


Figure 26. Existing passion fruit value chain; Researcher (2020)

Note: 1,143 Rwf= 1 Euro

CHAPTER FIVE DISCUSSION

This chapter comprises the interpretation of the results from the survey with passion fruit producers in Rwamagana district and the information from key informants. The study aimed to identify causes that affecting the quality of passion fruit in the value chain (production to the market) to provide recommendations to NAEB to address the problem of poor quality that results in high rejection of passion fruit on the international market and this is discussed in this section.

5.1 Current pre-harvest practices

Planting materials; there is a lack of quality planting materials that cause farmers to use seeds from what they have kept from previous seasons since 2014 up to now. Those materials could be diseased and could produce low quantity, and poor quality of the fruits which does not meet the export market requirement. This contradicts Santos, et al., (2016) who stated that the source of planting materials for passion fruit should be from a trusted source, vigorous, and free of diseases. Propagation can be done through seed, cuttings, and grafting whereby seedlings and grafted plants are more vigorous than cuttings (Santos, 2016).

The type of farming practice; no difference was found ($P=0.613$) in the type of farming between farmers who sell passion fruits to the exporters and those who sell on the local market. The majority (62%) of passion fruit farmers in Rwamagana district, mentioned they do organic farming yet they apply chemical fertilizers and pesticides in their farms. This shows that farmers do not understand organic farming practices very well. Additionally, the survey results show that most of the farmers have limited knowledge of the selection and application of pesticides whereby they try many pesticides, checking which one can control pests and diseases in their farms. This agrees with Robinah, et al., (2018) who stated that passion fruit growing lies mainly in the hands of small-scale farmers, who are attracted by the relatively high profitability and tangible market potential whereby they have little or no formal training about pest management practices resulting in overreliance on pesticides.

All farmer survey respondents mentioned that they apply fertilizers and do irrigation in their farming activities to enhance their quality of fruits at harvest. This is in line with advice from Prusky (2011) who states that lack of nutrients in the soil can seriously affect the quality of fresh produce at harvest. On the other hand, too much fertilizer can harm the growth and development of fruits (Prusky, 2011). According to Deshmukh, et al., (2017), water is highly required when fruits are approaching maturity, and if the soil is dry, fruits may shrivel and fall prematurely.

All farmers mentioned that they use natural control (mulching, pruning) and chemical pesticides to control pests and diseases in their farms. Farmers who sell their produce to the export market tend to use less of mixed pesticide spray compared to farmers who sell their produce to the local market. This is probably because they have some restrictions on the application of pesticides. As a result, they try not to use pesticide spray rather they mixed with natural control. In confirmation with Olango, et al., (2014) who stated several methods have been used elsewhere in passion fruits production to manage diseases including pesticides, biological control agents, cultural methods use of resistant varieties use of disease-free planting material but there is little or no success.

According to Berzman, et.al, (2015), Integrated Pest Management (IPM) makes growers less reliant on chemical crop protection agents, and in many cases, IPM also cuts the costs of cultivation while at the same time increasing yields and improving quality. This means IPM can also provide financial sustainability to farmers.

Preharvest interval; There is a recommended harvesting time after pesticide spray. For most pesticides, there should be possibly three or seven days waiting time before farmers harvest their produce (McMahon, 2019). The information from the field revealed that most of the farmers that work with the export market (42%) harvest their fruits less than a week after pesticide spray, while some harvest immediately or at least a week after spraying. However, it was found farmers who work with exporters do not differ from farmers who do not work with exporters in preharvest waiting time after pesticide application ($P=0.832$). This shows that preharvest interval is not followed by farmers who work with exporters and this affects the quality of passion

fruit which can cause rejects on the export market due to Maximum Residue Limits (MRLs) exerted by the international market. CBI (2020), indicates that consumers in Europe are becoming more aware of health issues and pay more attention to their diet and this has made them more concerned with fruits produced organically. Farmers who work with the export market use mixed farming less than those who do not work with the export market.

5.2 Harvest maturity parameters; The results from farmer survey respondents in Rwamagana district indicate that they harvest mixed maturities (50% ripe and 50% un ripen) market because they determine when to harvest by experience. One of the exporters interviewed mentioned that they buy all harvest from farmers and sorting and grading is done at NAEB packhouse". It is in line with El-Ramady et al., (2014), who stated that the quality of fruits cannot be improved after harvest, only it is maintained from the farm. Therefore, it is important to harvest fruits at the proper stage, with marketable features (size, shape, and color). The use of maturity index and/ or refractometer to measure sugars as a standard will greatly reduce pre-sorting losses hence increase the quantity and quality of passion fruit for the export market. According to Magwara & Opara (2015), the initial decision of consumers to purchase fruits and vegetables is influenced by external attributes such as appearance, color, shape, and size. Nevertheless, the decision to buy again is dependent upon consumer satisfaction based on flavor and internal quality, which are related to soluble solids content (SSC).

Furthermore, a big number of farmer survey respondents (60%) harvest using hands instead of knives and scissors and this increases high chances of bruises during harvest which can become a serious problem, as injuries can increase water loss leading to quick deterioration. This is in support with Kitinoja (2010) who states that manual harvesters should properly identify the maturity index and time for harvesting, they should also be well trained on how to harvest appropriately to minimize damages. The use of knives should be sharp and rounded to minimize the chance of scratches and excess damage to perennial plants.

5.3 Current postharvest practices

Sorting/Grading; another important factor that affects the quality of passion fruit on the export market is grading. There was no difference in grading practices between producers who sell passion fruits on the export market and those who sell to the local market ($P=0.126$). Poor sorting and grading practices increase the chance of rejection on the export market hence low quantity. According to RON (2016), fruits for export must be sorted and graded according to firmness, uniformity, of the same color and shape, and free of insect damage, physical injury, disease, brown discoloration, and other surface blemishes.

5.4 Challenges farmers face complying with the international market quality standards

5.4.1 Farmers perception about the export market

The field study results showed, passion fruit producers only depend on two exporters (Garden fresh and Proxifresh Rwanda Ltd) because they are the only ones in the export business in Rwamagana district. However, this market situation makes it difficult to have sustainable long term profit for passion fruit producers. The market price changes and cannot be controlled because it depends on market supply, seasonality, and demand condition which is inconvenient for passion fruit producers. One of the key informants from NAEB pointed out that exporters do not provide in advance quality requirements to farmers and they do not give clear detailed information to farmers on how they work with traceability. Additionally, the same interviewee mentioned that farmers have trusted for exporters because they do not fulfill the contract signed between them. The limited number of exporters leave farmers with improper agricultural practices, lack of market information, bargaining power, and price fluctuation consequently the poor quality of produced passion fruits.

5.4.2 Quality standards to meet export market requirements

Results from the field survey show that around 63% of farmers in Rwamagana district, apply some agricultural practices such as (use of organic manure, use of natural control, and harvesting mature and marketable size) to meet market export requirements. Similarly, exporters stated that passion fruits go to the export market should be big, free of diseases, and free of bruises. Even though farmers try to meet the export market requirements, they still apply pesticides and industrial fertilizers which could affect quality standards. Luning and Marcelis (2018) emphasize that meeting quality standards and traceability systems are typical quality features to meet the market demands of consumers in international markets.

5.4.3 Opportunities and constraints for passion fruit export market

Table 4 summarizes information from the field survey, online interviews, literature, and researcher interpretations about the opportunities and constraints for passion fruit export market development in Rwamagana district. It combines Political, Economic, Social, Technology, Environmental, and Cultural (PESTEC) and Strength, Weakness, Opportunity, and Threat (SWOT) analysis.

Table 1. PESTEC and SWOT of opportunities and constraints for the export market

PESTEC	SWOT			
	Strength	Weakness	Opportunities	Threats
Political	<ul style="list-style-type: none"> • Policies and regulations facilitating exporters • Government institution (RAB) involvement in pest and disease control 	<ul style="list-style-type: none"> • Insufficient facilities (cold chain) • Limited capacity for seed breeding 	<ul style="list-style-type: none"> • Non-government organizations in the horticulture sector. • Government willingness to involve in quality control 	
Economic	<ul style="list-style-type: none"> • Rwanda is part of the COMESA & EAC 	<ul style="list-style-type: none"> • Limited capital to produce the quantity required on the market. • A small plot of land farm • Difficulty and expensive to get farming inputs 	<ul style="list-style-type: none"> • The willingness of international buyers to pay a high price for a good quality • The passion fruit market is increasing both locally and on the international market 	<ul style="list-style-type: none"> • Banks have complicated procedures to get a loan • Request for collaterals • High-interest rate
Social and Cultural	<ul style="list-style-type: none"> • Producers are working in cooperative 	<ul style="list-style-type: none"> • The majority of producers are conventional farming passion fruit farming • Some of passion fruit farmers are not members of the cooperative 	<ul style="list-style-type: none"> • Farmers share farming techniques experience among themselves 	<ul style="list-style-type: none"> • The majority (80%) of passion fruit farmers are men
Technological	<ul style="list-style-type: none"> • One producer uses the refractometer and maturity index chart • Provide hybrid seeds 	<ul style="list-style-type: none"> • Limited technical knowledge on-farm management • Insufficient use of irrigation • Most farmers still use the experience to determine the maturity of fruits • Lack of adoption of GAP practices 	<ul style="list-style-type: none"> • Technical support from NGO's (USAID, FAO) 	<ul style="list-style-type: none"> • Lack of disease-free seeds
Environment	<ul style="list-style-type: none"> • Good climate for passion fruit 	<ul style="list-style-type: none"> • Use of varieties seeds that are not resistant to pests and disease • Application of lots of pesticides trying which one can work. • Not following the waiting time of harvesting after pesticide spray 	<ul style="list-style-type: none"> • Rwanda has abundant rainfall and natural water sources, diversified agro-climatic zones 	<ul style="list-style-type: none"> • Persistent of pests and diseases

Source: Researcher (2020)

5.5 Value Chain and stakeholders Analysis

5.5.1 Value Chain Analysis using problem tree

The problem tree method was used to map out the core problems, along with their causes and effects in the passion fruit value chain as found during the research. This helped to identify the main problem that can be addressed by the commissioner and stakeholders (Figure 28).

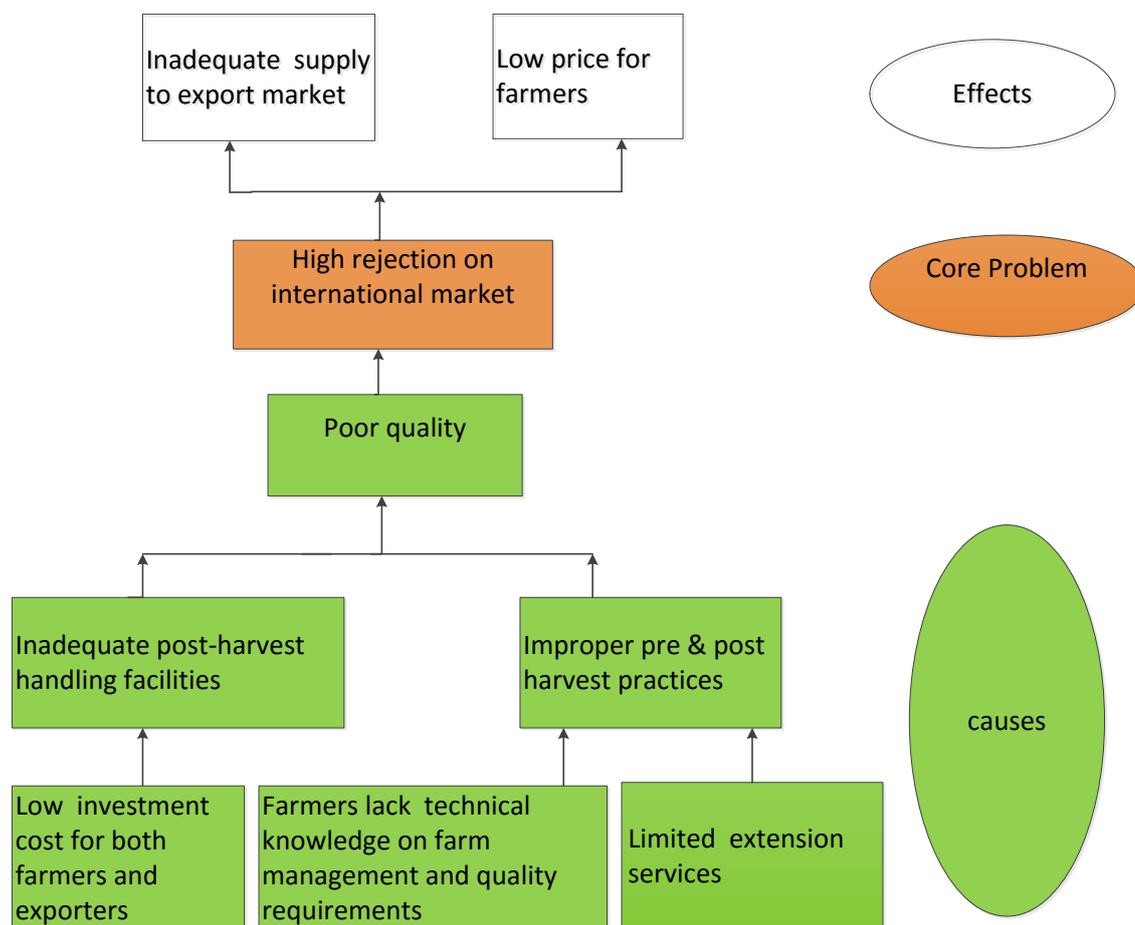


Figure 27. Problem tree of passion fruit export; Source: Researcher (2020)

The core problem for passion fruit export in Rwanda is high rejection due to Inadequate post-harvest handling facilities, poor quality of passion fruit on the export market caused by the limited financial investment capacity in passion fruit farming, limited technical knowledge on-farm management, quality control, and improper pre and post-harvest practices. Insufficient extension services (inadequate information about export quality criteria, limited research) contribute to improper agriculture practices, and all of this results in the low profit of farmers and inadequate supply for the export market.

5.5.2 Stakeholders Analysis

This importance versus influence Matrix helps to map out stakeholders and their relation in the passion fruit value chain. It generates insights on the importance and influence of each stakeholder.

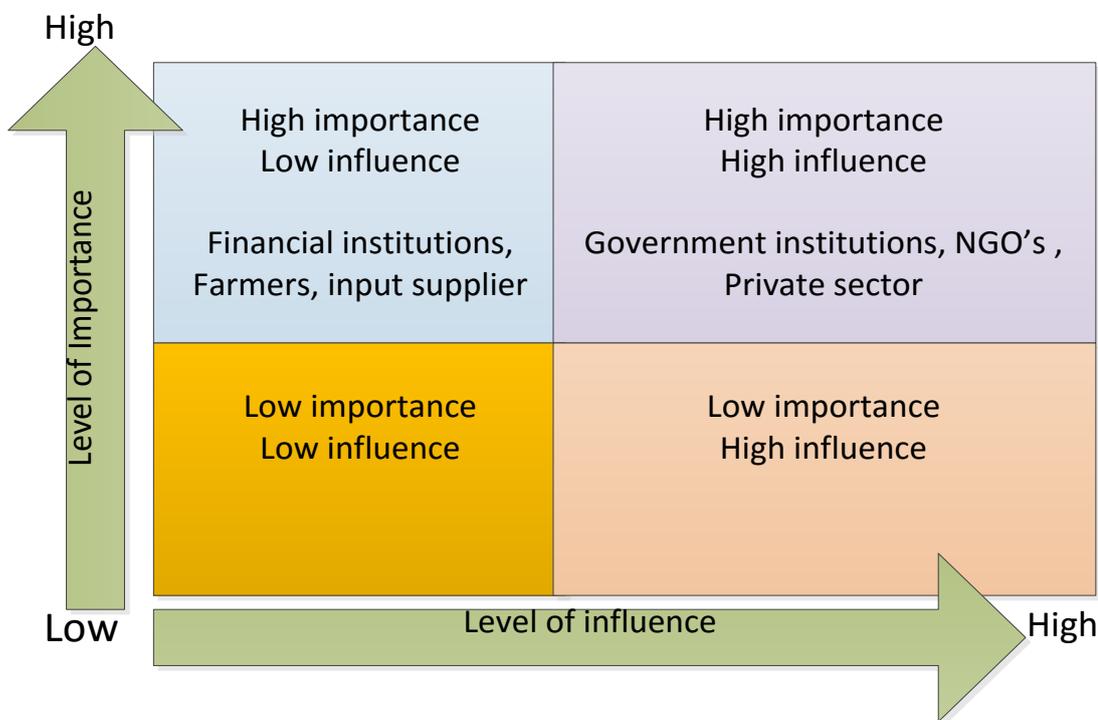


Figure 28. Stakeholders Analysis using Power/Influence Grid; Researcher (2020)

Exporters are highly important and have a large influence on the export of passion fruit to international markets. They know the quality standard requirement of the product to be supplied on the export market. They have a high level of interest in the value chain because they can make a profit by trading and adding value to passion fruit.

The government such as NAEB, RAB, MINAGRI is very important and has the highest level of influence/power in the value chain because they set policies and regulations to be followed on the international market.

Financial institutions are also very important with low influence in the passion fruit value chain, but they are not working with passion fruits because they are not eager to approach and work with financial institutions.

The NGOs and extension services for the passion fruit value chain are of high importance with high influence. They provide updated information about capacity building through technical training.

Farmers are of high importance and low influence in the value chain because they are the key actors. Although they have limited knowledge of quality improvement, post-harvest facilities, marketing information, and limited access to finance. These factors cause producers of passion fruit to have low influence along the value chain.

5.6 Reflection on the research process

This part of the reflection covers the methodology used during data collection both field survey and online interviews. It is comprised of challenges faced, experiences, and lesson-learned during the thesis. The research was conducted in Rwamagana district, Eastern province of Rwanda. Before the beginning of the research process, the survey questionnaire was piloted to six different people for their comments for improvement. During the piloting phase, some mistakes and unclear questions were identified and had to be corrected for final data collection. Since the study was conducted during the corona pandemic, a research assistant was recruited to collect data on my behalf. For the period of the field survey and online interviews, there were some modifications done other than what was planned in the research proposal due to the availability of both field survey and online interviews to get data.

Initially, the study was planned to be conducted in one sector (Kigabiro) in Rwamagana district but during the research process, it was conducted in 4 more sectors to cover the planned sample size. The changes were made because some cooperative members are registered in kigabiro sector where the study was supposed to be conducted and individual farmers were also scattered in the sectors near to kigabiro sector. In that discouraging situation, random sampling selection was quickly adopted where together with the research assistant, names were randomly picked on the list of cooperative members whereas the snowball method of sampling was adopted and one farmer was leading to another. Furthermore, the survey was supposed to cover 20 farmers from cooperative Ejoheza and 20 individual farmers the same area but the study was conducted on 21 farmers from cooperative and 19 individuals because like mentioned earlier it was difficult to get individual farmers as it was planned. Therefore, one farmer from cooperative Ejoheza was added on to compensate the very missing respondent on the counterpart to get the targetted number (40) of sample size.

Quantitative and qualitative data were collected using a semi-structured questionnaire, during the data collection process research assistant was at least supposed to collect data from 5 respondents depending on their availability, but sometimes he could get 3-4 respondents and the filled questionnaire was directly submitted to my computer. This helped me to track the data collection process which facilitated me to conduct in-depth interviews to have information from both farmers who responded to the field survey and key informants who responded to online interviews. During data collection, some farmer respondents were friendly and willing to participate in the survey but some were hesitating to provide information. Thus, the research assistant had to explain the objective of the study and show them the letter that was given to him by the school (Van Hall Larenstein) to assist us in the field. Another challenge was that some information is contradicting between farmers' respondents and some key informants. This shows either misinterpretation of questions of the research assistant or poor communication between farmers' respondents and key informants. This could be one of the recommendations to the commissioner (NAEB) to conduct another research to get the bottlenecks of the contradictions of information between 2 sides.

Additional information was collected using in-depth interviews. 6 key informants were interviewed using an online semi-structured questionnaire. Likewise, in the beginning, 5 interviews were planned but then one more knowledgeable interviewee from the government in the department of seed breeding was added on the list of interviews to get clear information about the lack of quality seeds that kept being mentioned by other respondents as the main challenge to meet export market requirements. Online interviews were quite puzzling to conduct due to poor internet connection which was either connecting and disconnecting or delays in communication. Moreover, some key informants were avoiding some questions or excuse themselves by saying that that was confidential information. I had to explain to them the objective of the research as well as their names to be anonymous during the report. Then they started to persuade to answer questions and provide information.

Generally, data collection successful despite the challenges. Nevertheless, data would have been more valid and reliable if more key informants (e.g. financial institutions, importers, etc.) were interviewed. Moreover, the focus group discussion would have minimized the bias information given by survey respondents. Lastly, if the questionnaire was translated into the local language beforehand, questions could have been understood the same for all farmer survey respondents. Regardless of the challenges, the research process has helped me to improve my communication, decision making, and perseverance, and writing skills which will help me in my career.

CHAPTER SIX CONCLUSIONS AND RECOMMENDATIONS

The research objective was to identify causes that affect the quality of passion fruit in the value chain (production to the market) to provide recommendations to NAEB to address the problem of poor quality that results in high rejection of passion fruit on the international market in Rwamagana district. This chapter represents the conclusions of the results from the study on the current agricultural practices that affect the quality of passion fruit sold on the export market, and quality standards requirements to meet the export market, opportunities, and constraints for improving the quality of passion fruit for the export market.

6.1 Conclusion

6.1.1 Current pre-harvest practices affecting the quality of passion fruits in Rwamagana district

The results of this study showed that the quality of passion fruit is affected by pre-harvest practices due to lack of quality planting materials, lack of proper harvesting techniques, pesticide application, and harvesting maturity parameters.

Planting materials; The results from farmer's survey respondents showed that most of the planting materials (45%) is sourced from farmers' farm, and few from cooperative Ejoheza, private nursery operators, and Agro dealers. The passion fruit seeds that are being used by farmers have been used for 4 years of production. This means that they are no longer resistant to disease hence low quantity and poor quality of passion fruits for the export market. Additionally, one of the key informants from (RAB) mentioned that they have not yet started tried hybrid seed in Rwamagana. Therefore, planting material sourcing is one of the factors that affect the quality of passion fruit produced for the export market in Rwamagana district.

The type of farming practice; The study results revealed that there was no difference was found ($P=0.613$) in the type of farming between farmers who sell passion fruits to the exporters and those who sell on the local market in Rwamagana district. This confirms with one of the exporters who mentioned that some of their buyers require organic passion fruit while others do not emphasize on organic farming. This shows that farmers do not specialize in farming practices (organic or conventional). Hence, farmers do some organic farming activities mixed with conventional farming. This is another aspect that contributes to the poor quality of passion fruits destined for the export market.

Preharvest interval; The information from the field revealed that most of the farmers that work with the export market (42%) harvest their fruits less than a week after pesticide spray, while some harvest immediately or at least a week after spraying. However, farmers who work with exporters do not differ from farmers who do not work with exporters in preharvest waiting time after pesticide application ($P=0.832$). This implies that passion fruit farmers in Rwamagana district lack knowledge and skills about recommended PHI for export. Thus, exporters seem not to facilitate farmers on awareness of the effect of pesticide residue on the quality of the export market. Likewise, this could lead to the exceedance of maximum pesticide residues (MRLs) which can cause a high rejection of the export market.

6.1.2 Harvest maturity parameters

The results from farmer survey respondents indicate that they harvest mixed maturities (50% ripe and 50% un ripen) because they determine when to harvest by experience and when they get a buyer. On the other hand, one exporter interviewed mentioned that they buy all harvest from farmers, and sorting and grading are done at NAEB packhouse". This is another reason for high rejects on the export market because of mixed maturities harvested. This is could be due to poor communication between farmers and export.

6.1.3 Current postharvest practices affecting the quality of passion fruits in Rwamagana district

Sorting/Grading; The study results show that there no difference in grading practices between producers who sell passion fruits on the export market and those who sell to the local market ($P=0.126$). This inline with one of the exporter who said sorting and grading take place at the NAEB packhouse by exporters. Sorting and grading are one of the most important practices required to meet export market requirements. Pre-sorting and grading should take place on the farm level to avoid low supply caused by high rejection after sorting and grading at the packhouse. Lack of sorting and grading practices at the farm level increases the chance of rejection on the export market hence low quality that affects quantity supplied on the export market.

6.1.4 Challenges farmers face complying with the international market quality standards

❖ Farmers' perceptions regarding export market requirements

The field study results showed that only two exporters (Garden fresh and Proxifresh Rwanda Ltd) in Rwamagana district are involved in the passion fruit export business. In that case, farmers have limited access to export market options. As a result, farmers lack good agricultural practices, limited or no market information, less bargaining power, and price fluctuation consequently the poor quality of produced passion fruits. Thus, this is among the challenges farmers face to comply with export market requirements.

❖ Quality standards to meet export market requirements

Results from the field survey show that around 63% of farmers in Rwamagana district, apply some agricultural practices such as (use of organic manure, use of natural control, and harvesting mature and marketable size) to meet market export requirements. Similarly, exporters stated that passion fruits go to the export market should be big, free of diseases, and free of bruises. However, farmers hardly meet the quality standards because there is a lack of quality seed disease-free, limited knowledge on improved farming practices, and limited capacity to invest in farming for the export market.

❖ Opportunities

More than 50% of the survey farmer respondents mentioned that their farming practices have been improved compared to the time before working with the export market. Some individual farmers mentioned they learn passion fruit farming techniques and experience from their fellow cooperative members. Moreover, the government of Rwanda has set up facilities (e.g. packhouse) to develop export for horticulture produce. Furthermore, farmers have received some technical support (irrigation system) from NGOs such as USAID and FAO. This enhances the capacity of farmers to improve their farming practice, thus meeting export market requirements.

❖ Constraints

Regardless of the mentioned opportunities for the passion fruit subsector, there are also some limitations for passion fruits to meet export market requirements. Information from farmer respondents and key informants show that farmers limited capital for (irrigation system, agricultural inputs) the small farmland, limited knowledge about export requirements, lack of storage facilities (cold room), and difficulty procedures (collaterals, production record) to get a loan from the bank. As a result, farmers are hampered to comply with international market quality requirements.

❖ Stakeholder's role to improve the passion fruit export market

The Rwandan government through its organizations (RAB and NAEB) influences the passion fruit value chain through facilitating the development of farmers and exporters involved in the subsector and providing alternative passion fruit seeds to farmers. Additionally, NGO's (USAID, FAO), and the private sector (FAME Africa) provides technical support (irrigation system, seeds) to farmers in Rwamagana district. Exporters provide a market for farmers and add value to passion fruits that are sold on the international market. Financial institutions (e.g Umutanguha finance company Ltd) provide financial services including; loans, servings, etc. Even though some stakeholders play a big in the passion fruit chain, there is still poor coordination between government and other stakeholders with an emphasis on providing extension services, capacity building on-farm management, limited knowledge of farming techniques, market requirements, and financial capital.

6.2 Recommendations

➤ For Passion fruit producer

- With support from district agronomist, passion fruit farmers should upgrade their knowledge and skills on GAP (pests and disease control, fertilizer application, etc.) through participation in organized training by the end of 2021.
- By the end of 2021 at least, 2 pioneer passion fruit farmers from cooperative should be supported by NAEB in collaboration with Rwamagana district to adopt GlobalGAP practices.

➤ Rwamagana district

- Rwamagana district should continuously encourage and sensitize individual passion fruit farmers to form at any rate 2 more cooperatives for easy accessibility of extension services and any other agriculture support by 2022.
- Rwamagana district should continuously advocate and attract investors for passion fruit subsector development.

➤ For NAEB

- NAEB in collaboration with RAB should provide quality disease-resistant seeds to passion fruit farmers in Rwamagana to control pests and diseases by 2022.
- NAEB in collaboration with Rwamagana district should lead the provision of technical training to passion fruit farmers about good agricultural practices (pesticides, fertilizers application) to improve the quality of passion fruits destined for the export market.
- In collaboration with exporters, NAEB should train passion fruit farmers on basic processing (pre-sorting, grading) and do follow up at least twice in a year.
- NAEB should continuously advocate for passion fruit farmers to financial institutions to be facilitated in loan procedures to boost their farming practices.

➤ The partnership between passion fruit stakeholders

- NAEB should at least organize 2 workshops per year on information sharing about the passion fruit subsector through for ensuring effective government's strategic plan implementation.
- NAEB should initiate the collaboration between a government organization and research universities to accelerate research activities on passion fruit development by 2021.
- The NAEB department in charge of quality control should involve exporters to disseminate and follow up on quality standards for passion fruit by the end of 2021.

➤ **Proposed passion fruit value chain improvement**

A large portion of Rwamagana district agriculture still falls in the hands of resource-poor, and untrained farmers who still wait for buyers/traders to come on their farms, and they are offered low prices. According to KIT, Faida MaLi and IIRR, (2006), farmers should be specialists with improved farming skills, to produce a better crop of higher and more consistent quality and quantity that satisfies the buyer. Consequently, farmers can make money to improve their livelihood. Figure (30) shows an intervention that can strengthen farmers through chain empowerment.

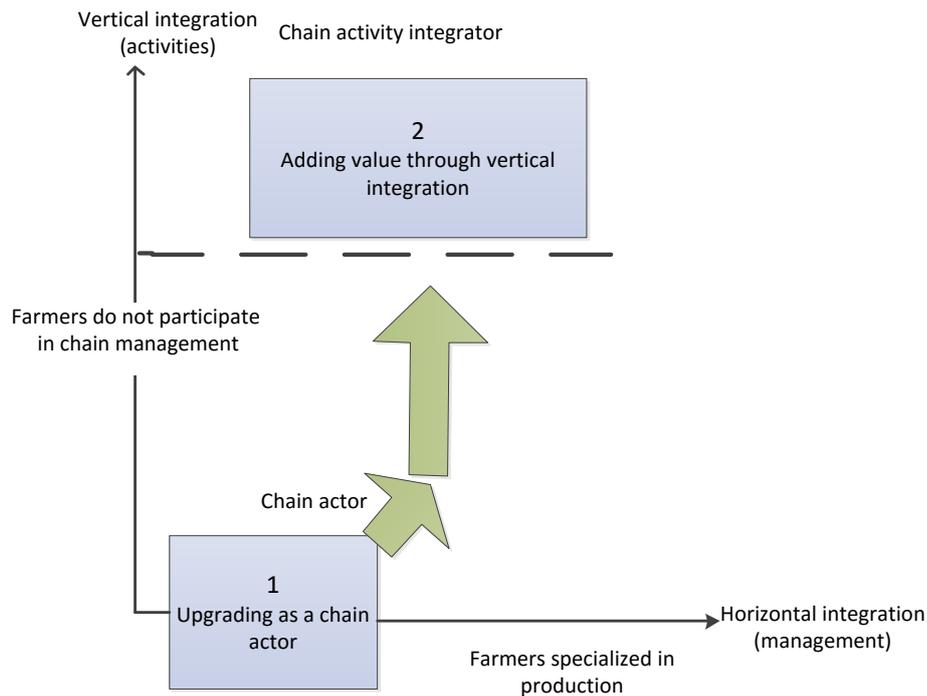


Figure 29. Strategies for empowering farmers; adopted from KIT, Faida MaLi, and IIRR (2006)

Farmers specializing in production (1); should lead the training on passion fruit growers to specialize and integrate their farming practices for the export market. The needed training for passion fruit farmers is; how to improve their farm management skills such as (crop production, planting planning, record keeping, integrated crop pest, and disease management) and financial management. This will equip farmers with knowledge and skills about good agricultural practices that will help them to continuously improve their farming, and farm records. Farmers should be aware of the requirements to produce for the international market. As a result, they can produce large quantities and with good quality fruits. However, this cannot be archived without government and private sectors (public-private partnership) intervention.

Developing chain partnership (2); for long term goals and sustainability of passion fruit farming business, passion fruit farmers (cooperative) should be facilitated by NAEB to make linkages with business partners (exporters, financial institutions) and NGOs through forming farmer business schools. Here farmers should be trained on production planning, understanding market demands, and negotiation skills. Through record-keeping of inputs used can help farmers to have an understanding of the production costs involved, which can help farmers to make good decisions of prices precisely. It is better to help farmers to understand that cooperation between other actors (e.g. seed supplies) and other stakeholders (e.g. exporters, NGOs) because the value chain is about actors performing their roles in their position.

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Appendix 1. Overview of the research approach

S/N	Research Questions	Methods for data collection	Source of data	Tools for Analysis
Sub question 1a.	What are the existing pre-harvest practices that affect the quality of passion fruit grown for export?	<ul style="list-style-type: none"> • Survey 	<ul style="list-style-type: none"> • Producers 	<ul style="list-style-type: none"> • Quantitative; Microsoft Excel and SPSS version 25
		<ul style="list-style-type: none"> • Desk study 	<ul style="list-style-type: none"> • Literature review 	
Sub question 1b.	What are the harvest maturity parameters of passion fruit that are observed by producers?	<ul style="list-style-type: none"> • Survey • Desk study 	<ul style="list-style-type: none"> • Producers • Literature review 	<ul style="list-style-type: none"> • Quantitative data(Transcription and Coding analysis).
Sub question 1c.	What are the existing postharvest practices that affect the quality of passion fruit?	<ul style="list-style-type: none"> • Survey • Desk study 	<ul style="list-style-type: none"> • Producers • Literature review 	<ul style="list-style-type: none"> • Quantitative; Microsoft Excel and SPSS version 25
		<ul style="list-style-type: none"> • Desk study 	<ul style="list-style-type: none"> • Literature review 	
Sub question 2a.	What is the producers' perception regarding export market requirements?	<ul style="list-style-type: none"> • Survey 	<ul style="list-style-type: none"> • Producers 	<ul style="list-style-type: none"> • Transcription and Coding analysis
Sub question 2b.	What are the current quality standards practiced by passion fruit producers to meet the export market requirement?	<ul style="list-style-type: none"> • Survey 	<ul style="list-style-type: none"> • Producers 	<ul style="list-style-type: none"> • Transcription and Coding and analysis
		<ul style="list-style-type: none"> • Online Interview 	<ul style="list-style-type: none"> • Producers & key informants. 	<ul style="list-style-type: none"> • Transcription and Coding and analysis
Sub question 2c.	What are the opportunities and constraints for improving the passion fruit export market?	<ul style="list-style-type: none"> • Survey • Interview • Desk study 	<ul style="list-style-type: none"> • Producers, key informants & Literature review 	<ul style="list-style-type: none"> • Transcription and Coding and, SWOT & PESTEC
Sub question 2d.	Who are the stakeholders and their roles in the value chain of passion fruits?	<ul style="list-style-type: none"> • Survey • Desk study 	<ul style="list-style-type: none"> • Producers • Literature review 	<ul style="list-style-type: none"> • Value chain using problem tree analysis and stakeholders power/influence Grid Matrix

Appendix 2. Survey questionnaire with passion fruit producer



This questionnaire is designed to collect information from farmers about factors that affect the quality of passion fruit and criteria required to meet the export market in Rwanda. The information collected will be used as a recommendation to NAEB to improve the quality of passion fruit. Information collected will be treated with confidentiality. Thank you for your cooperation.

1. What is your name?

2. Gender

- Female
 Male

3. Age

4. In which district is your farm located?

5. In which sector is your farm located?

6. Are you a member of the passion fruits cooperatives or farmers' association?

- Yes
 No

7. If yes, what is the name of the cooperative?

8. How does working in cooperative help you to meet the quality of passion fruits needed for export?

- Access to training
 Easy to get quality seeds
 Bargaining power for a better price
 Availability of transportation

9. If no, why?

10. What type of variety do you grow?

- yellow passion fruit
 purple passion fruit

11. Where do you source planting materials?

- Own farm
- Private nursery operator
- Agro dealers
-

12.If private nursery,mention them

13.If Agrodealers, mention them

14. What type of farming practices do you practice?

- Conventional farming
- Organic farming
-

15. Do you use fertilizers?

- Yes
- No

16. If yes, what kind of fertilizer?

- Organic Manure
- Inorganic fertilizer
- Mixed organic manure and Inorganic fertilizer
-

17. If yes, what type of fertilizers used?

18. Do you irrigate your orchard?

- Yes
- No

19. What method do you use to control pests and diseases?

- Pesticide spray
- Good Agriculture Practices(mulching, pruning, etc)
-

20.If spray pesticides, which one?

21.if spray, how many days do you harvest after pesticide spray

- Immediately after spray
- Less than a week
- More than a week
-

22. At what stage of fruit do you harvest?

- Fully ripe
- 50% ripe (when it half-ripe)
- Fully green

23.How do you know when to harvest passion fruits

- By experience
- Maturity index chart
- use refractometer
-

24.Which tool do you use during harvesting?

- Clippers
- Sharp knife
- handpicked
-

25.At what time of the day do you harvest passion fruits

- Early in the morning
- Evening (sun goes down)
-

26.At what time of the day do you transport passion fruits to market or collection centre?

- Early in the morning
- During the day
- In the evening
-

27. What kind of container do you put fruits during harvesting?

- Basket
- Crates
- Sacs
-

28. Where do you put your produce while waiting for a buyer or to transport to the market?

- Inside the house
- Open field
- Field shade
-

29. What container do you use during transportation

- Sacks
- crates
- Basket
-

30. What is the average production per season?(Kg)

31. Do you sell to exporter?

- Yes
- No
- sometimes

32. If no why?

33. To whom do you sell passion fruits? (Make sure where exactly)

- Exporter
- Middleman
- Wholesaler
- Retailer
-

34. What is the estimation of the quantity of passion fruit sold to an exporter? (Kg)

35. If work with the exporter, what is his/her name?

- Garden Fresh
- LOTECH
- PROXIFRESH
-

36. At what price do you sell passion fruit to exporters?

37. What unit of measurement do you use when selling?

- Bucket

Sacks

Kg

38. What is the estimation of quantity of passion fruit do you sell at local, middleman or company market?

39. At what price do you sell passion fruit?

40. What unit measurements do you use?

sacks

kg

bucket

41. Do you encounter rejects on export market?

Yes

No

Sometimes

42. If yes, where do you sell the rejects (ibitagiye kuri export)

Local market

Middlemen

Processing Plant

43. Which of the following count the highest defect on export market? (1= Not important, 2= Less important, 3= Important, 4=Very important 5=Other

	1	2	3	4	5
Sunburn	<input type="radio"/>				
Deformed/Misshapen	<input type="radio"/>				
Bruised	<input type="radio"/>				
Diseased	<input type="radio"/>				
damaged	<input type="radio"/>				
Immature	<input type="radio"/>				

44. At what price do you sell?

45. What unit of measurement do you use when selling?

Bucket

Kilograms

Sacks

46. What is the distance from your farm to the collection center (Km or hours)

47. Do you sort before taking passion fruits to exporter or market?

- Yes
- No
- Sometimes
-

48. Do you do grading (gushyira mubyiciro) before taking passion to exporter or market

- Yes
- No
- Sometimes

49. If yes, what class (grades) do you make?

- "Extra" Class (free of any defects)
- Class I (slight defects)
- Class II (not qualify for inclusion in the higher classes)
-

50. Do you work with the export market?

- Yes
- No
- sometimes

51. Are you aware of the quality criteria to meet the export market?

- Yes
- No

52. If yes, what constraints (Imbogamizi) do you face to meet export requirements?

53. If yes, what practices do you apply to meet the export requirements?

54. What are the opportunities do you see in working with exporter?

55. Have you received any kind of support?

- Yes
- No

56. If yes, what kind of support?

- Training about GlobalGAP
- Irrigation system
- Planting materials
-

57. Where did you get support from?

- Government
- Exporter
- NGO's
-

58. What do you suggest can be done by NAEB to improve passion fruits quality?

Appendix 3. Interview checklist for exporters

1. Tell me about your background
 - Name
 - Source of passion fruit
 - Number of farmers' work with
 - The country where you export
2. What are quality standards that enable Rwandan passion fruit to access the export market?
3. Are the producers aware of the export requirements?
4. What constraints do passion fruits producers face to meet export requirements?
5. In which ways do you support passion fruit producers to meet the export market requirement?
6. What plans do you have for rejected passion fruits?
7. What do you do with the rejects?
8. What do you suggest can be done to improve passion fruit quality?

Appendix 4. Interview checklist for the key informant (NAEB staff)

1. Tell me about your background
 - Name
 - Place of work
2. What experience do you have with passion fruit producers and exporters?
3. What are quality standards that enable Rwandan passion fruit to access the export market?
4. What are the causes of rejections in the export market?
5. Are the producers aware of the export requirements?
6. If yes, why they encounter rejects?
7. If no, what do you do for the awareness?
8. In which ways do you support passion fruit producers to meet the export market requirement?
9. What constraints do passion fruits produce face to meet export requirements?
10. What do you suggest can be done to improve passion fruit quality?

Appendix 5. Interview checklist for district extension officer

1. Tell me about your background
 - Name
 - Place of work
2. What experience do you have with passion fruit producers?
If yes, in which way?
3. What are quality standards that enable Rwandan passion fruit to access the export market?
4. Are the producers aware of the export requirements?
5. In which ways do you support passion fruit producers to meet the export market requirement?
6. What constraints do passion fruits producers face to meet export requirements?
7. What do you suggest can be done to improve passion fruit quality?

Appendix 6. Interview Checklist for seed import certifying department (MINAGRI)

1. Tell me about your background
 - Name
 - Place of work
2. What are the qualities recommended for passion fruit planting materials?
3. Is that kind of planting material available to farmers?
4. If not, why?
5. How do you make farmers aware of quality planting materials?
6. What do you think are the challenges passion fruit producers encounter to access quality planting materials?
7. Is there any support do you give passion fruit producers to overcome those challenges?

Appendix 7 Type of farming

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.008 ^a	1	.927		
Continuity Correction ^b	.000	1	1.000		
Likelihood Ratio	.008	1	.927		
Fisher's Exact Test				1.000	.613
N of Valid Cases	40				

Source: SPSS statistical test from survey (2020)

Appendix 8. Preharvest interval

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.369 ^a	2	.832
Likelihood Ratio	.371	2	.831
Linear-by-Linear Association	.161	1	.689
N of Valid Cases	40		

Source: SPSS statistical test; Field survey (2020)

Appendix 9. Grading practices

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.143 ^a	2	.126
Likelihood Ratio	3.863	2	.145
N of Valid Cases	40		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.38.

Source: Field survey (2020)

Appendix 10. List of farmer survey respondents

ID	What is your name?	Gender
1	Gaspar Eledephonse	Male
2	Bashir Rutagengwa	Male
3	Rwema cesar	Male
4	Kavaruganda shinani	Male
5	Radjab uwineza	Male
6	Abdoul karim sebahire	Male
7	Emmanuel Rwakayigamba	Male
8	RUKUNDO ERIC	Male
9	Rutanisa valens	Male
10	Simon Rubanda	Male
11	Turatsinze karim	Male
12	Mutsindashyaka hashim	Female
13	Niyomugenga Theogene	Male
14	Gatesi Aisha	Female
15	Gatsinzi swaibu	Male
16	Rwigamba Philbert	Male
17	Jeanne niyoyita	Female
18	Munyemana jean Petit	Male
19	Ndagijimna jean claude	Male
20	Gatarigamba alphonse	Male
21	Munyeragwe charles	Male
22	Ndikumana	Male
23	Nsengimana noela	Male
24	Jofre rukundo	Male
25	Twagirimana jean pierre	Male
26	Richard byiyimana	Male
27	Nyiranzabahimana gaudence	Female
28	Ntijyina Ernest	Male
29	Hitimana Catherine	Female
30	Twagirimana jean	Male
31	Uwitonze justin	Male
32	Ntawicumurame chaste	Male
33	Aimable badasingwa	Male
34	Munyemana leo	Male
35	Mwanaidi musabyemariya	Female
36	Edmond gakire	Male
37	Mugume flank	Male
38	Aron	Male
39	Tuyisenge dany	Male
40	Mporanzima charles	Male

Appendix 11. List of key informants

FUNCTION	ORGANIZATION/INSTITUTION
Production Manager	Exporter (Proxifresh Rwanda Ltd)
Exporter	Exporter (Garden fresh)
Cold Chain Specialist	National Agricultural Export Development Board (NAEB)
Horticulture specialist	Rwanda Agriculture Board (RAB)
Import inspector officer	Rwanda Agricultural and livestock Inspection and Certification Services (RALIS)
Extension Officer	Rwamagana District

Appendix 12. Photo taken during filed data collection



Appendix 13. Checklist used by NAEB to check farm quality




Quality

**NATIONAL AGRICULTURAL
EXPORT DEVELOPMENT
BOARD**

Republic of Rwanda

CHECKLISTS DURING FIELD VISIT AT FARM LEVEL FOR PESTS AND DISEASES SURVEILLANCE AND HACCP GAP ASSESSMENT

1. Names and addresses of producer:

-Name:

-Contact Number:

-District/sector/cell:

-GPS farm Coordinates: *X:...../ *Y:...../ *Z:.....

-Name of exporting Company:

2. Type of grown crop and covered area:

i..... ii.....

iii..... iv.....

3. Identified pests and diseases and their incidence rate:

i....., ii.....

iii....., iv.....

4. Pests and diseases control plans and pesticides applied by producers:

-

-

-

5. Types of used inputs and their Sources: -Seeds/seedlings

- Pesticides,

- Manure,

- Tools

6. Use of pesticides:

a) Chemical dosage and application skills:

b) PHI respect:

. REI respect:

c) Status of spraying equipment:

Status of protective equipment:

d) Skills level of workers applying pesticides (trained?):

e) Records for pests and diseases scouting:

f) Records for pesticides application (date of application and quantities in store and effect):

g) Field surrounding status:

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**NATIONAL AGRICULTURAL
EXPORT DEVELOPMENT
BOARD**



Republic of Kenya

7. Is there premises and structures located at the farm level which can the avoid contamination fresh fruits; vegetables and harboring pests such as insects, rodents and birds?
8. Do you have agricultural chemicals store? Are they contained in their respective containers? If not are the containers labeled?
9. The distance between store of agricultural and production in meters is
10. Is there any contact between Inputs and fresh fruits and vegetables, especially close to harvest?
11. How do you prevent cross-contamination from runoff or leaching by securing areas where manure, biosolids and other natural fertilizers are treated and stored?.....
12. How often do you wash Sprayers and mixing containers?
13. Did you test the soil and water before growing produce?
14. Are irrigation water and potable water contact with pesticides?
15. Do you have hygienic and sanitary facilities located in close proximity?
16. Do have adequate have adequate means of hygienically washing and drying hands?
17. Do the workers wear clean suitable protective clothing and foot wear?
18. Are the cuts and wounds covered?
19. Do the workers involving the handling of fruits and vegetables wash their hands before starting work and after lunch time?
20. Do the personnel have bad behavior of smoking, spitting, chewing gum or eating, or sneezing or coughing over unprotected fresh fruits and vegetables?
21. Do the employees wear jewellery, watches, rings?
22. Are the Equipment and containers coming into contact with fresh fruits and vegetables made from non-toxic materials?
23. Do you have separate, segregated and lockable containers for waste?
24. Types of records taken and kept:.....

N.B: Provided technical advices by the team (other side=Verso).

Inspector:.....

Time:..... Date:...../20..... Signature:.....

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