Investigating the Indigenous Postharvest Technologies and Practices Used In Smallholder Farming Systems, and Their Impact on Food Security: The Case of Maqongqo, Mkhambathini Local Municipality, KwaZulu-Natal

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ABSTRACT

The sustainability of indigenous knowledge and its use has remained a key challenge in many parts of the developing world. Through the review of substantial literature, the researcher has identified that the indigenous postharvest practices and technologies have not been adequately researched and documented to inform policy formulation and be shared with younger generations to ensure the sustainability of these postharvest practices and technologies. Therefore, this study aimed to investigate the Indigenous postharvest technologies and practices used in smallholder farming systems and their impact on household food security. The study had three specific objectives. The first objective was to identify the indigenous postharvest practices and technologies used in smallholder farming systems across different crop types. The second objective was to determine the factors that influence the use of indigenous postharvest practices and technologies. And the third and last objective was to identify the effects of using indigenous postharvest practices and technologies and their impact on household food security. This research study was limited to a group of smallholder farmers in Maqongqo. A total of 120 purposive participants participated in this study.

Regarding research data collection, Participatory Rural Appraisal using one focus group discussion, semi-structured and unstructured interviews were held with all key informants, Household Food Insecurity Access Scale, direct observations, and surveys were used to collect essential data from the sample population. Descriptive statistics and correlation tests using Statistical Package for Social Sciences version 27 were used for data analysis to summarize and analyze the quantitative data. The responses from open-ended questions from the questionnaire and focus group discussions were analyzed to identify common themes. Results showed that indigenous postharvest practices and technologies were used mainly for processing, preparation of produce for storage, preserving crop harvest and protecting stored harvest from pests.

The leading indigenous postharvest practices used are sun drying, winnowing, destalking, hand threshing, shelling and natural field storage. The main indigenous postharvest technologies used in Maqongqo were fibre bags, plastic buckets and cool dry areas, mainly the floor. Farming experience, age, familiarity of the indigenous postharvest practices and

technologies, the confidence and faith in indigenous postharvest practices and technologies, and the consideration of preharvest factors has an influence on the use of indigenous postharvest practices and technologies. The use of indigenous postharvest practices and technologies in Maqongqo did not lead to the attainment of food security among smallholder farming households. It is essential to note that smallholder farmers in the current study had various livelihood sources of which all contributed towards their household food security, these sources included income from part-time and full-time employment, income from the sale of the surplus produce, social support grants and pensions. The use of indigenous postharvest practices and technologies on their own as a food security strategy is discouraged. Instead, the integration of modern and indigenous postharvest techniques and technologies is encouraged and recommended to account for the shortfalls of using indigenous postharvest practices and technologies to achieve food security among rural and urban farming households and ensure that the livelihoods of the rural poor are sustainable.

Keywords:

Food security, indigenous postharvest practices, indigenous postharvest technologies, smallholder farmer, postharvest losses, indigenous knowledge

DECLARATION

I, Wonder Ntokozo Ngubo, declare that:

i. The research, except where otherwise indicated, is my original research.

ii. This dissertation has not been submitted for any degree or examination at any other university.

iii. This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from those persons.

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Signed: **Date:**……06/01/2021……

Mr. Wonder Ntokozo Ngubo

As candidate's Research Supervisor, I agree to the submission of this dissertation for examination.

Signed:……**Date:**……7/1/2021

Professor Maxwell Mudhara

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LIST OF ABBREVIATIONS

CCCU	Canterbury Christ Church University
CI	Confidence Interval
DST	Department of Science and Technology
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
HFIA	Household Food Insecurity Access
HFIAS	Household Food Insecurity Access Scale
ICT	Information and Communication Technology
IGNOU	Indira Gandhi National Open University
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
M	Mean
NSFSL	National Science Foundation of Sri Lanka
PAHs	Polycyclic Aromatic Hydrocarbons
PRA	Participatory Rural Appraisal
SD	Standard Deviation
SISA	Simple Interactive Statistical Analysis
SPSS	Statistical Package for Social Sciences
TK	Traditional Knowledge
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development

CHAPTER ONE: INTRODUCTION

1.1. Background

Food security, postharvest food losses, and the sustainability of Indigenous Knowledge Systems are critical issues in many parts of the world, especially in the developing world (Maremera, 2014; Tlhompho, 2014). Household food insecurity is a recurrent severe problem for smallholder farmers for whom hunger periods are frequent, mainly due to food shortages, food losses, and poverty (Masarirambi *et al.,* 2010). Food security has several vital components: food access, food availability, food distribution, a stable food supply, and food utilization (Mandisvika *et al.,* 2015). Smallholder farming has good potential to contribute significantly to food security (Maremera, 2014). The use of indigenous knowledge can help achieve rural development, reduce rural poverty issues, and alleviate food insecurity problems (Mahlangu and Garutsa, 2014). This study seeks to investigate the Indigenous postharvest technologies and practices used in smallholder farming systems and their impact on food security.

Indigenous knowledge is the traditional cultural knowledge that covers all forms of knowledge and experiences, including technologies, skills, practices, and beliefs that enable a community to achieve sustainable livelihoods in their environment (Tlhompho, 2014; United Nations Environment Programme (UNEP), 2008). Agriculture is an important sector for the economies of most African countries (Lwoga *et al.,* 2011). Indigenous Knowledge Practices in smallholder farming systems affect household food production and food security (Ndwandwe, 2013). Hunger, food insecurity, and malnutrition are a problem for almost 48% of the people living below the poverty line ($2 per day) in South Africa (Nyembe, 2015). Tlhompho (2014) writes that most smallholder farmers are dependent on agriculture as a source of household food, income, and sustainable livelihoods. They, smallholder farmers, depend on their indigenous community-based agricultural knowledge for agricultural production and income.

UNEP (2008) writes that Indigenous Knowledge Systems (IKS) are still intact among indigenous communities in many parts of Africa. But does these IKS include indigenous postharvest practices used in smallholder farming systems, and if yes, what impact do they have on household food security? Kamwendo and Kamwendo (2014) argued that the abandonment

of the IKS is one of the causes of food insecurity, as we see it today. But does this suggest that the recognition and adoption of IKS practices in agriculture and smallholder farming can lead to household food security? One can ask themselves at which level of society does this abandonment of IKS cause food insecurity; at the individual, household, community, provincial, or national level. Maremera (2014) writes that smallholder farmers' lack of postharvest handling knowledge and lack of effective and efficient cold storage facilities to mitigate postharvest losses threatens their profitability.

IKS are not limited to any culture, society, or race, and they are said to be potentially transformative tools (Mahlangu and Garutsa, 2014; Warren *et al.,* 1995). Notsi (2012) argues that African indigenous knowledge, farming practices, and skills of the cultivation of indigenous vegetables lie with the elders. Notsi (2012) states that IKS for the cultivation of indigenous foods is complex, cost-effective, environmentally friendly, and sustainable. Notsi (2012) wrote that ecologically friendly farming methods must be adopted to improve food security among poor rural communities. Thus, IKS in farming must be promoted, adopted, and improved.

Masarirambi *et al.* (2010) argue that postharvest losses of fruits and vegetables in developing countries can reach up to 50%, depending upon the commodity type. Postharvest processes bring immeasurable benefits in reducing food losses, increasing shelf-life, and adding value to the product (Masarirambi *et al.,* 2010). Several fruits and vegetables are grown, harvested, handled, and processed using local indigenous knowledge at the household level in many rural areas (Masarirambi *et al.,* 2010). Many postharvest practices for preserving produce are available, and these include sun drying, solar drying, vacuum packing, minimal processing, freezing, and irradiation (Ofor *et al.,* 2010). Ofor *et al.* (2010) write that the major problems associated with the indigenous storage systems used are the postharvest losses arising from the methods.

Indigenous food preservation and storage ways play a critical role in contributing to household food security (Kamwendo and Kamwendo, 2014). Prior to introducing modern agricultural methods, traditional societies used farming methods that were suitable for local ecosystems; however, some people now regard indigenous practices as primitive (Dlamini, 2007; Kamwendo and Kamwendo, 2014). Improving postharvest handling and processing,

indigenous or not, could be one way of overcoming perishability constraints, reducing postharvest losses, and ensuring a sustainable supply of high-quality food; and thereby improving food availability and thus positively affecting household food security (Maremera, 2014; Masarirambi *et al.,* 2010).

Notsi (2012) writes that African indigenous farming methods have both limitations and strengths. Indigenous African farming systems have a capacity to increase and diversify agricultural and farm incomes, capable of growing food production or food supply and availability, and present local farmers with an opportunity to manage different crops simultaneously (Notsi, 2012). Indigenous farming systems have several weaknesses; these include but are not limited to low production risk. They are labour intensive, and their activities are mostly carried out by women, leading to low output and may lead to food and nutrition insecurity (Notsi, 2012).

Some of the problems associated with indigenous postharvest practices, particularly with indigenous storage systems, include rotting, respiration, sudden temperature changes, sprouting while in storage, and pests like insects and nematodes (Ofor *et al.,* 2010). Smallholder farmers' indigenous postharvest practices need to be environmentally friendly; they should help conserve biodiversity, mitigate climate change, and be energy-saving (Masarirambi *et al.,* 2010). This background information illustrates and highlights the overall need to investigate the Indigenous postharvest technologies and practices used in smallholder farming systems and their impact on household food security.

1.2. Research problem

Postharvest handling practices of smallholder farmers are relatively unknown because they have not actively participated in formal value chains (Maremera, 2014). Notsi (2012) asserts that the challenges and prospects of promoting indigenous farming systems in ensuring food security still need to be systematically investigated. Notsi (2012) argues that there is a need to document and disseminate African indigenous farming methods. Notsi (2012) claims that both modern intensive and African indigenous farming methods have limitations and strengths, which need to be investigated and documented.

Mahlangu and Garutsa (2014) have argued that indigenous knowledge custodians have failed to appropriately disseminate this knowledge to the younger generation. This failure to share indigenous knowledge has resulted in the restriction of indigenous knowledge to the elderly, which further necessitates the research and documentation of indigenous postharvest practices to ensure that this knowledge is appropriately distributed and maintained. Through the review of substantial literature, it has been identified that the indigenous postharvest methods have not been adequately researched and documented to inform policy formulation to contribute to household food security and be shared with younger generations to ensure the sustainability of these postharvest practices. Therefore, this study aimed to investigate the Indigenous postharvest technologies and practices used in smallholder farming systems and their impact on food security.

1.2.1. General objective

To investigate the indigenous postharvest technologies and practices used in smallholder farming systems and their impact on household food security**.**

1.2.2. Specific objectives

1.2.2.1. To identify the indigenous postharvest practices and technologies used in smallholder farming systems across different crop types.

1.2.2.2. To determine the factors that influence the use of indigenous postharvest practices and technologies.

1.2.2.3. To identify the effects of using indigenous postharvest practices and technologies and their impact on food security.

1.3. Hypothesis

The use of indigenous postharvest practices and technologies can improve household food security among smallholder farming households.

1.4. Importance of the study

Significant social progress has been occurred in South Africa over the last 20 years, however poverty, hunger and unemployment are still prevalent (Department of Science and Technology (DST), 2019). Black people in South Africa, particularly women who are said to be custodians of IK, are the most vulnerable to poverty (DST 2019; Kamwendo and Kamwendo,

2014). The use of IK could be one of the approaches used to alleviate poverty, hunger and food insecurity in South Africa but this IK has not been adequately documented. This study yielded important information about the indigenous postharvest technologies and practices used in smallholder farming systems and their impact on household food security. With regard to the social capital of local people in Africa, Indigenous knowledge is an important asset and is the main resource for their livelihoods (Lwoga *et al.,* 2011). In order to minimize smallholder farmers' postharvest losses, it is essential that the extent and causes of postharvest losses of smallholder farmers be established (Abass *et al.,* 2014).

In addition, appropriate measures and interventions must be identified for each farming system to improve postharvest handling and processing of smallholder farmers' produce to overcome perishability constraints and ensure a sustainable supply of adequate quality food (Abass *et al.,* 2014; Masarirambi *et al.,* 2010). Masarirambi *et al.* (2010) concluded that increasing smallholder farmers' knowledge of the proper use of improved postharvest technologies would impact smallholder farmers' households' ability to reduce postharvest losses. Hence this study sought to identify the indigenous postharvest technologies and practices used in smallholder farming systems, their impact on food security, and identified ways of increasing the access of smallholder farmers to information about the sustainable use of indigenous postharvest technologies and methodologies in their smallholder farming systems. The findings from this study may help provide important information that may assist agricultural extension officers, farm advisers, and researchers in designing and implementing effective programmes and projects that aim to improve the postharvest practices used in smallholder farming systems, minimize postharvest food losses, and increase smallholder farmer's household incomes; thereby improving food access and food security.

1.5. Limitations of the study

- This study was limited to a group of smallholder farmers in Maqongqo, and this may not be an exact representation of the entire population of smallholder farmers.
- Even though this study's findings may help understand the indigenous postharvest practices and technologies used by smallholder farmers and their impacts on household food security, the results from this study may not be generalizable or applicable entirely to smallholder farmers in areas outside of Maqongqo.

- There were limited time and resources to conduct this research study; therefore, a larger sample could not be taken; thus, results may not be representative of the population.

1.6. Definitions of key terms

- Ofor *et al.* (2010), Risiro *et al.* (2013), UNEP (2008), and Warren *et al.* (1995) define IK as knowledge which has been accumulated by a people or society over generations (time) by observation, experimentation, and by handing on older people's experience and wisdom in any particular area of human endeavor. IKS is a system of local knowledge that is unique to a given culture or community. However, IK is dynamic since it is constantly changing with time and is transdisciplinary, as new knowledge and experiences are continuously added through social practice and interaction from within and outside the local community (Shilenge, 2016).
- In this study, a smallholder farmer refers to a farmer (male or female) who operate in less than 2 hectares of land, including those who do not own the land they work or farm on.
- "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996).
- Postharvest practices refer to subsequent methods done immediately after removing a plant or plant part (vegetable or fruit) from its growth media till the agricultural product reaches the final consumer in the desired form (Masarirambi *et al*., 2010).
- Indigenous postharvest practices refer to indigenous methods and processes employed immediately after removing a plant or plant part (vegetable or fruit) from its growth media.

1.7. Assumptions

It was assumed that all smallholder farmers in the research sample would honestly and in good conscience respond to the survey questions. It was assumed that smallholder farmers were knowledgeable about indigenous postharvest practices and technologies. It was also

assumed that the participating smallholder farmers would not withhold any vital information that may affect the research study's findings.

1.8. Organization of the dissertation

This dissertation is written in the conventional format. It comprises five chapters, excluding the references and appendices. The first chapter introduces the study, and it highlights the importance of this study. The second chapter presents a review of the literature on IKS, smallholder farming, the indigenous postharvest practices and technologies used in smallholder farming, factors influencing the use of indigenous postharvest practices and technologies, and its impacts on household food security. The third chapter presents the methodology adopted in the study; it details the sampling technique and the procedure for data collection and analysis. In chapter four, the findings of the research are presented and discussed. Finally, chapter five presents the conclusions and recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

The majority of rural people in South Africa and Africa, including smallholder farmers, are dependent on indigenous knowledge (IK) to sustain their livelihoods (Phokele and Sylvester, 2015). IK faces the risk of extinction due to increased urbanization, globalization, and modernization (Taremwa *et al.,* 2016). This literature review describes the concepts of indigenous knowledge systems (IKS), smallholder farmers, postharvest, and food security. It also outlines and discusses the impacts of using indigenous postharvest practices and technologies on smallholder farming households' food security in Africa and South Africa.

2.2. The Concept of IKS, Smallholder Agriculture, Post-harvesting and Food Security

Through the accumulation and use of IK, many African communities have efficiently and consistently harvested and post harvested fruits and vegetables in their smallholder farming practices since the dawn of history. According to Taremwa *et al.* (2016), IKS in Africa are traditionally applied in harmony with the natural and spiritual world. IK refers to knowledge which has been accumulated by a people or community over time by observation, experimentation, and by handing on older people's experience and wisdom in any particular area of human endeavour (Ofor *et al.,* 2010; Risiro *et al.,* 2013; UNEP, 2008; Warren *et al.,* 1995). IK is sometimes termed 'Local Knowledge', 'Traditional Knowledge', and even 'Common Sense Knowledge (Hart and Vorster, 2006; Warren *et al.,* 1995).

IK is not static; local people instead continuously develop it over time and even over generations, and IK is not confined or restricted to the original developers or inhabitants of an area, nor is it restricted to a particular subject, topic, or area of study (Hart and Vorster, 2006; Taremwa *et al.,* 2016; Warren *et al.,* 1995). The development of IK is based on a number of factors, and it has a number of characteristics; these include experiences, influences of externally derived knowledge, it is often tried and tested over generations, it is adapted to local environmental conditions, it forms part of the local culture and is dynamic as it changes continuously over time (Hart and Vorster, 2006; Taremwa *et al.,* 2016). Frequently women are the primary custodians of IK; in South Africa, they are the main contributors to smallholder

or subsistence agriculture, food security, and livelihoods (DST, 2004; Kaya, 2016). IK is said to be an essential local resource in terms of its importance and influence on agricultural development initiatives because it is significantly used in local-level decision making (Kaya, 2016; Notsi, 2012; Taremwa *et al.,* 2016).

Smallholder production of fruits and vegetables has been increasing significantly throughout the world over the last few years, partly due to increasing human populations (Wills *et al.,* 1998). Smallholder farming in South Africa is characterized as diverse, complex, and vulnerable to various human-made and natural threats and disasters, including but not limited to climate change (Hart and Vorster, 2006; Phokele and Sylvester, 2015). Smallholder farmers in South Africa, irrespective of gender and race, generally fall along a continuum between being resource-rich, resource-medium, and resource-poor (Hart and Vorster, 2006). These smallholder farmers may be involved either in commercial or subsistence agriculture or maybe practicing both commercial and subsistence agriculture by producing mainly for household consumption but selling the surplus agricultural produce (Hart and Vorster, 2006).

Hart and Vorster (2006) define a smallholder farmer as any farmer, male or female, who is black, including African, Coloured, and Indian, who is farming individually rather than communally on less than three hectares of land. In this study, a smallholder farmer refers to a farmer (male or female) who operates in less than two hectares of land, including those who do not own the land they work on, including those who farm communally in groups. Smallholder black farmers in South Africa are mainly considered to be resource-poor, but some may be classified as resource-medium because they can afford to adopt modern innovative or conventional agricultural technologies and inputs (Hart and Vorster, 2006). Resource-poor smallholder farmers in South Africa are involved in agriculture mainly for subsistence purposes, and in contrast, most resource medium smallholder farmers tend to farm for commercial purposes, but they also consume some of their agricultural produce (Hart and Vorster, 2006).

Hart and Vorster (2006) noted that all types of smallholder farmers use a mixture of indigenous and conventional farming practices. But is this really true for poor smallholder farmers in rural KwaZulu-Natal, and are there no smallholder farmers who are dependent exclusively on either indigenous or modern conventional practices? Notsi (2012) estimates

that about 90% of smallholder farmers in Africa, including in Southern Africa, are dependent on saved seeds and exchanges with neighbours and relatives as their sources of plant material to use in the next growing seasons. IK is used greatly in postharvest handling and management of produce and crops by smallholder farmers (Masarirambi *et al.,* 2010; Notsi, 2012)

Since fruits and vegetables are living biological organisms, their quality deteriorates after harvesting (Wills *et al.,* 1998; Wu, 2010). The rate at which the harvested fruits and vegetables deteriorate depends on many factors. These factors include the type of postharvest handling practices used, postharvest management's efficiency and effectiveness determines the final quality of agricultural products or produce (United Nations Industrial Development Organization (UNIDO, undated). Masarirambi *et al.* (2010) and UNIDO (undated) refer to postharvest practices as the subsequent methods done immediately after removing a plant or plant part (vegetable or fruit) from its medium of growth till the produce reaches the final consumer in the desired form.

The postharvest phase begins when a plant or plant part is removed from its growth medium (Mandisvika *et al.,* 2015; Phokele and Sylvester, 2015). Extending the postharvest life of harvested produce requires knowledge, including knowledge to develop low-cost but effective technologies and practices that reduce the rate of deterioration (Wills *et al.,* 1998). Postharvest knowledge can be divided into two groups, indigenous postharvest knowledge and international postharvest knowledge. International knowledge refers to global knowledge characterized by high generalizability, cross-culture, non-indigenousness, and various sources (Ching Mok, 1998). The use of both these forms of knowledge and expertise influences the ways smallholder farmers handle their produce after harvesting; therefore, they have an impact, direct or indirect, on the rate at which produce is lost or preserved at postharvest.

Thus, the use of either indigenous or international postharvest knowledge has an impact on the overall productivity of smallholder farmers and has an effect on all the four pillars of food security as it impacts both the physical availability of food (quantity) through loss or preservation and on the quality of the available food. Postharvest practices and technologies are essential for increasing agricultural production, reducing postharvest losses, enhancing storage for off season reserve of agricultural products, and adding value to agricultural

produce (Masarirambi *et al.,* 2010; Ofor *et al.,* 2010; Phokele and Sylvester, 2015). Formal definitions of indigenous postharvest practices and indigenous postharvest technologies were not obtained during the literature review. However, in this study, indigenous postharvest practices refer to indigenous methods, sciences, and processes employed immediately after removing a plant or plant part (vegetable or fruit) from its growth media. Indigenous postharvest technologies refer to the traditional tools and devices used during the execution of indigenous postharvest practices or operations, including indigenous storage.

The term 'food security' has been defined differently by different people, and its international definition has evolved many times over the past decades. Food Security is widely described as the idea and situation that "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). The use of indigenous postharvest practices and technologies is likely to have significant impacts on smallholder farmers' livelihoods and food security in South Africa, particularly on those who are resource-poor.

2.3. Indigenous Postharvest Practices Used in Smallholder Farming

Phokele and Sylvester (2015) found that a good percentage of smallholder farming households in the Limpopo Province, South Africa, are still using indigenous-postharvest systems and practices in their study of indigenous postharvest systems. Indigenous postharvest practices and technologies used in smallholder farming systems have been identified as an important component of the strategy that aims to reduce postharvest losses by improving traditional drying, storage, processing, and preservation methods (Phokele and Sylvester, 2015).

The use of indigenous postharvest practices and technologies is usually in some rural areas in Africa and contributes positively to the livelihoods of the rural poor, mainly women, by providing alternative sources of food and contributes to the overall economic growth through the increased economic opportunities it creates (DST, 2004; Masarirambi *et al.,* 2010; Phokele and Sylvester, 2015). There are several IKS postharvest practices used in smallholder farming systems (El-Ramady *et al.,* 2015; Khrishnan *et al.,* 2014; Masarirambi *et al.,* 2010; National

Science Foundation of Sri Lanka (NSFSL), 2006); Notsi, 2012; Phokele and Sylvester, 2015; Taiwo *et al.,* 1997; United States Agency for International Development (USAID), 2012). These indigenous practices are performed mainly by hand, and they include sun drying, smoking, salting, sugar addition, pre-treatment sieving or winnowing, blanching, fermentation, shelling, intercropping, destalking, using calcium carbide, washing or cleaning, pickling, threshing, and natural field storage (El-Ramady *et al.,* 2015; Khrishnan *et al.,* 2014; Masarirambi *et al.,* 2010; Notsi, 2012; NSFSL, 2006; Phokele and Sylvester, 2015; Taiwo *et al.,* 1997; USAID, 2012).

Sun drying is one of the oldest and simplest techniques in smallholder farming used to preserve food and agricultural produce (Masarirambi *et al.,* 2010; Taiwo *et al.,* 1997). Sundrying can be defined as the drying of agricultural produce; fruits, vegetables, and meat, using the direct or indirect solar radiation (Kitinoja and Gorny, 1999). Akintola and Fakoya (2017) refer to sun-drying as the process which consists of using the sun and air movement to remove moisture and preserve agricultural produce. The time it takes to sun dry agricultural produce depends on the type and nature of produce, the sun's intensity, and the surfaces used for drying (Akintola and Fakoya, 2017; Kitinoja and Gorny, 1999; Masarirambi *et al.,* 2010).

There are several advantages and benefits of using sun drying (Akintola and Fakoya, 2017; Taiwo *et al.,* 1997). Sun drying helps in retaining the maximum possible quality of agricultural products, to reduce the moisture content to enable safe storage of produce, it is the least expensive indigenous food preservation method, increases the shelf life of produce, and reduces the weight and volume of produce which therefore reduces the cost of storage and transport, and it is very viable in areas where the climate is hot and dry (Kitinoja and Gorny, 1999; Taiwo et al., 1997; UNIDO, undated; Vorster, 2007).

The use of indigenous sun drying also, however, has a number of disadvantages; these include that sun drying may result in a product of lower overall quality, it may make agricultural produce susceptible to predation by animals, discolouring of fruits and vegetables, considerable product losses, reduced protein quality, it does not allow very much control over drying times, and it may expose agricultural produce to attack by insects, rodents, flies and to contamination by sand or dirt and animal droppings (Akintola and Fakoya, 2017; Kitinoja and Gorny, 1999; Taiwo *et al.,* 1997). Mandisvika *et al.* (2015) have argued that indigenous

postharvest practices with specific to sun drying are not effective in reducing postharvest food losses and are therefore ineffective in enhancing food security.

Smoking refers to a food preservation method used to preserve agricultural produce, partly by drying and partly by adding naturally produced anti-microbiological constituents from the smoke to the agricultural produce, including fish (Akintola and Fakoya, 2017). The goodness and healthfulness of smoked agricultural products using the traditional oven or kiln depend on many factors (Akintola and Fakoya, 2017; Taiwo *et al.,* 1997). These factors include the wood type used for the smoking process, the temperature used, the duration of smoking, kiln type used, the closeness of the produce from fire, the type of crop being smoked, and the fat content of the agricultural produce (Akintola and Fakoya, 2017; Taiwo *et al.,* 1997). Smoking has a number of benefits; these include that it extends the shelf life of agricultural produce; it prevents bacterial growth and enzyme activity, which therefore prevents or reduces spoilage (Akintola and Fakoya, 2017; Taiwo *et al.,* 1997). Akintola and Fakoya (2017) argue that the adoption of smoking may reduce the levels of a range of antioxidants and antimicrobial chemicals such as Polycyclic Aromatic Hydrocarbons (PAHs) and PAH-associated health effects such as cancer and cancer-related diseases.

Akintola and Fakoya (2017) have stated that sun drying and smoking are major interventions smallholder farmers use to mitigate postharvest losses, but they argue that these methods are constrained by gross under-capacity and improper handling. Salting refers to the preservation of food in or with salt; this process through osmosis reduces the water content of the food product, which then limits or prevents various biochemical and enzymatic reactions and microbial growth and therefore helps in preventing the spoilage of agricultural produce (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997). The principle employed during the salting of food is based on the knowledge that poisonous bacteria cannot live in salty conditions, and a concentration of 6 to 10% salt in plant or animal tissue will prevent bacterial activity, thereby resulting in a longer shelf life (Akintola and Fakoya, 2017). Youssef and Roberto (2014) write that salts' application just before harvest may be an effective way to minimize grey mould during storage.

Akintola and Fakoya (2017) and Taiwo *et al.* (1997) caution against the use of salting in food preparation and processing since the high intake of salt is harmful to good health, and this

concern is founded by the reports of increased heart problems in some individuals. Through the use of indigenous knowledge (IK) and Traditional Knowledge (TK), humans globally have employed salting, sun-drying, and smoking for centuries as means of controlling spoilage in agricultural produce (Akintola and Fakoya, 2017). At present, the traditional processing techniques of salting, smoking, and sun-drying are at the centre of guaranteeing protein, food security, and nutritional well-being (Akintola and Fakoya, 2017).

Pre-treatment sieving, also known as winnowing, can be defined as the process of removing straw, sand, small stones, weeds, chaff, and other extraneous materials from the harvested agricultural produce (UNIDO, undated). Winnowing is considered to be an important step for obtaining clean agricultural produce for storage and further processing (UNIDO, undated). The use of winnowing in smallholder farming has the following benefits; removes foreign material from agricultural produce, increases purity and market value of agricultural produce, and it helps to avoid contamination of agricultural produce by insects, sand, stones, and other contaminants (UNIDO, undated).

Blanching is defined by Masarirambi *et al.* (2010) as a pre-treatment that is used to destroy enzymatic activity, mostly in vegetables, before unit operations of dehydration or freezing. Kitinoja and Gorny (1999) and Luna-Guevara *et al.* (2015) refer to blanching as a short heat treatment that ends specific enzymatic reactions in the fresh produce and releases tissue gases. Blanching helps to decrease microbial population present on the surface of fresh produce, helps to extend shelf life of produce, and it helps to retain bright desirable colour, good texture, and fresh flavour food processing (Kitinoja and Gorny, 1999; Luna-Guevara *et al.,* 2015; Vorster, 2007).

Vorster (2007), in the study of the role and production of traditional leafy vegetables in three rural communities in South Africa, found that blanched leaves can be stored longer, do not disintegrate easily, and may be damaged less by insects as compared to non-blanched leaves or produce. Although blanching helps smallholder farmers, certain blanching techniques may result in a loss of vitamins from produce, particularly vitamin B, C, and niacin (Kitinoja and Gorny, 1999). As a result of using blanching, several undesirable changes could occur to agricultural produce; these may include a change in sensorial qualities, firmness changes, and reduced bioavailability of some nutrients from produce (Luna-Guevara *et al.,* 2015).

Indigenous food fermentation has been used by humans to preserve foods and improve their aroma and digestibility for many generations (Taiwo *et al.,* 1997; Wafula *et al.,* 2016). Fermentation is defined as the conversion of carbohydrates and sugars to alcohols and carbon dioxide or organic acids using yeasts, bacteria, or a combination of the two under aerobic or anaerobic conditions or in oxygen-starved muscle cells (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997; Wafula *et al.,* 2016). Wafula *et al.* (2016) argue that food fermentation plays an important role in most developing countries, including Southern African countries, from nutrition, health, social and economic perspectives. There are numerous benefits of using indigenous fermentation in smallholder farming (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997; Wafula *et al.,* 2016). These benefits include increasing the shelf-life of produce, it increases the safety, palatability and sensory quality of the raw agricultural products, it reduces undesired and toxic compounds, and may increase the availability and utilization of proteins and vitamins, and thus positively impacts on human health and nutrition (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997; Wafula *et al.,* 2016).

Indigenous fermentation practices tend to be associated with low production costs, needs less labour inputs, and the raw materials required for production and preparation are often locally and readily available (Wafula *et al.,* 2016). Indigenous fermentation is done mainly to enrich diets through the development of a diversity of flavours, smells, and textures in food substrates, to preserve food, to ensure the biological enrichment of food substrates, to eliminate antinutrients, and to decrease cooking time and fuel requirements (Khrishnan *et al.,* 2014; Wafula *et al.,* 2016).

Fermentation is used to make indigenous foods such as sour porridge (commonly referred to as *Isicukwane* in IsiZulu) and A*mahewu* from leftover mealie meal and porridge respectfully. Therefore, this helps reduce food wastage and reduce postharvest food losses while ensuring or enhancing food and nutrition security. The methods of fermentation that are used in rural Africa are often applied on a small scale or household basis, and they are characterized by the use of simple and unsterilized equipment, unregulated conditions, sensory variations, poor durability and unattractive packaging of the processed products, resulting in foods of unpredictable quality (Wafula *et al.,* 2016).

Pickling refers to a technique for preserving food in vinegar or other acids (Khrishnan *et al.,* 2014). Pickling is also described as the process of food preservation by anaerobic fermentation in brine, vinegar, alcohol, and vegetable oil (Khrishnan *et al.,* 2014). The use of pickling by smallholder farmers provides a number of advantages and benefits (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997). These benefits include its ability to preserve agricultural produce for months, it does not require that agricultural produce be completely sterile before it is sealed, and the traditionally produced pickles are a source of healthy probiotic microbes (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997). Pickling has, however, been noted to have some health hazards or disadvantages; these include that pickles are thought to be a possible carcinogen, and pickles are said to increase the risk of oesophageal cancer by two folds (Khrishnan *et al.,* 2014; Taiwo *et al.,* 1997).

Threshing refers to the postharvest operation of separating the paddy grains from the rice straw (UNIDO, undated). Threshing can also be defined as the act of removing sorghum and grains from the heads, which is the point where they are attached to the plant (UNIDO, undated). The time required for threshing depends on several factors; these include the variety of grains, the degree of dryness of the grain, and the threshing method (UNIDO, undated; USAID, 2012). Indigenous threshing practices are usually done by hand, these are considered to be time consuming, labour intensive, slow, and the output they produce is relatively low. At the same time, the contamination of paddy or grains with sand, stone, immature grain, and other foreign materials is very high. These threshing practices often increase grain loss, leading to a reduction in overall agricultural output (UNIDO, undated**).** Therefore, threshing can negatively affect food availability at the smallholder farmer's household level, limiting their access to markets and farm incomes from grain. Consequently, it can negatively impact both physical and economic access to food, thereby reducing the overall food and nutrition security of smallholder farmers' households and those dependent on them for food. The most common indigenous threshing practices are 'beating with sticks on the ground or in sacks', 'grinding crops on stones', and 'using legs to march on straw' (UNIDO, undated; USAID, 2012).

Shelling refers to separating the grains, and the shells in the case of groundnuts, from the portion of the plant that holds them (Food and Agriculture Organization (FAO), 2008; UNIDO, undated; USAID, 2012). There are many benefits of shelling (USAID, 2012). These include

reducing the required storage capacity or requirements and reducing agricultural produce and grains' susceptibility to pests (UNIDO, undated; USAID, 2012). Hand shelling is considered by UNIDO (undated) to be labour intensive, but it is regarded by FAO (2008) to be useful for small-scale farmers, especially for the selection of seed for the following planting season.

This intensiveness of labour may present an opportunity for employment to the unemployed, which can lead to an increase in individual and household incomes, leading to improved food access. Hence, shelling may indirectly help improve household food and nutrition security. The harvested agricultural produce can also be stored using what is known as natural or field storage (Ofor *et al.,* 2010). During natural field storage, mature crops such as yam tubers are left in the soil until they are to be prepared for the household's consumption and for the market; the main benefit of using natural field storage is that it does not require any money to develop the storage system but the main disadvantage of using natural storage is the lack of protection from pests and diseases (El-Ramady *et al.,* 2015; Ofor *et al.,* 2010).

Khrishnan *et al.* (2014) wrote that the raw material for indigenous food preservation techniques are easily available; the tools used are easy to maintain and are affordable to local people, including smallholder farmers. Khrishnan *et al.* (2014) found, during the study of traditional methods of food preservation, its scientific understanding and technological intervention, that pickling, fermentation, and canning are the most commonly used indigenous food preservation techniques. Khrishnan *et al.* (2014) argued that as the living standard of people is improving, smallholder farmers are adopting modern food preservation techniques and abandoning the indigenous methods, which were once an integral part of their households and agricultural lives (Khrishnan *et al.,* 2014).

Phokele and Sylvester (2015) wrote that most smallholder farmers who use indigenous postharvest practices and technologies celebrate postharvest activities. Smallholder farmers believed that postharvest celebrations bring luck in the next growing season (Phokele and Sylvester, 2015). However, Phokele and Sylvester (2015) do not specify what the postharvest celebrations entail but mention that these postharvest celebrations vary from farmer to farmer, from area to area, and depend on financial wellbeing. However, during these postharvest celebrations, there is an element of food sharing through communal feasting of the harvested produce. There may be a temporary relief and alleviation of food insecurity for

those food insecure individuals and households for that specific period in the area where the celebrations take place.

Indigenous marketing consists of selling agricultural produce, indigenous or otherwise, in local and urban markets to traders (collectors), directly to consumers, or to both traders and consumers (Lasimbang, 2008). Indigenous economic systems in rural areas help ensure the sustainable use of resources and enforce or strengthen social responsibility and harmonious relationships through cooperation (Lasimbang, 2008). Indigenous economic and marketing systems of agricultural produce, which are characterized by various small-scale economic activities, play a significant role in ensuring food security among rural smallholder farmers (Lasimbang, 2008). In the current study, indigenous marketing has been defined as the informal activity of selling surplus agricultural produce often within the local community, at barter centres and as street vendors often without any proper business or marketing planning and principles involved. Indigenous marketing differs from the more common social marketing approaches in that it is often characterised by little to no market research and advertising, focusses on the short term and does not aim to create or promote any social change (Kubacki and Szablewska, 2017; Lasimbang, 2008).

Lasimbang (2008) argued that the indigenous marketing systems of agricultural produce in rural Africa help ensure that resources are sustainably used and that these systems strengthen social responsibility and cohesion. Smallholder farmers earn an income and livelihood through their participation in indigenous marketing systems (Lasimbang, 2008). This enables them to acquire some of the other livelihood assets that would improve the sustainability of their livelihoods; which include purchasing the foods that the household does not produce, paying for the household expenses, purchasing better seeds, adopting more efficient post-harvest methods, obtaining an education and even adjusting field size and many more (Lasimbang, 2008; Masarirambi et al., 2010; NSFSL, 2006; Vorster, 2007).

The marketing channels of indigenous fruits and vegetables in Africa's rural areas are informal and poorly developed which tends to negatively affect the access of smallholder farmers to markets and therefore limiting their agricultural incomes and undermining the contribution of their agricultural practices and activities in terms of food and nutrition security (Lasimbang, 2008).

2.4. Indigenous Postharvest Technologies used in Smallholder Farming

Khrishnan *et al.* (2014) wrote further that a significant proportion of people and smallholder farmers use both the indigenous postharvest methods and modern postharvest techniques. There are a number of indigenous postharvest technologies used by smallholder farmers; these include pits, nested packaging (using dry leaves to package agricultural produce), fibre bags, wood ash, clay pots, barns, sand or coir baskets, and IK silos (El-Ramady, 2015; Masarirambi *et al.,* 2010; Notsi, 2012; Ofor *et al.,* 2010; Phokele and Sylvester, 2015; USAID, 2012). Pits were and are still used by primitive cultures and communities for storing various types of fruits and vegetables (El-Ramady *et al.,* 2015).

Pits are dug at the crop fields' edges, usually at the highest point in the field, especially in high rainfall regions (Ofor *et al.,* 2010). The pit is then lined with straw or other organic material and filled with the crop that is being stored, then covered with a layer of organic material followed by a layer of soil (Ofor *et al.,* 2010). However, the main disadvantages of using pits for storing harvested produce is the lack of ventilation; it prohibits the regular checking of produce that is in storage, and the direct contact that occurs between the stored produce heats up the produce and thereby cause the stored produce to begin to rot (Ofor *et al.,* 2010). The rotting of stored produce leads to produce losses which has negative implications for household food and nutrition security through its negative effects on food availability, access and stability. IK silos refer to traditional or indigenous structures used to store agricultural produce; these structures are developed and function as some form of decentralized storage (FAO, 2008; USAID, 2012). Early civilizations used silos, indigenous or otherwise, for the long-term storage of grain and various other agricultural produce (El-Ramady *et al.,* 2015).

Indigenous silos are not only used for storing agricultural produce or harvested crops, but they also provide for the correct and suitable environment for a proper ensiling process to take place (Ofor *et al.,* 2010). Therefore, it reduces postharvest crop and animal or livestock feed losses (FAO, 2008; Ofor *et al.,* 2010). However, the use of IK silos for storing agricultural produce may lead to losses of dry matter from crops and a significant deterioration of the crops' quality (FAO, 2008; Ofor *et al.,* 2010; USAID, 2012). FAO (2008) states that household silos, particularly metal silos, help to minimize postharvest losses, maintain the quality and safety of grains, and thus contribute to improving household food security, food utilization, human health, and nutrition.

IK silos, metal or otherwise, are cheap and easy to use, they help to prevent the attack or contamination of stored produce and animal feed by pests and rodents, and they often require very little space and can be put close to the household's home (FAO, 2008; Ofor *et al.,* 2010; USAID, 2012). Another significant advantage offered by IK silos is that they can be constructed on the agricultural fields' sides, saving significantly in terms of labour during harvesting and transportation (Indira Gandhi National Open University (IGNOU), 2006). Thus enabling the smallholder farmers to perform other activities including paid labour that would contribute towards the sustainability of their livelihoods and household food security. Wood ash can also be used to preserve or keep agricultural produce fresh, whereas the storing of sun-dried produce in bags or clay pots controls for pests and mould building (Notsi, 2012). There are several factors that influence the use of indigenous postharvest practices and technologies by smallholder farmers in rural areas, and these factors are discussed in detail below.

2.5. Factors Influencing the Use of Indigenous Postharvest Practices and Technologies in rural areas

Most smallholder farmers place a higher value on reducing risks than on maximising production; Hart and Vorster (2006) assert that smallholder farmers are more interested in optimising the productivity of scarce farm resources than in increasing land and labour productivity. Does this imply that reducing risk and optimising scarce resources' productivity are among the key factors influencing smallholder farmers' decisions regarding using indigenous postharvest practices and technologies? If yes, are these the only factors influencing the use of indigenous postharvest practices and technologies? It can be noted that smallholder farmers choose a particular agricultural technology and practice based on decisions made for the entire farming system, and not only based on a specific crop (Hart and Vorster, 2006; Ofor *et al.,* 2010).

Dube and Musi (2002) state that there are many factors that are barriers and enablers to the use of IK practices, but one has to ask themselves what are those factors? Ndwandwe (2013) concluded that the use of Indigenous knowledge practices is not based on access to finances but on smallholder farmers' perceptions of their effectiveness, confidence, and faith in the local practices. Age could be one of the factors influencing the use of IKS in postharvest; this can affect the sustainability of the linkages between IKS and food security since most of the

IK is held by the older generations who are less capable of physically implementing this knowledge, and they might die with this knowledge (Risiro *et al.,* 2013). Dlamini and Kaya (2016) and Risiro *et al.* (2013) asserted that the older generations are not willing to take risks with new or modern technologies and practices. But is it really because they are unwilling to take risks with the new technologies, or do they lack the knowledge and financial resources to acquire the new technologies? How can the retention and sustainability of IK be achieved in South Africa?

Dlamini and Kaya (2016) write that the younger generation of smallholder farmers has expressed willingness to integrate indigenous and modern technologies to improve production, reduce post-harvest losses, and enhance food preservation. According to Taremwa *et al.* (2016), the majority of smallholder farmers who use IKS perceive IKS to be more effective when compared to modern farming practices, technologies, and systems. Asogwa *et al.* (2017) and Taremwa *et al.* (2016) write that smallholder farmers emphasize that the use of IKS requires little investment; they are affordable, are easily manageable for low-income earners, and are simple. Asogwa *et al.* (2017) wrote that IKS employs technologies that smallholder farmers are familiar with.

Gender could also be one of the factors influencing the use of indigenous postharvest practices and technologies in smallholder farming systems. Kamwendo and Kamwendo (2014) argue that women's IK and skills on food security and postharvest issues often differ from those held by men, resulting in varying priorities for the use of IKS. Due to the difference between the IK and skills held by men and women on food security issues, the patterns of control, participation in different forms of agriculture, access, and indigenous knowledge use tend to be affected (Kamwendo and Kamwendo, 2014). It is asserted by Kamwendo and Kamwendo (2014) that women are more involved in subsistence farming while men are more engaged in commercial farming; and that more female smallholder farmers than males participate in postharvest operations.

Kamwendo and Kamwendo (2014) argue that traditional or indigenous postharvest food processing practices such as winnowing, seed selection, threshing, shelling, pounding, sun drying, cooking, and preserving food are mostly considered to be work that should be done by women. Kamwendo and Kamwendo (2014) suggested that women are more skilled and

are more involved in packing agricultural produce or products, particularly legumes and grains, than men. Taiwo *et al.* (1997) support this by stating that women play a major role in food processing, preparation, and preservation using indigenous technology.

However, it is important to mention that Kamwendo and Kamwendo (2014) kept referring to patriarchal societies to support their arguments on gender roles, mainly in postharvest agriculture, and the assumed differences regarding the IK and skills held by women and men. One may question and perhaps even doubt the relevancy, applicability, and truthfulness of such arguments to modern rural societies which are now more or less developed or in the process of developing and modernizing; in areas where access to information and training is not restricted to either men or women; and also because men and women are now viewed as equals under the law. More importantly, it should be asked what the implication of gender roles and differences in the use of indigenous postharvest practices and technologies is in terms of food and nutrition security?

Consideration of preharvest factors, such as the stage of maturity of the crops, disease and insect pressure, and weather or climatic conditions, may have an influence on the use of the different types of indigenous postharvest practices and technologies; since they greatly influence both the state of the crop at harvest and the crop's storage and nutritive potential, and may therefore influence smallholder farmers' decisions on which indigenous postharvest practices and technologies would be best suited for the postharvest handling of the harvested crops based on the state of the harvested crops (El-Ramady *et al.,* 2015; Hewett, 2006).

Education may potentially be another factor that influences smallholder farmers' decisions regarding the use of indigenous postharvest practices and technologies in rural areas. Phokele and Sylvester (2015) assert that people with high levels of education can make proper farming decisions compared to those with low or no education and that these people can read and interpret agricultural advisory information from the extension officers and other sources of indigenous knowledge. Access to agricultural extension services may influence the use of various postharvest practices and technologies in smallholder farming, including indigenous postharvest practices (Asogwa *et al.,* 2017; Mugwisi, 2016). Agricultural extension refers to the transfer of agricultural-related information, knowledge, and technologies between smallholder farmers, researchers, or agricultural workers (Mugwisi, 2016). Agricultural

extension services in South Africa are usually provided and managed by the Department of Agriculture. There are a number of effects or impacts of using indigenous postharvest practices and technologies in smallholder farming, and these have varying effects or implications for food security among smallholder farming households; these impacts are discussed in detail below.

2.6. The Effects of Using Indigenous Postharvest Practices and Technologies on Household Food Security

The primary purpose of using indigenous postharvest practices and technologies is to reduce as much as possible the rate at which agricultural produce deteriorates at postharvest (Phokele and Sylvester, 2015; Wills *et al.,* 1998). One has to ask themselves whether or not the indigenous postharvest practices and technologies employed by smallholder farmers achieve this purpose and how they impact the food security of smallholder farming households. Wills *et al.* (1998) write that a quantitative estimate of postharvest losses must precede any attempt to improve the postharvest practices and technologies. This may help estimate the impact of using IKS on food availability, utilization, access, stability, and overall food security. Wills *et al*. (1998) wrote that the quality of produce could not be improved or enhanced at postharvest, but that quality can only be maintained at postharvest.

Hart and Vorster (2006) noted that IK is adapted to local environmental conditions; this may lead one to assume that the indigenous postharvest practices and technologies are adapted to the local environmental conditions of where they are employed. Therefore, the physiological disorders identified by Wills *et al.* (1998), which arise from adverse postharvest environmental conditions, are minimised by using indigenous postharvest practices and technologies. Delays in placing produce in cool storage at postharvest often result in rapid deterioration in the quality of produce (Wills *et al.,* 1998). Mandisvika *et al.* (2015) and Masarirambi *et al.* (2010) argue that indigenous processing and marketing systems may be responsible for high postharvest food losses due to contamination and deterioration at postharvest, which thus imply that the use of such systems has a negative impact on the overall food security of those employing them.

High postharvest losses greatly reduce the agricultural productivity of smallholder farmers, which reduces their market access. Therefore, reducing the agricultural incomes and thus reduces both physical and financial access to food, which consequently results in reduced household food availability and utilization. This, thereby, negatively impacts the food security of smallholder farming households and those dependent on them for food and nutrition security. The negative effects of using indigenous postharvest practices and technologies on agricultural incomes and household food security greatly undermines the South African National Development Plan targets of reducing income poverty and ensuring household food and nutrition security by 2030 (National Planning Commission, 2011).

Phokele and Sylvester (2015) write that indigenous postharvest systems use contributes positively to food access by increasing the quantity and quality of the harvested produce available for household consumption and selling at the markets. Taremwa *et al.* (2016) argued that considering the indigenous knowledge systems, practices, and technologies in smallholder farming is likely to enhance smallholder farmers' livelihoods through incomes from food production, markets, and the overall local economy. This argument, thus, highlights the importance of using indigenous knowledge and technologies in terms of improving food security.

There is great potential for indigenous knowledge, practices, and technologies to contribute towards the attainment of food security since the livelihoods of the rural poor are dependent on them (Asogwa *et al.,* 2017). It is argued by Kamwendo and Kamwendo (2014) that women, through the use of indigenous postharvest knowledge, mainly that which is related to food storage and preservation, have contributed greatly to food and nutrition security. But does this argument suggest that the use of indigenous postharvest knowledge, practices, and possibly technologies is gender-based, and if yes, how do the impacts on food security through the use of indigenous postharvest knowledge, methods, and technologies by men differ from those that result through the use of such knowledge, practices, and technologies by women?

IK, including indigenous postharvest knowledge, is used by the poor and smallholder farmers to gain control of their lives, to maintain their cultural identity, and involves collective wisdom to mitigate food security-related challenges (Dlamini and Kaya, 2016). The use of indigenous

postharvest practices and technologies is highly recommended by Phokele and Sylvester (2015) to enhance food security and revitalize sustainable agriculture due to the perceived positive impacts on food accessibility.

During the Apartheid era, IKS and their practitioners were marginalized and suppressed, which negatively affected the development of South Africa's economy and society, which created the distortion of social, cultural, and economic development (DST, 2004). But what is the implication of this regarding food security at national, provincial, and local levels? Indigenous farming practices, including indigenous postharvest practices, are an ecologically tolerant and resilient crop production system as it optimises crop production security by adapting to the local environment, which helps to ensure that food supply, availability, access, and stability are ensured over time (DST, 2004).

Kaya (2016) characterises IK as the social capital of poor people and resource-poor smallholder farmers since this is the only asset they depend on for sustainable livelihoods in health, resource and environmental management, and food security. In some parts of Africa, smallholder farmers improve the quality of their food crops through the use of IK (Kaya, 2016). One has to question how smallholder farmers improve the quality of their food crops by using indigenous Knowledge when it has been argued by Hewett (2006) and Wills *et al.* (1998) that the quality of produce can only be maintained at postharvest, not improved or does this improvement occur before or during harvesting? But perhaps it is the quality of the final agricultural product that can be improved or that can be better preserved compared to agricultural products that are handled at postharvest using non-indigenous postharvest methods. The use of indigenous or traditional postharvest practices such as soaking, cooking, germinating, and fermentation can be used to improve the quality of legumes in terms of nutrition (Asogwa, 2017).

Improving the quality of food crops helps to enhance food utilization among those who can access and consume those food crops, which increases their food security. It can also help increase smallholder farmers' incomes by improving their access to markets since high-quality produce and products generally cost more than low-quality produce, which can enhance their access to other livelihood assets and resources and other food types that they do not produce themselves. Therefore, this can increase their diet diversity and thus improve their food and

nutrition security. Kamwendo and Kamwendo (2014) assert that IKS can assist in food preservation and storage, thereby leading to food security through the face of increasing natural disasters, weather, and climatic events by improving food stability.

Indigenous ways of food processing and preservation helps to improve food safety and preserve nutritional components that are beneficial to smallholder farmers and the consumers' nutritional and health status (Asogwa *et al.,* 2017; FAO 2008; Khrishnan *et al.,* 2014; UNIDO, undated; Wafula *et al.,* 2016). There are positive impacts on food security that may come from what can be termed 'indigenous value addition' in terms of agricultural produce; for example, the use of cauliflower leaves for human consumption either fresh or dried and using the stem of cauliflower as livestock feed (NSFSL, 2006). Asogwa *et al.* (2017) asserted that the use of indigenous food processing practices and technologies could help generate employment for women, and they can then earn an income from the use of the indigenous knowledge that they possess.

One has to wonder though about the effect of indigenous marketing systems of agricultural produce on food security and about the impact on the smallholder farming system caused by the existence of the middle man who, as suggested by the NSFSL (2006), buys produce from the smallholder farmers at low prices and sells to the consumers at the market at high prices. One could argue that since most indigenous postharvest practices are labour intensive and require manual labour, there may be a creation of employment opportunities which can therefore lead to an increase in household incomes; thus, access to food may be improved, and therefore food and nutrition security may be enhanced (IGNOU, 2006; NSFSL, 2006). There are several challenges that smallholder farmers face with regards to the access and use of indigenous (and modern) postharvest information and knowledge; these challenges are discussed in detail below.

2.7. The Challenges that Smallholder farmers face Regarding the Use of Indigenous (and Modern) Postharvest Information and Knowledge

Kaya (2016) asserted that even though women are custodians of IK for food security, their knowledge tends to be undervalued in research and policy development. This assertion may prompt one to question whether or not the undervaluing of the IK held by women impacts smallholder farmers' ability to access indigenous postharvest information. If it does, how can

this situation be rectified, and what is its significance in terms of food security? Asogwa *et al.* (2017) and Lwoga *et al.* (2011) argued that there are various challenges faced by smallholder farmers in managing their Indigenous Knowledge and in accessing external knowledge. These challenges range from personal and social barriers to using Information and communication technologies to poor recognition, infrastructure, policy, and weak linkages between research, agricultural extension services, and farmers (Asogwa *et al.,* 2017; Lwoga *et al.,* 2011).

The personal and social barriers that impact access to indigenous and external knowledge may include but are not limited to education, cultural beliefs and stereotypes, community politics, religious beliefs, and social groupings (Lwoga *et al.,* 2011; Zimu-Biyela, 2016). It has been argued that the influence of western culture and the changing status of women in society has negatively impacted the use of indigenous knowledge (Asogwa *et al.,* 2017). Smallholder farmers should be trained to capture and preserve their knowledge in different formats to prevent knowledge loss, including in oral, print and, Information and Communication Technology (ICT) formats (Lwoga *et al.,* 2011; Zimu-Biyela, 2016).

Asogwa *et al.* (2017) have argued that the lack of documentation has hindered IK's utilization and that the custodians of this knowledge are not willing to share this valuable information or knowledge. In 2004, South Africa adopted the IKS Policy, which recognizes, affirms, develops, promotes, and protects IKS in South Africa (DST, 2004). The DST (2004) argues that the absence of additivity in innovations in IKS, including in indigenous postharvest systems, means that IK remains rudimentary, and they attribute this relatively static nature of IK to the lack of mechanisms and incentives for sharing IK within and between IKS. The DST (2004) has stated that the creation of incentives for sharing IK needs to be the cornerstone of the South Africa IKS Policy.

This will therefore promote the sharing of IK, including indigenous postharvest information and knowledge within and outside smallholder farming systems, and will possibly increase the adoption of indigenous postharvest practices and technologies by smallholder farmers, which can therefore lead to either a positive or negative impact on their household's food and nutrition security. In South Africa, IKS information and knowledge, including indigenous postharvest information, can be accessed in various ways; in IKS databases, libraries, museums, in IKS Centres, in IKS Laboratories, and there are oral forms of IKS (DST, 2004;

Lwoga and Ngulube, 2008; Myeza and Kaya, 2016). One has to ask themselves whether or not poor smallholder farmers know about the above sources of IK, whether they have access to them, and are they able to use them effectively keeping in mind that most of the older rural smallholder farmers are illiterate, so are they able to access this knowledge in an easy to understand format?

Kaya (2016) and Taremwa *et al.* (2016) assert that IK is traditionally transmitted orally within and across communities and generations. Smallholder farmers, mostly women, also develop IK from their close interaction with the natural environment in collecting, producing, and post-harvesting various food crops for food and nutrition security (Kaya, 2016). But what is the exact indigenous postharvest information smallholder farmers, including the younger educated generation, and their household members have access to? Lwoga and Ngulube (2008) and Myeza and Kaya (2016) note that ICT assists in knowledge retention as they have a role to play in collecting, storage, sharing, transfer, dissemination, and retaining vital implicit and explicit knowledge, which tends to be at risk of loss.

Therefore ICT can be a vital tool in increasing the access of smallholder farmers to indigenous postharvest information; however, this will have to be preceded by the implementation of projects or programmes that aim to improve the training and access of smallholder farmers to ICT because local communities, as asserted by Myeza and Kaya (2016), often have no access to ICTs to meet the challenges of 21st Century and globalization. It is proposed that modern technologies such as email, mailing lists, newsgroups, discussion forums, and knowledge web blogs could be used to improve the access of smallholder farmers, particularly the young and educated generation of smallholder farmers to IK (Myeza and Kaya, 2016).

The older generation of smallholder farmers' access may be improved by conducting workshops and training sessions with them in their indigenous languages to ensure understanding. Adeniyi and Subair (2013) found, in a study on accessing Indigenous knowledge resources in libraries and the problems encountered by librarians managing IK in Oyo State in Nigeria, that IK resources are not represented adequately in libraries. Thus, this lack of adequate representation limits people’s access to such important knowledge across various fields of study, including information related to indigenous postharvest practices (Adeniyi and Subair 2013).

Anderson (2005) write that the key issues that are currently facing collecting institutions and people with regards to IK revolve around issues of ownership and access and that these issues exist because of the historical power dynamics that meant that Indigenous people and their cultures were studied and documented in unprecedented ways. Anderson (2005) writes further that in general, Indigenous people are not the legal copyright owners of the IK materials collected from them, which therefore means that they have very little say in how the material is used and accessed and may possibly be denied access to such information.

2.8. A Review of the Methodological Approaches Used on Other Studies

Phokele and Sylvester (2015), in a study of indigenous postharvest systems in Mamone Village, used the purposive sampling method for selecting their study area. They employed cluster random sampling to select five wards within the village in which data was collected. They randomly selected a sample size of 50 smallholder farming households who use indigenous postharvest activities from the five wards. Phokele and Sylvester (2015) used descriptive statistics found on the Statistical Package for Social Science (SPSS) to code, capture, and analyse their data.

Even though Phokele and Sylvester (2015) asserted that the use of indigenous postharvest systems is contributing to food accessibility, nothing in their results justifies this assertion. Phokele and Sylvester (2015) did not perform any association tests between the use of indigenous postharvest systems and impacts on food security; that is, they didn't attempt to identify causal or even existing relationships between using indigenous postharvest practices and food security. Dlamini and Kaya (2016), in a study of environmental security, indigenous knowledge systems and implications for food security in South Africa, used both primary and secondary data. Dlamini and Kaya (2016) employed a participatory and qualitative approach during the collection of the primary data during which interviews, focus group discussions, and participatory observations were conducted to interact with IK holders and practitioners while secondary data was collected through document analysis. Dlamini and Kaya (2016) used purposive sampling to select their sample population, and since the collected data was qualitative in nature, they used content analysis to analyse the data.

Risiro *et al.* (2013), in the study of the IKS in practice in the Zaka District of Masvingo, also used purposive sampling and informant interviews with an interview guide to collect primary data. Notsi (2012), during the study of African indigenous farming methods used in the cultivation of African indigenous vegetables, used a mixed-method and a comparative case study approach to collect and analyse the collected data; questionnaires, interviews, focus group discussions, photographic camera and voice recorder were used to collect data. Notsi (2012) examined the quantitative data using descriptive statistical analysis in SPSS, while the qualitative data was analysed using content analysis.

Notsi (2012) considered ethical issues such as permission, anonymity, consent, and confidentiality during the study, but no information was given to the sampling technique employed during the research study. Notsi (2012) recommends integrating modern intensive and indigenous farming systems in ensuring food security and nutrition in rural communities. In this study, a mixed-method approach using Participatory Rural Appraisal (PRA) was adopted. Purposive sampling was used to select a sample size of 120, which is much larger than the sample used by Phokele and Sylvester (2015). A focus group discussion, structured and semi-structured interviews, direct field observations, and questionnaires were used to collect data. PRA is "a more extended process that involves not only the collection of information but also its eventual use by the community as it plans further activities" (Freudenberger, undated).

An interview refers to a process through which the researcher asks the population of interest questions and uses his/her best judgement in probing beyond the superficial to get at crucial information that will be of use in data analysis to meet the specific or main objectives of the study (Freudenberger, undated; Tracy, 2020). A focus group discussion refers to a type of qualitative research data collection method in which a group of people, smallholder farmers in this case, are asked about their attitudes towards a product or practice, their perceptions, beliefs, and perspectives to create a meaningful understanding of their situation (Howitt, 2019; Kumar, 2011; May, 2011; Mishra, 2016; Oliver, 2010).

A direct observation refers to a data collection tool that enables the factual determination of what is going on in the area and allows the observer to gain first-hand knowledge of how the project or activity is being executed or implemented (Howitt, 2019; Ile et al., 2012). Howitt

(2019) and Kumar (2011) refers to an observation as a purposeful, systematic, and selective way of watching and listening to an interaction or phenomenon as it happens. A survey is a tool that generates information by tracking a range of characteristics of the selected population, mainly by administering or using questionnaires to collect the required data (Ile et al., 2012; Tracy, 2020). A questionnaire refers to a written list of questions, the responses or answers to which are recorded by the respondents, and thus it is important to ensure that questions in a questionnaire are straightforward and easy to read and understand (Kumar, 2011; Tracy, 2020).

Although Dlamini and Kaya (2016), Kamwendo and Kamwendo (2014), and Phokele and Sylvester (2015) stated that the use of IK positively impacts on food security; none of them during their studies used any food security measurement tools to directly measure the impact of using indigenous practices and technologies on food and nutrition security. The Household Food Insecurity Access Scale (HFIAS) was used during this study to directly measure food access or lack thereof. The HFIAS refers to a simple tool that measures household food security, with a key focus on food consumption strategies adopted by households when facing a lack of access to food (Coates *et al*., 2007). The HFIAS tool can show how families eat when having limited resources to acquire food to meet their dietary needs (Coates et al., 2007; Jones et al., 2013; Pangaribowo et al., 2013). During data collection for this study, questions relating to the other food security dimensions of food availability and utilisation were asked, both in the questionnaire and during the focus group discussions. Data collection and analysis in this study, similar to Phokele and Sylvester (2015), was based on research objectives and questions.

2.9. Summary

This chapter provided a detailed description of the concepts of IKS, smallholder farmers, postharvest, and food security. There are many arguments about the importance, reasons for use, and impacts of using indigenous postharvest practices and technologies on the food security of smallholder farming households. There are various indigenous postharvest practices and technologies used in smallholder farming in South Africa, Africa and in many other parts of the developing world. The use of these indigenous postharvest practices and technologies is influenced by a number of factors. The effect of using indigenous postharvest

practices and technologies in smallholder farming varies from farmer to farmer, depends on the practice and technology employed and on the type of crop being handled as well as the pest management practices employed. IKS information and knowledge, including indigenous postharvest information, can be accessed in various ways. The use of indigenous postharvest practices and technologies is likely to significantly impact the livelihoods, food access, food storage and processing, and food security of smallholder farmers in South Africa.

CHAPTER THREE: METHODOLOGY

3.1. Introduction

The chapter outlines the research design adopted for the study. The sampling techniques and the sample size, data collection, and data analysis procedures adopted in the study were also presented in this chapter. The study aimed to investigate the indigenous postharvest technologies and practices used in smallholder farming systems and their impact on food security.

3.2. Methodological Approach

A multi-method approach to research was used to collect and analyse the research data; thus, quantitative and qualitative methods were employed (Appendix 10). A multi-method approach to research was adopted because it enables the examination of all the different aspects of the research question and the way these aspects relate or interact with each other, and therefore ensuring greater validity of the collected data and findings (Bickman and Rog, 2009; Clark and Ivankova, 2015; Creswell, 2014; Oliver, 2010). Combining qualitative and quantitative methods reduces the potential chances of biases resulting from using only a single method (Creswell, 2014; Oliver, 2010). Participatory Rural Appraisal tools, observations, questionnaires, structured and unstructured interviews were conducted during data collection.

Descriptive statistics were used to summarise and present data in a logical form and identify relationships between the variables in the data (Oliver, 2010). The research methodology for this study was guided by the developed conceptual framework (Figure 1). The conceptual framework shows five variables that were identified as essential for responding to the research question. The assumed relationships and connections between the identified variables are presented in Figure 1. The five variables are food security, IKS, smallholder farming, access to postharvest information, and postharvest practices. The conceptual framework for this study was developed by understanding the research problem and the review of relevant literature.

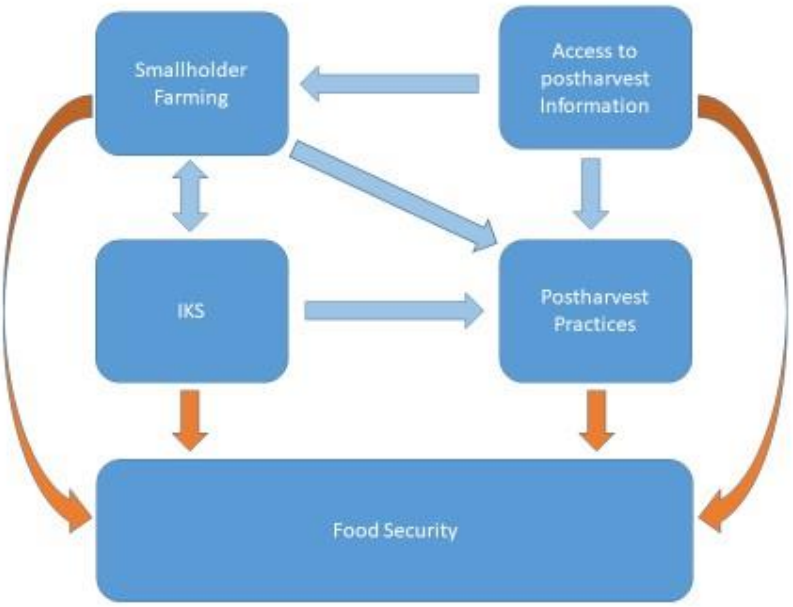

Figure 1. Conceptual framework for this study, clearly depicting the relationship between the different variables investigated during this study.

The conceptual framework above shows that food security is affected by the IKS, smallholder farming, access to postharvest information, and postharvest practices. Having access to postharvest information influences the knowledge base of smallholder farmers, it influences their decisions in terms of using or not using the various postharvest practices known to them and can lead to them incorporating the new information or knowledge to the postharvest practices they currently employ, and they may even develop new postharvest handling methods and technologies. The use of postharvest handling methods can positively or negatively impact household food security, depending on the nature of their influence on the deterioration of produce at postharvest (Asogwa *et al.,* 2017).

Given that the indigenous postharvest information obtained or possessed by smallholder farmers contribute to improved crop production, processing, storage and reduced postharvest losses; food security may be improved through increased food availability, access and stability. However, if the use of the indigenous postharvest information or knowledge leads to increased postharvest losses, decreased crop productivity and compromised storage; food security may be negative affected through reduced food availability and access, and may

even reduce the incomes that smallholder farmers obtain from the marketing of their surplus produce.

3.3. Description of the study area

This study was conducted in Maqongqo (Figure 2), a rural residential area located in Ward 1 within the Mkhambathini Local municipality. Ward 1 is the one with the highest population among the seven wards comprising Mkhambathini Local Municipality (Mkhambathini Municipality, 2016). The study area is geographically located at -29.581631^0 S and 30.579739^0 E and is composed mainly of African people. Maqongqo is located about 23,1 kilometres away from Pietermaritzburg. According to the Mkhambathini Municipality (2016), only 8% of the Mkhambathini Local Municipality population is above the age of 60. These are the people who are said to be the main custodians of IK (Mahlangu and Garutsa 2014).

Many people in Maqongqo are involved in smallholder farming, with commercial and subsistence agriculture being identified in the Mkhambathini Municipality (2016) as one of the strengths of the municipality. Smallholder farming is assumed to contribute significantly to household food security for those that are involved (Mahlangu and Garutsa, 2014; Masarieambi *et al*., 2010). Mkhambathini municipality is faced with a number of challenges that have consequences regarding food security; these challenges include high levels of unemployment, poverty, and inequality, and the municipality experiences very low economic growth (Mkhambathini Municipality, 2016).

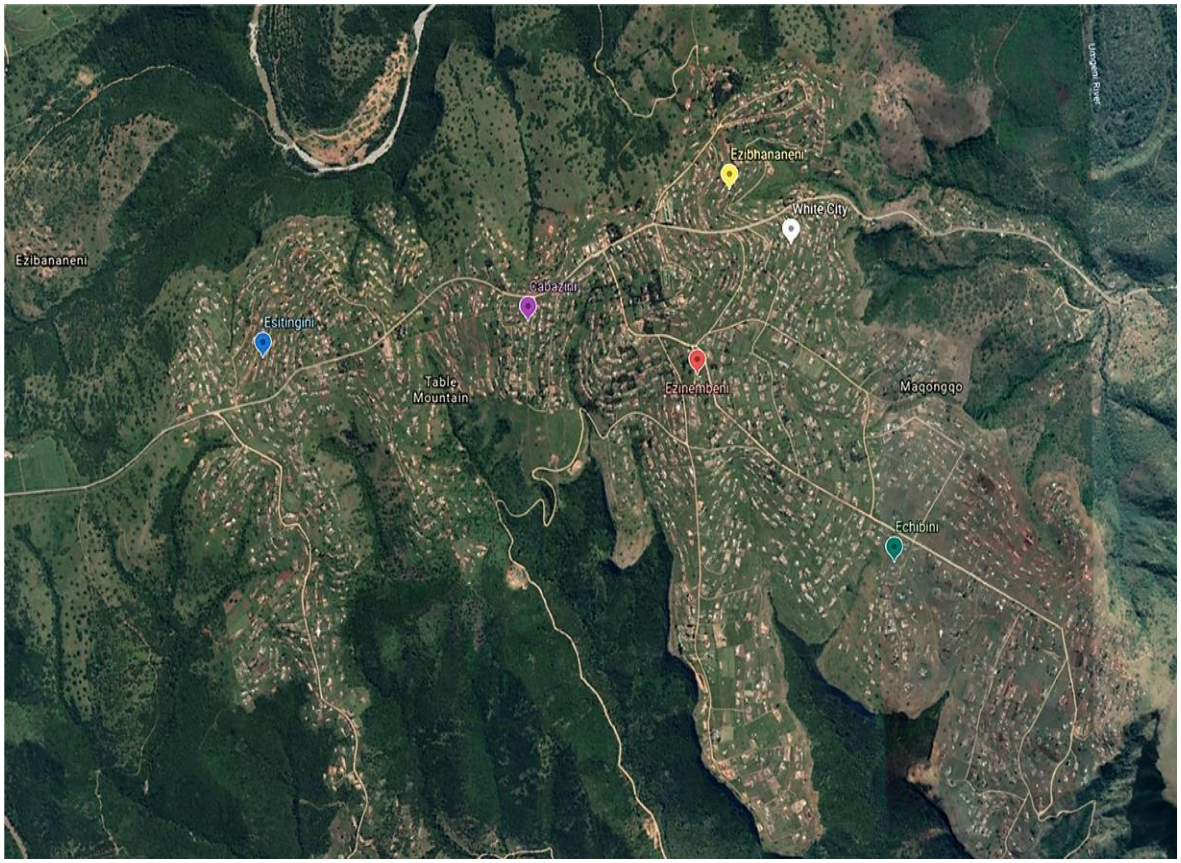

Figure 2. Aerial map of Maqongqo, Mkhambathini Local Municipality.

3.4. Sampling technique

Based on budgetary constraints and the argument by Matata *et al.* (2001) that a sample size of 80 to 120 people is adequate for most socio-economic studies in Sub-Saharan Africa, a total of 120 purposive participants participated in this study. These participants were selected based on the criteria that they are smallholder farmers who reside within Maqongqo, perform their farming practices within Maqongqo, and farm on land that is less than 2 hectares. A purposive sample is one which occurs when the selection of the sample population is made according to known characteristics (May, 2011; Oliver, 2010).

3.5. Data Collection Instruments

Prior to data collection, a number of activities were done to ensure that data collection within the study area would be possible, these activities included the identification of the necessary data to collect, the preparation of data collection instruments, obtaining ethics approval from the University of KwaZulu-Natal, obtaining approval to conduct research from the Ward

Councillor and Committee in Maqongqo, one site visit was conducted prior to data collection to enable the researcher to get familiarity with the study area and identify specific sub-areas to collect data from, recruiting and training of two enumerators who assisted during data collection (field work), and the questionnaires were pre-tested before being administered for the actual study using a sample of eight smallholder farming households in Copesville, which is an urban area that is located within the Msunduzi Municipality in Pietermaritzburg.

The purpose of pretesting was to evaluate the time taken to complete the questionnaire, clarify the questionnaire questions, and eliminate ambiguities or difficulties in wording and presentation. A number of methodologies and research instruments were applied in this study to ensure methodological triangulation, which helped to ensure that greater validity in the data and findings is achieved. Research data collection instruments are all the tools used during the research process to collect the necessary data on the sample population (May, 2011; Oliver, 2010). With regards to data collection, Participatory Rural Appraisal using a focus group discussion, semi-structured and unstructured interviews (with audio tapes) were held with the smallholder farmers, Household Food Insecurity Access Scale (HFIAS), direct observations, and surveys were used to collect essential data from the sample population.

A combination of open-ended and closed-ended questions during the interviews and in the administration of questionnaires were used to ask smallholder farmers whether they use indigenous postharvest practices to find the extent of the use of indigenous postharvest practices and their impact on household food security. Focus group discussions were conducted to obtain in-depth qualitative information on the effects of using indigenous postharvest practices on household food security among those employing them. Focus group discussions are considered an efficient research instrument because the group context sessions create an environment within which the participants, smallholder farmers in this context, can reveal their experiences and ideas (Howitt, 2019; May, 2011). Both the interviews and focus group discussion were conducted in IsiZulu.

A ‘non-participant’ observation was performed during this study. This type of observation occurs when the researcher does not get involved in the group's activities being researched but remains a passive observer, watching and listening to its activities and drawing conclusions from this (Kumar, 2011; Tracy 2020). Direct observations in this study were

electronically recorded in picture formats; this helped ensure that the observations could be viewed numerous times before they were analysed (Kumar, 2011). The food security status of smallholder farmers and their households in this study was measured using the HFIAS.

The HFIAS sums the responses to 9 questions that are related to the four domains of food security, including 4-level frequency response questions (Coates *et al.,* 2007). A score from 0 to 27 is obtained and may be categorized into a 4-level variable or categories which are 'food secure', 'mildly food insecure', 'moderately food insecure and severely food insecure (Coates *et al.,* 2007; Jones *et al.,* 2013; Pangaribowo *et al.,* 2013). It measures food security in terms of anxiety, physical availability and access, food quantity, and economic access at household and regional levels (Coates *et al.,* 2007; Jones *et al.,* 2013; Pangaribowo *et al.,* 2013). The HFIAS was used to measure the food access of smallholder farming individuals and households in Maqongqo, and it was, to an extent, used for the estimation of food availability within the smallholder farming households.

Trained enumerators recorded most responses to the questionnaires in this study because some of the smallholder farmers could not read or write properly, which helped ensure that the survey was completed timeously and quicker. The survey period was between March and May 2020. In total, 120 questionnaires, written in English but administered in isiZulu, were completed in Maqongqo. The questionnaire covered all the specific objectives of the study and had questions about the respondents' socio-economic demographics, about smallholder farming in general, about indigenous postharvest practices and technologies employed in smallholder farming, and the effect of using indigenous postharvest practices and technologies on food security and sustainable livelihoods. Also, questions relating to the challenges smallholder farmers face regarding accessing and using indigenous postharvest practices and technologies. This study's research data was collected in line with the research objectives to find answers to the key research questions and objectives.

3.6. Data Analysis

Descriptive Statistics (including frequencies, means, Cross-tabulations), correlations, Chi-square, Fisher's exact and Independent Samples T-Tests found in the Statistical Package for Social Sciences (SPSS) version 27 were used for data analysis to summarize and analyse the

quantitative data. Foster (1998) has warned that there is a practical risk that the data interpreter may obtain masses of output, which overwhelm your ability to interpret and understand them. A codebook, which summarizes the instructions used to convert the collected data into a format that SPSS can understand, was prepared before all the data collected from questionnaires and interviews is entered into SPSS (Pallant, 2010). The collected data was coded and entered into SPSS for statistical analysis. The collected and captured data was screened and cleaned before data analysis. Descriptive statistics were used to identify connections between variables in the quantitative data.

Descriptive statistics were used to determine the proportion of smallholder farmers using various Indigenous postharvest practices and technologies. Cross tabulations, Chi-square tests, Fisher's exact tests, Cramer's V tests, and independent samples t-tests were done on some variables to check for any relationships. Cross-tabulations, Fisher's exact tests, Independent samples t-tests, Cramer's V tests, and chi-square tests were used to identify the other factors influencing the use of indigenous postharvest practices and technologies and determining the effects of using indigenous postharvest practices and technologies on household food security.

A chi-square test is common when testing whether or not there is a relationship between categorical variables, namely nominal and ordinal variables (Mukwedeya 2018). The Chi-Square test does, however, give inaccurate results when analysing data with expected values that are small, that is, if there is an expected value or number that is less than 5 (McDonald 2014). GraphPad (2020) and McDonald (2014) advised that the Fisher's exact test of independence be used when the sample size and expected numbers per cell are very small and when analysing two nominal variables for differences or independence.

The Fisher's exact test tends to be more accurate than the Chi-square test when expected values are minimal, mainly when one or more of the expected values are less than 5 (GraphPad 2020; McDonald 2014; Simple Interactive Statistical Analysis (SISA) undated). Hence, the Fisher's exact test was used for testing independence amongst variables when the chi-square test's assumptions were not met; that is when the values or frequency for some cells was less than 5. SISA (undated) stated that the Fisher's exact test works very similarly to the Chi-square test. During data analysis, the indigenous postharvest practices and

technologies used by smallholder farmers were manipulated or transformed based on their function at postharvest to form four categories.

These categories were indigenous processing, indigenous storage, indigenous marketing, and indigenous pest control. These categories were used for performing statistical tests, including Chi-Square tests, Fisher's exact test, and independent samples t-tests. However, two of these categories, namely indigenous processing and indigenous storage, did not meet any of the above statistical tests' assumptions. Hence, they were excluded from the analysis of the categorised indigenous postharvest practices and technologies. Therefore, the Chi-square tests, Fisher's exact test, and independent samples t-tests were conducted only for those variables meeting the requirements of these tests, namely indigenous pest control and indigenous marketing. Fisher's exact test of independence was used for determining the other factors that influence the use of indigenous postharvest practices and technologies.

Cramer's V tests were used for testing whether there is an association between the smallholder farmers' household's socio-economic variables, food security (particularly food access), and indigenous postharvest practices. Although Cramer's V is usually used to measure the association's strength between nominal variables, some researchers do use Cramer's V for ordinal and grouped data (Frey, 2018). Van Den Berg (2020) wrote that Cramer's V should be used when determining the strength of the association between ordinal and nominal variables, which are categorical variables. Thus, this was done during the analysis of data in this study. Similar to chi-square, Cramer's V measures the strength of the relationship between nominal and ordinal variables but differs from chi-square in that it eliminates the sample size and its effects when measuring the strength of the association (Kearney, 2017; Liebetrau, 1983).

The household's food security (food access) status was obtained from the results of the HFIAS. Coates *et al.* (2007) recommend that the HFIA Prevalence be reported in addition to the average HFIAS Score during the analysis of HFIAS data. Content analysis, which Kumar (2011) defines as the analysis of the content of interviews and field observational notes in order to identify emerging themes, was applied to all data collected from open-ended questions on questionnaires, focus group discussions, observations, and key informant interviews to identify themes, concepts, trends, and patterns. The open-ended questions from the

questionnaire and focus group discussions were analysed for the occurrence of common themes.

Four main steps were followed during content analysis, as suggested by Kumar (2011). First, the main themes were identified, then codes were assigned to the main themes, then responses under the main themes were classified, and finally, the identified themes and responses were integrated into the text of the research report. Coding, which is a process of gathering material or information by theme or subject or topic, was employed for the qualitative data, including responses to open questions found in questionnaires. The conclusions from the separate qualitative and quantitative results were compared for similarity and were both used to explain the study's findings and conclusions.

3.7. Ethical Considerations

It is stated that ethical issues are omnipresent in any kind of research (Orb *et al.,* 2001). In research, there is often a conflict between the goals of the research to make generalisations for the greater good of people and the participants' rights to maintain privacy (Fouka and Mantzorou, 2011; Orb *et al.,* 2001). Ethics, in this case, would refer to doing good and avoiding (or reducing) harm. Participants' desire to participate in a study is influenced by their willingness to share their personal experiences (Orb *et al.,* 2001). There are a number of ethical principles that must be adopted when conducting research; these include autonomy (which considers the respect for people as the recognition of the rights of the participants), beneficence (which refers to doing good for other people and avoiding harm) and justice, which relates to fairness, equity, avoiding exploitation and abuse of the research participants (Fouka and Mantzorou, 2011; Kumar 2011; Orb *et al.,* 2001).

This research study adopted all the principles stated above, and an ethical clearance was obtained from the researcher's institution based on the research tools and questions asked. The study participants were briefed about the study's key aspects (including its main objectives and the methodology employed or adopted to achieve those objectives) to ensure that smallholder farmers were informed about the study. The participants' right to decide whether or not to participate in the study and their rights to withdraw from the research study at any time without punishment was recognised; thus, consent was sought prior to data

collection. The identity of all the participants in this research study was also be protected. It is crucial to note that “Clear plans must be in place to address particular needs that may arise during the course of any research but which may lie outside the researcher’s knowledge, skills or expertise, bearing in mind the need for confidentiality” (Canterbury Christ Church University (CCCU), 2006).

3.8. Summary

In this chapter, a brief overview of where the study took place was presented. This chapter focused on discussing the research methodology employed in this study and discussed research design, research data collection instruments, data collection techniques, sample and the sampling technique that was used, data analysis techniques and tools, ethical considerations, and the limitations of this study.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Introduction

The study investigated the indigenous postharvest practices and technologies used in smallholder farming systems and their impact on food security. The study was conducted in Maqongqo, Mkhambathini Local Municipality in KwaZulu-Natal. Qualitative and quantitative research was used to collect and analyse the research data; thus, both quantitative and qualitative methods were employed. SPSS version 27 was used to analyse the research data. This chapter presents the study's findings, and the results are discussed in relation to the specific objectives.

4.2. Respondents socio-economic demographic information

An overview of the socio-economic demographic characteristics of the smallholder farmers who participated in this study is presented in the section. Smallholder farmers' gender, education level, employment status, household incomes and sizes, and farming experiences are discussed briefly below.

4.2.1. Gender of respondents

In this study, 75.8 percent of the smallholder farmers were female, while 24.2 percent were male, suggesting that more women than men engage in farming. This finding is consistent with Kalungu *et al*. (2013), who found that more women than men get involved in agricultural activities. Maziya *et al*. (2017) found that more female-headed households are engaged in crop farming than male-headed households. Kamwendo and Kamwendo (2014) argued that engagement in postharvest activities is gender-related.

4.2.2. Size of household and age of respondents

Table 1 shows the descriptive statistics of the household size and age of smallholder farmers. The youngest smallholder farmer was 20 years old, the average age of the respondents was 56 years, and the oldest smallholder farmer interviewed was 82 years old. Age has been identified as a factor that influences the use of IK in smallholder farming (Risiro *et al.,* 2013). Depending on the situation at hand, age may affect the decision to adopt or use indigenous

postharvest practices and technologies. Dlamini and Kaya (2016) argued that IK is held by the older generations who are less capable of physically implementing it. Thus, the elderly are less able to use the IK that they have to influence and impact their livelihoods and food security. This study found that most of the smallholder farmers were among the elderly.

The smallest household had one person, and the largest household had seventeen people. The average household size was six people. Household size may potentially have negative implications for food security (Maziya *et al*., 2017). Logic would suggest that the larger households need more resources to sustain; these resources include food, which may limit capital investments on modern agricultural practices and technologies, thereby promoting the use of indigenous agricultural practices, including at postharvest.

Table 1. Size of smallholder farmer's household and age of respondents

Variables	Minimum	Maximum	Mean	Std. Deviation
Age (Years)	20.0	82.0	56.1	13.3
Household Size	1.0	17.0	6.0	3.4

4.2.3. Level of education

The results show that 19.2 percent of smallholder farmers had no formal education, 40.8 percent had primary education, 35.8 percent had secondary education, and 4.2 percent had tertiary education. A large proportion of the smallholder farmers in Maqongqo had access to formal education. Formal Education has been considered to be among the reasons that influence the use of indigenous postharvest practices and technologies, where those with high levels of education could make informed farming decisions and are more prone to using modern practices and technologies given that they can afford to implement them (Phokele and Sylvester, 2015).

In a study of indigenous postharvest systems in Mamone village in Limpopo Province, Phokele and Sylvester (2015) found that 26 percent of the smallholder farmers had no schooling, and 20 percent had tertiary or post-secondary education. These proportions are higher than those found in the current study. Phokele and Sylvester (2015) found more illiterate smallholder farmers than in the current study. A large proportion of smallholder farmers in both studies

employed indigenous postharvest practices and technologies, regardless of whether or not they had received formal schooling.

4.2.4. Employment status

In this study, 11.7 percent of the respondents had full-time employment, 7.5 percent were employed part-time, 30.8 percent were unemployed, while 49.2 percent were pensioners, and 0.8 percent were self-employed. Employment status determines an individual's access to income (off-farm income), thus determining their access to food and the type of farming practices and technologies they can adopt in their smallholder farming activities (Lasimbang 2008). The results show that most of the smallholder farmers in Maqongqo relied on pensions for income, mostly from old age grants.

4.2.5. Smallholder farmers' household income

The results show that 0.8 percent of the households receive a monthly income below R800, 8.3 percent receive an income between R801 and R1500, 45.8 percent receive an income between R1501 and R3500, and 45.0 percent receive an income above R3500. Kitinoja and Gorny (1999), Lasimbang (2008), NSFSL (2006) asserted that having access to sufficient income and the level of income that smallholder farmers receive influences their use of indigenous practices and technologies.

From the Focus Group Discussion (FGD), smallholder farmers stated that low household incomes due to unemployment and lack of adequate access to markets influenced their decision to use indigenous postharvest practices and technologies instead of expensive modern (mechanised) practices and technologies (Appendix 6). The wealthier households that receive higher incomes have a higher capacity to adopt new agricultural technologies (Taiwo *et al.,* 1997). Hence, they are more likely to use modern postharvest practices and technologies than indigenous postharvest practices and technologies, or even a combination of the two.

During the FGD, a smallholder farmer indicated that the low household incomes, due to unemployment and lack of adequate access to markets, led them to use the indigenous postharvest practices and technologies instead of expensive modern, mechanised practices and technologies (Appendix 6). However, a Cramer's V test between the use of indigenous

postharvest practices and technologies and household income resulted in no statistically significant association between household incomes and the use of indigenous postharvest practices and technologies.

4.2.6. Farming experience

Regarding the smallholder farmers' farming experience, 18.3 percent had farming experience between 1 and 5 years, 15.8 percent had farming experience between 6 and 10 years, and 5.8 percent had farming experience between 11 and 15 years. While 5.8 percent of smallholder farmers had farming experience between 16 and 20 years, 9.2 percent had farming experience between 21 and 25 years, and 45.0 percent had a farming experience that is more than 25 years. Farming experience may be among the factors that influence the use of indigenous postharvest practices and technologies.

The more experienced and invariably older smallholder farmers may be considered more likely to use indigenous postharvest practices and technologies as they are more knowledgeable and familiar with them and are likely to possess more indigenous knowledge, including indigenous postharvest practices and technologies (Asogwa *et al.,* 2017). However, Fisher's exact tests found no statistically significant differences in terms of farming experience between the users and non-users of indigenous pest control and indigenous marketing.

4.3. Accessing information about Indigenous postharvest practices and technologies

Smallholder farmers' access to indigenous and external knowledge depends on many personal and social barriers and enablers (Lwoga *et al*., 2011). Having adequate access to information, including indigenous postharvest information, may impact its eventual adoption. Women and their changing status in society have adverse effects on the utilization of indigenous knowledge (Asogwa *et al*., 2017). The various ways through which smallholder farmers access information about indigenous postharvest practices and technologies, and their eventual adoption, are presented and discussed below.

4.3.1. Ways smallholder farmers use to access information on indigenous postharvest practices and technologies

It is stated in the South African National Development Plan that all people in South Africa should have the ability to effectively acquire and use knowledge, this includes indigenous knowledge (National Planning Commission, 2011). There were a number of different sources utilised by smallholder farmers to obtain indigenous postharvest information. Smallholder farmers' access to information about the various indigenous postharvest practices and technologies is essential because they cannot adopt them without information about these indigenous practices and technologies. Local people (96.7 percent) are the main sources of indigenous postharvest information. Mugwisi (2016) found that books and agricultural workshops were utilized by 51.2 percent and 49.4 percent, respectively, as the main sources of indigenous knowledge and information in Zimbabwe. This is higher than the proportion of those who used books (library) in the current study. None of the smallholder farmers that participated in this study had participated in agricultural workshops.

In this study, 3.3 percent had accessed the indigenous postharvest information from a formal education facility, including the library. In comparison, 1.7 percent accessed the indigenous postharvest information from social media and social groupings, and the other 1.7 percent accessed the indigenous postharvest information through agricultural extension services. Mugwisi (2016) also found that there were other sources utilised for accessing indigenous information, such as social gatherings, farmer groups, and village meetings. The results show that 5.0 percent of the smallholder farmers used other sources to access indigenous post-harvesting information. The other sources included commercial farmers that the smallholder farmers used to work for, for example, Zakhe (Burnfield Farm).

Smallholder farmers were also taught informally by colleagues who were knowledgeable about farming. Mugwisi (2016) stated that indigenous knowledge is accessed from several sources, which could be formal or informal, which is consistent with the findings of the current study. However, several factors could hinder the access of smallholder farmers to indigenous knowledge and information. Such factors include their level of education, challenges with regards to accessing and using information and communication technologies such as cellular

phones and computers, community politics, and the social groups to which smallholder farmers belong (Lwoga *et al.,* 2011).

Cell phone ownership and use are widespread among smallholder farmers in Maqongqo, including among the elderly. Some 85.0 percent of the farmers owned a cellular phone. Still, only 15.0 percent of them used their cellular phones to access and share information on indigenous practices, including indigenous postharvest information. The findings indicate that the use of ICT in accessing and sharing information about indigenous practices and technologies is underutilised. According to the Mkhambathini Municipality (2016), substantial progress has been made to deliver infrastructures such as electricity and telecommunication infrastructure. Nevertheless, these services' provision remains one of the challenges facing the Mkhambathini Municipality (Mkhambathini Municipality, 2016).

From the Field observations, it was observed that cellular phones among smallholder farmers in Maqongqo were limited to socializing and maintaining family relationships and friendships. Recent studies suggest that using ICT can assist in knowledge retention as they have a critical role to play in managing vital implicit and explicit indigenous agricultural and non-agricultural knowledge, which tends to be at risk of loss (Lwoga and Ngulube 2008; Myeza and Kaya 2016). Myeza and Kaya (2016) argued that the use of ICT in increasing smallholder farmers' access to indigenous agricultural information would have to be preceded by the implementation of projects to improve the training and access of smallholder farmers to the several forms of ICT, including cellular phones, which they already have, computers, internet, and its uses and more.

There is a need, therefore, to educate smallholder farmers about the potential of incorporating ICT in their farming practices, particularly with regards to the attainment and sharing of indigenous information. This would help contribute towards the sustainability of indigenous knowledge and information, including information about indigenous postharvest practices and technologies. Lwoga *et al.* (2011) stated that smallholder farmers should be trained to capture and preserve their knowledge in multiple ways, including oral, print, and ICT formats.

4.3.2. Promoting the use of indigenous postharvest practices and technologies.

Several strategies could be employed to encourage the use of indigenous postharvest practices and technologies in Maqongqo. A large proportion (90.8 percent) of the respondents believed that the government should employ or implement projects and programmes that aim to promote the access to and use of indigenous postharvest practices and technologies in smallholder farming. Of the smallholder farmers that suggested that the use of indigenous postharvest practices and technologies could be promoted by the government employing policy measures to encourage its use, 86.6 percent were unaware that there was already an IKS policy employed in South Africa.

Of the respondents, 91.7 percent suggested that the provision of IKS education in their indigenous language could increase the use of indigenous postharvest practices and technologies. Another 86.7 percent believed that improving access to indigenous information and technologies could be employed. In this study, 37.5 percent of the respondents said that the development of IKS libraries or centres in their communities could be one way to promote the use of indigenous postharvest practices and technologies. Some 95.0 percent of the respondents recommended promoting the sharing of indigenous postharvest information and technologies within or between communities to encourage the use of indigenous postharvest practices and technologies.

Only 5.0 of smallholder farmers suggested other strategies such as schools teaching people on indigenous ways of living, including indigenous farming practices to ensure that rural people can produce adequate food for themselves and possibly earn an income. One farmer pointed that “government should provide us with people who will teach us about ways of effectively handling produce and using indigenous postharvest practices and technologies, and show us how we could effectively integrate modern postharvest practices and technologies and the indigenous practices” (Appendix 7). Asogwa *et al.* (2017) suggested that the use of indigenous knowledge, including information about indigenous practices, technologies, and foods, could be improved by providing adequate ICTs in libraries to make indigenous information and knowledge accessible.

4.4. The indigenous postharvest practices and technologies used in smallholder farming

There is potential for the use of indigenous knowledge, practices, and technologies to contribute towards food security, minimization of postharvest losses, and the sustainability of the livelihoods of the rural poor smallholder farmers (Asogwa *et al*., 2017; Mandisvika *et al.,* 2015; Masarirambi *et al*., 2010). The results presented in the sections below include findings on the crops produced by smallholder farmers, indigenous postharvest practices and technologies used, the factors influencing their use, and the impacts of using indigenous postharvest practices and technologies on food security.

4.4.1. Crops produced by the smallholder farmers in Maqongqo

Table 2 shows the main crops that smallholder farmers in Maqongqo produce. Grains (mainly maize) are produced by 97.5 percent of smallholder farmers, roots and tubers (beans, sweet potatoes, potatoes, yams) are produced by 93.3 percent of the smallholder farmers, while

64.2 percent of the smallholder farmers produce various types of vegetables, 11.7 percent of them farm fruits and only 5 percent of the smallholder farmers farm other types of crops which included curry leaves tree (*Murraya koenigii*), mint and peanuts. The smallholder farmers in the current study identified crop type to be among the factors that influenced their use of indigenous postharvest practices and technologies.

Table 2. Main crops that are produced by smallholder farmers in Maqongqo

Crop types	**Percent (n = 120)**
Grains	97.5
Roots and tubers	93.3
Vegetables*	64.2
Fruits	11.7
Other	5.0

* leafy vegetables, brinjal, pepper, beetroot

4.4.2. Use of indigenous postharvest practices and technologies in Maqongqo

Smallholder farmers in this study described indigenous knowledge as the knowledge possessed and used by local, rural people, and that is practiced by them, and people like them that is they come from a similar tribe, race, cultures, and more, or by people living in similar conditions to theirs (Appendix 6). One smallholder farmer described indigenous knowledge as "the knowledge of our forefathers that has been passed down from generation to generation. This knowledge encompasses a wide range of areas, including farming and the various ways through which we handle crops and harvest" (Appendix 6). There are many indigenous postharvest practices and technologies used by smallholder farmers in rural South Africa in their smallholder farming activities.

These practices were and are being practiced in Maqongqo by smallholder farmers mainly to preserve their produce; to minimize losses due to spoilage, prevent insect infestation, reduce losses caused by animal invasions, and preserve seed for the next growing season. In this study, 97.5 percent of smallholder farmers use indigenous postharvest practices and technologies. This outcome concurs with Masarirambi *et al.* (2010) assertion that indigenous postharvest knowledge, practices, and technologies are still extensively used by smallholder farmers. These findings are also in line with Phokele and Sylvester (2015), who found that a large percentage of smallholder farmers are still using indigenous postharvest systems and practices.

4.4.3. Indigenous postharvest practices that smallholder farmers use in Maqongqo

Various studies argued that the numerous indigenous postharvest practices smallholder farmers use are usually done by hand (Abass et al., 2014; El-Ramady et al., 2015; Khrishna et al., 2014; Masarirambi et al., 2010; Notsi, 2012; Phokele and Sylvester, 2015). Table 3 shows the indigenous postharvest practices used by smallholder farmers in Maqongqo. Of the smallholder farmers, 75.8 percent used sun-drying, only 2.5 percent used smoking, 68.3 percent used winnowing, while fermentation was used by 0.8 percent of the smallholder farmers, and 45.0 percent used shelling (illustrated in Figure 3 below).

Figure 3. Shelling of maize, shelled maize and the bath tubs used by smallholder farms for storing produce

In the study, destalking (Maize) was employed by 98.3 percent, washing and cleaning of the harvested produce were employed by 37.5 percent, pickling (beetroot, pepper, and carrots) was used by 10.0 percent, while threshing was used by 72.5 percent, and natural field storage was employed by 94.2 percent of the smallholder farmers in Maqongqo. Phokele and Sylvester (2015) found that eight percent of the smallholder farmers used winnowing, while four percent used blanching, and 26 percent used sun drying as an indigenous postharvest practice. None of the smallholder farmers in the current study used blanching. Njomo *et al.* (2019), in a study about enhancing indigenous agricultural management techniques, found that smallholder farmers employed different indigenous drying methods.

These methods included drying produce in house ceilings, drying produce using sawdust and dry grass, drying produce in shelves, and sun drying. Farmers in Maqongqo only employed sun and air drying (Appendix 5 - Picture). Asogwa *et al.* (2017) argued that the use of indigenous postharvest practices such as sun drying provides a long-term and economical way for

preserving agricultural produce, which could ensure food availability and access during times of scarcity or during the dry season and thereby contributing positively towards food security. Asogwa *et al.* (2017) stated that the sun drying of agricultural produce was common in Nigeria, where the proportion of those using the practice was around 94.2 percent, which is slightly higher than the proportion of those who practice sun drying in the current study. The use of indigenous postharvest practices and technologies helps promote the diversity of diets and gives smallholder farmers access to a variety of food products, which could enhance nutrition security (Asogwa *et al*., 2017; Mugwisi, 2016).

Table 3 shows that 10.8 percent and 5.8 percent of the smallholder farmers used *Artemisia afra* (Umhlonyane in isiZulu language) and paraffin, respectively as insect repellents. Both paraffin and *Artemisia afra* are used to repel insects from the stored, often dry, produce to prevent and reduce postharvest losses, and to an extent, the shelf life of the stored produce. Some smallholder farmers who use paraffin as an indigenous postharvest method mentioned that they also use paraffin to preserve seeds for the next growing season as paraffin reduces insect infestations and sprouting of the stored seeds and grains. The use of *Artemisia Afra* supports the assertion that plants and their use play an important role in indigenous pest management (Chhetry and Belbahri, 2009).

A substantial proportion of smallholder farmers (13.3 percent) employed other indigenous postharvest practices. These other indigenous practices include soaking of produce (sorghum) for up to seven days, adding orange peels to stored produce to prevent rotting, air drying (Appendix 1 and 7), grinding maize, hanging crop produce on the roof or avocado tree to keep it away from rats, peeling, adding Jeyes fluid to stored produce mainly to preserve seeds for the next growing season, and adding bicarbonate of soda to stored dry beans. Jeyes Fluid contains *isopropanol* and *chlorocresol,* which gives it a strong odour, and *polyalkylphenol*, which is used in detergents and pesticides (Bridge Biotechnology, 2021). According to Van Der Linde (2000), jeyes fluid has been used as a pesticide on various vegetable crops and also as a repellent for insects and nematodes.

Cheng *et al*. (2020) and Smilanick *et al.* (1999) argued that bicarbonates at postharvest can be used to control for spoilage, mould development and various plant pathogens, this may help explain why some smallholder farmers in Maqongqo add bicarbonate to their stored produce.

Regarding the use of orange peels as a postharvest practice, Ojebode *et al.* (2016) noted that the use of plant extracts including orange peels (*Citrus Sinensis*) is a cost effective and non-toxic way for preventing and reducing pests and this helps in minimising produce losses during storage. The use of orange peels therefore helps improve pest control, thereby reducing harvest losses resulting from pest infestations which helps improve the productivity of smallholder farmers and ensure that food is stored effectively over longer period. Thus improving food availability, access and stability, and therefore positively impacting on household food security. Indigenous postharvest practices such as soaking and fermentation are used to reduce the levels of antinutrients such as phytates and tannins and helps to improve the nutritional quality of leguminous plants, mainly beans (Asogwa *et al*., 2017).

Table 3. Indigenous postharvest practices used by smallholder farmers in Maqongqo

Indigenous postharvest practices	**Crop handled**	**Percent (n = 120)**
Sun drying	Grains, Beans, sorghum	75.8
Smoking	Maize and seeds	2.5
Winnowing	Beans, sorghum	68.3
Fermentation	Sorghum	0.8
Shelling	Maize	45.0
Destalking	Maize, Yams, Fruits	98.3
Washing or cleaning	Sweet potatoes, Brinjal, Pepper, Cabbage and Yams	37.5
Pickling	Pepper, Carrots, Beetroot, Vegetables and Onions	10.0
Threshing	Beans	72.5
Natural or field storage	Maize, Yams, Potatoes, Sweet Potatoes	94.2
Use of *umhlonyane*		10.8
Adding paraffin to stored, dry produce	All dry produce in ex-situ storage	5.8
Other practices (e.g. soaking, pealing)	Sorghum, Yams, Maize	13.3
Postharvest celebrations		0.8

The digestibility of indigenously handled foods or produce is said to be improved or increased through soaking since this practice softens the dry produce and enable smallholder farmers to further process the produce to make a variety of foods, and soaking makes milling easier (Asogwa *et al*., 2017; Bolade *et al*., 2018). This, therefore, helps in the promotion of nutrition security among those consuming the agricultural produce, which has been handled using the practices mentioned above. Some smallholder farmers in the current study indicated that they use sorghum to make porridge and traditional beer. In a study about enhancing indigenous agricultural management techniques, Njomo *et al.* (2019) found that smallholder farmers in Bui Division in Cameroon also domesticated cats an indigenous postharvest practice to minimize postharvest losses that result from the consumption of stored produce by rats. In this study, however, none of the smallholder farmers indicated that they domesticated cats to minimize the losses they incur due to rats feeding on their harvest.

Postharvest celebrations are employed as an indigenous postharvest practice by only 0.8 percent of smallholder farmers in Maqongqo. Phokele and Sylvester (2015) found in their study of the indigenous postharvest systems in Mamone Village that 62 percent of the smallholder farmers that they interviewed postharvest celebrations. This figure is much greater than that found in this study. Postharvest celebrations form part of the traditional belief systems in some communities in which smallholder farmers reside. There is a belief by some smallholder farmers that performing postharvest celebrations brings luck to the smallholder farmers in the next growing season (Phokele and Sylvester, 2015). This belief is held by some of the smallholder farmers in the current study. Postharvest celebrations in the current study involved sharing cooked and raw agricultural produce with neighbours and friends; this was a sign of thanking their ancestors. Postharvest celebrations were performed to show appreciation for the successful harvest and show people that the land provides food (Appendix 7). Smallholder farmers in Maqongqo used more than one indigenous postharvest practice.

4.4.4. Indigenous postharvest technologies that smallholder farmers used in Maqongqo

Smallholder farmers in Maqongqo used more than one indigenous postharvest technology.

Table 4 shows the indigenous postharvest technologies used by smallholder farmers in Maqongqo. Of the smallholder farmers; 0.8 percent use pits while 5.8 percent use nested packaging, 45.8 percent use fibre bags while 4.2 percent use barns, 0.8 percent use IK silos (Figure 4), and 4.2 percent use rope (*Intambo*) to hang produce to keep it away from scavengers and rope is also used to hang produce over the smoke during smoking. Smallholder farmers in Maqongqo noted that the main problem they faced as a result of using pits for storing produce is that the produce usually rots and sprouts while in storage due to heat and water infiltrations.

Figure 4. Traditional rondoval used as an Indigenous silo for storing produce (mostly maize or grains)

Asogwa *et al.* (2017) wrote that using fibre bags as an indigenous technology was also common in Anambra State Nigeria, with the proportion of those using them being around 68.3 percent, which is higher than the proportion of those who use fibre bags in this study. Njomo *et al.* (2019) wrote that pits are best utilised in winter or the dry season since rotting of stored produce due to direct contact with rainwater is minimal. Plastic bags, plastic bottles, and plastic buckets are used by 3.3 percent, 2.5 percent, and 35.8 percent, respectively, of the interviewed smallholder farmers (Table 4).

Table 4. Indigenous postharvest technologies smallholder farmers used in Maqongqo

Indigenous postharvest Technologies	**Percent (n =120)**
Pits	0.8
Nested packaging	5.8
Fibre bags	45.8
Barns	4.2
IK silos	0.8
Intambo/rope	4.2
Plastic bags	3.3
Plastic bottles	2.5
Plastic buckets	35.8
Cool dry place/floor	22.5
Other technologies	18.3

Table 4 shows that 22.5 percent of smallholder farmers employ cool dry areas, mainly the floor, as an indigenous technology to store the harvested produce after post-harvest handling (Illustrated in Figure 5). The smallholder farmers that used cool dry areas as a storage technology indicated that they frequently experience postharvest losses since leaving produce on the floor exposes the produce to insects, rats, dirt and is highly prone to changes in temperature conditions, which has in some cases resulted in the sprouting and rotting of stored produce. This practice of storing produce on the floor, therefore, leads to reductions in food availability and to reduced food access, which would negatively impact household food security.

Figure 5. Produce (maize, beans, potatoes and pumpkins) stored on the floor uncovered

From Table 4, 18.3 percent of smallholder farmers indicated that they use other indigenous postharvest technologies in their postharvest operations. These technologies include rooftop (Appendix 2 and 5), metal drums, ice cream tubs (2 litres), bathtubs, refrigerator (deep freezer), and tins (20 litres). Phokele and Sylvester (2015) found, in their study of indigenous postharvest systems in Mamone Village, that at least 70 percent of the smallholder farmers that they interviewed used plastic containers, clay pots, baskets, IK silos, and cool dry areas for postharvest storage. The storing of produce on the floor or cool dry area was also a common indigenous technology employed by smallholder farmers in Bui Division in Cameroon (Njomo *et al.,* 2019).

4.4.5. Marketing of indigenously post-harvested produce in Maqongqo

Some smallholder farmers in Maqongqo sell their surplus produce, which they have prepared using indigenous postharvest practices and technologies. Of the smallholder farmers, 27.5 percent of them sell their indigenously post-harvested or handled produce. All smallholder farmers who indicated that they sell their indigenously post-harvested produce said they sell informally to local people, usually neighbours, or during government pension payout days to

the elderly within the community. Only one of the interviewed smallholder farmers noted that they also sell informally as a street vendor in town.

The income that the smallholder farmers obtain from the marketing of their surplus enables them to acquire some of the other livelihood assets that would improve the sustainability of their livelihoods. These include but are not limited purchasing other food types that the household does not produce, paying for the household expenses, purchasing better seeds, adopting more efficient post-harvest methods, and obtaining an education. Food access, availability and utilization are improved as the household generates extra income from the selling of surplus produce, thereby positively impacting on household food and nutrition security. The marketing of indigenously post harvested produce also help smallholder farmers get rid of the surplus produce that they cannot efficiently store and thus reducing the wastage of produce, and consequently increases the food access of those depended on smallholder farmers for food, particularly the non-producers of food.

The marketing of produce that has been indigenously post harvested will help contribute towards the attainment of the South African National Development Plan targets of eliminating income poverty by reducing the proportion of households with a monthly income below R419 per person and ensuring household food and nutrition security (National Planning Commission, 2011). The marketing of surplus produce will also help contribute towards the achievement of the Sustainable Development Goal of ending hunger, achieving food security and improving nutrition since even the non-producers of food will be able to have access to the marketed agricultural produce and the economic access of smallholder farmers to other food types that they do not produce will be increased (United Nations Development Programme, 2015).

Smallholder farmers who sell their indigenously post-harvested or handled crops or produce in Maqongqo are involved in indigenous marketing. Lasimbang (2008) stated that indigenous marketing or economic systems are characterised by small-scale economic activities, subsistence food production, and by the marketing of surplus food to first the local people within the community before other areas such as in barter centres. Taiwo *et al.* (1997) argued that the marketing of indigenously handled agricultural produce is usually limited to the local

area where they are produced, supporting this study's findings since all of the smallholder farmers who sell their produce in Maqongqo do so in their local community.

4.4.6. Integrating indigenous and modern postharvest practices and technologies

The integration of indigenous and modern postharvest practices in this study involved mostly using pesticides (such as *fatal aluminium phosphide*) and insecticides (such as doom blue death powder) on indigenously stored dry produce, including some that are stored naturally on the field. Simultaneously, the integration of indigenous postharvest practices and modern postharvest technologies in this study involved refrigeration of fresh produce after cleaning, destalking, refrigeration of pickles, and the refrigeration of the 2-litre bottles or plastic bags containing sun or air-dried beans.

Of the smallholder farmers who participated in this study, 1.7 percent of them integrated indigenous and modern postharvest practices, 5.0 percent combined indigenous postharvest technologies and modern postharvest practices, and 17.5 percent of them integrated indigenous postharvest practices and modern postharvest technologies. Taiwo *et al.* (1997) wrote that integrating modern technologies and practices with traditional practices has been done for various reasons; this includes reducing processing time, reducing postharvest losses or wastage, and minimising labor.

Dlamini and Kaya (2016) have asserted that the younger generation of smallholder farmers are willing to integrate indigenous and modern postharvest practices and technologies to improve agricultural production or productivity, enhance food preservation and reduce postharvest losses. Mandisvika *et al.* (2015) have concluded that indigenous postharvest management strategies and practices need to be combined with the new modern postharvest technologies so as to ensure that postharvest losses are minimised.

4.5. Factors that influence the use of indigenous postharvest practices and technologies

There are several factors, barriers, or enablers to the use of indigenous knowledge, including the use of indigenous postharvest practices and technologies (Dube and Musi, 2002). Table 5 shows the factors that influenced smallholder farmers' decisions to use indigenous postharvest practices and technologies. Approximately 10.0 percent of smallholder farmers mentioned that the lack of affordability and access to finance needed to implement modern

postharvest practices and technologies were among the factors that determined their adoption of the indigenous postharvest practices and technologies. Some smallholder farmer's defined lack of affordability as the lack of finance sufficiency to purchase some of the required material and technologies needed to employ the more advanced and effective modern postharvest practices and technologies. The lack of affordability, therefore, means not having the financial ability to purchase or adopt some of the more effective modern postharvest practices and technologies to some smallholder farmers. This finding is inconsistent with Ndwandwe (2013), who concluded that the use of indigenous knowledge is not based on access or lack thereof to finance.

Table 5. Factors that influence the use of indigenous postharvest practices and technologies in smallholder farming systems

Factors	**Percent (n=120)**
Lack of affordability and access to finance	10.0
The need to reduce postharvest losses	35.8
The need to maximize agricultural production	14.2
Confidence and faith in IPP&T	50.0
IPP&T are effective and efficient	45.0
Familiarity of IPP&T	97.5
Consideration of preharvest factors	84.2
Type of crop being handled	35.0
Lack of familiarity with IPP&T	2.5
Other factors	3.3

Note- IPP&T means Indigenous Postharvest Practices & Technologies

One smallholder farmer stated that they do not know any other free or cheap ways for handling produce after harvesting, and another said that they use indigenous postharvest practices and technologies so as "to cheaply maximize produce" (Appendix 6). Mandisvika *et al.* (2015) noted that smallholder farmers' lack of adequate finance or income to acquire advanced technologies leads them to use indigenous practices that are considered time-consuming. However, Ndwandwe (2013) concluded that other factors affected the use of

indigenous knowledge practices; these include the perceptions that smallholder farmers have regarding the effectiveness of the indigenous practices and the confidence and faith the smallholder farmers have in the local indigenous practices.

Fifty percent of smallholder farmers considered the confidence and faith in indigenous postharvest practices and technologies as the main factors influencing their choices to use the indigenous postharvest practices and technologies. Confidence and faith on the indigenous postharvest practices and technologies was described as the great positive feeling, belief and surety or certainty that the indigenous postharvest practices and technologies used would successfully lead to sufficient production and preservation of harvest. While 45.0 percent of them suggested that the effectiveness and efficiency of the indigenous postharvest practices and technologies was the reason for using these practices and technologies. Taremwa *et al.* (2016) wrote that the majority of smallholder farmers who use indigenous farming practices perceive them to be more effective when compared to modern farming practices. From the FGD (Appendix 6), one smallholder farmer noted that indigenous postharvest practices are efficient practices for processing harvest.

Table 5 shows that the need to reduce postharvest losses was noted by 35.8 percent of the interviewed smallholder farmers, while 14.2 percent of them considered the need to maximize agricultural production as among the main factors influencing the use of the indigenous postharvest practices and technologies. At the same time, 97.5 percent and 84.2 percent of smallholder farmers said that the familiarity of indigenous postharvest practices and technologies and the consideration of preharvest factors, respectively, were among the reasons for using the indigenous postharvest practices and technologies. This is consistent with Asogwa *et al.'s* (2017) argument that smallholder farmers in Africa are familiar with the indigenous practices and technologies of food processing, preservation, and storage.

Some 35.0 percent of smallholder farmers considered the type of crop being handled as a factor influencing their choices to use indigenous postharvest practices and technologies. Some 3.3 percent of smallholder farmers in Maqongqo considered other factors to influence their decision to use the indigenous postharvest practices and technologies. The other factors that influenced the use of indigenous postharvest practices and technologies include that these practices and technologies are simple and easy to understand and use. In contrast, the

lack of knowledge about the indigenous postharvest practices and technologies led to some smallholder farmers not using these practices and technologies. From the FDG (Appendix 6), smallholder farmers indicated several other reasons for using indigenous practices and technologies. These reasons include, but are not limited, to the need to prepare the harvest for storage and cooking or consumption, "protect harvest from rats and insects", "this is what and how I was taught to handle produce by my parents" and "these are common practices in the community".

In Bui Division in Cameroon, Njomo *et al.* (2019) found that the use of indigenous postharvest practices and technologies also depended on the climatic and weather conditions of the place where they are used and on the harvest time. Masarirambi *et al.* (2010) wrote that the timing of harvest and postharvest processing were essential as they related to the readiness of the crop and persisting weather conditions. This assertion may help explain why a significant proportion of smallholder farmers considered the preharvest conditions to be important in making decisions relating to the use of indigenous postharvest practices and technologies. The lack of familiarity with indigenous postharvest practices and technologies was considered by all (2.5 percent) those who do not use indigenous postharvest practices and technologies as the main factor that led them not to use the practices.

It is evident from the results in Table 5 that the familiarity of the indigenous postharvest practices and technologies, the confidence and faith in indigenous postharvest practices and technologies, and the consideration of preharvest factors were the main reasons that influenced the use of indigenous postharvest practices and technologies in smallholder farming. The results presented in Table 8 support Dube and Musi (2002), Hart and Vorster (2006), Mandisvika *et al.* (2015); Ndwandwe (2013), and Ofor *et al.* (2010) that more than one factor influences the decisions of smallholder farmers to use the indigenous postharvest practices and technologies, and that these are not all financial in nature. Taremwa *et al.* (2016) stated that smallholder farmers emphasize the use of indigenous farming practices because they are simple, require little investment, and employ technologies that smallholder farmers are familiar with. The results discussed above support this assertion.

4.5.1. Other factors that influence the use of indigenous postharvest practice and technologies

In the current study, several other factors influenced smallholder farmers' use of indigenous postharvest practices and technologies, including gender, age, access to extension services, household income, education level, and farming experience. This further emphasizes the arguments made by Dube and Musi (2002), Hart and Vorster (2006), Mandisvika *et al.* (2015); Ndwandwe (2013), and Ofor *et al.* (2010) that numerous factors influence smallholder farmers' decisions to use the indigenous postharvest practices and technologies.

There were no statistically significant associations between the use of indigenous postharvest practices and technologies and the household variables of education level, gender, access to agricultural extension services, and household incomes, thus suggesting that these factors do not influence the use of indigenous postharvest practices and technologies. However, a Cramer's V test between the use of indigenous postharvest practices and technologies and farming experience resulted in a statistically significant Cramer's V coefficient ($p=0.006$). This result indicates a high association between the use of indigenous postharvest practices and technologies and smallholder farmers' farming experiences. Thus, farming experience influences the use of indigenous postharvest practices and technologies. A total of 65.8 percent of the smallholder farmers who use indigenous postharvest practices and technologies in this study had been farming for more than ten years, that is, 11 years to more than 25 years.

Only 12.5 percent of those who practiced indigenous marketing had a farming experience of more than 10 years, and 20.9 percent of those who practiced indigenous pest control had a farming experience of more than 10 years (Table 6). There were no significant statistical differences or associations identified between farming experience and indigenous marketing as well as between farming experience and indigenous pest control (Table 6). Therefore smallholder farmers' farming experience does not influence the practice of indigenous pest control and marketing. Maziya *et al.* (2017) wrote that farmers' experience in farming likely has a positive impact on household food security and that the more experienced farmers are more likely to make informed decisions. However, there were no statistically significant differences regarding smallholder farmers' food security status in the current study, regardless of their farming experience.

Table 6. Relationship between indigenous marketing, indigenous pest control and farming experience

Farming experience vs. Indigenous Marketing				**Cramer's V Signif. Level (Exact)**	**Farming experience vs. Indigenous Pest Control**			**Cramer's V Signif. Level (Exact)**
Farming experience	**Indigenous Marketing**				**Indigenous Pest Control**			
	No (Percent)	Yes (Percent)	Total (Percent)		No (Percent)	Yes (Percent)	Total (Percent)	
1 to 5 years	15.0	3.3	18.3		16.7	1.7	18.3	
6 to 10 years	12.5	3.3	15.8		13.3	2.5	15.8	
11 to 15 years	3.3	2.5	5.8	0.470	4.2	1.7	5.8	0.633
16 to 20 years	4.2	1.7	5.8		5.8	0.0	5.8	
21 to 25 years	7.5	1.7	9.2		8.3	0.8	9.2	
more than 25 years	30.0	15.0	45.0		35.0	10.0	45.0	
Total	72.5	27.5	100.0		83.3	16.7	100.0	
n = 120								

There were no statistically significant associations between gender and the use of indigenous pest control, and between gender and the practice of indigenous marketing (Table 7). Therefore, this suggests that gender does not influence the use of indigenous pest control, indigenous marketing practices, nor does it influence the general use of indigenous postharvest practices and technologies in smallholder farming. These results are not consistent with the argument made by Abass *et al.* (2014), Asogwa *et al.* (2017), and Kamwendo and Kamwendo (2014) that more women than men participate in postharvest operations.

Abass *et al.* (2014) found; in a study of postharvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania that fewer men than women were engaged in manual postharvest activities; which is consistent with the findings from the current study. Asogwa *et al.* (2017) has stated that women hold a vast amount of indigenous knowledge in terms of food production, processing, and storage, which could help reduce food and nutrition security. This study's findings indicate that both male and female smallholder farmers possess knowledge about the various indigenous postharvest practices and technologies and are actively employing this knowledge in their postharvest operations.

Table 7. Chi-square tests and Fisher's exact tests between the various household characteristics; indigenous pest control, and indigenous marketing

Chi-Square Tests and Fisher's exact tests		
Variables	**Chi-square significance level (n=120)**	**Fisher's exact significance level (n=120)**
Gender vs. the use of indigenous postharvest practices and technologies		0.145
Access to agricultural extension services vs. the use of indigenous pest control		0.129
Access to agricultural extension services vs. the use of indigenous marketing		0.303
Household head vs. Indigenous pest control	0.608	
Household head vs. Indigenous marketing	0.294	
Gender vs. Indigenous pest control		0.153
Gender vs. Indigenous marketing		1.000

The Chi-square test between being the household head and the use of indigenous pest control, and between the household head and the use of Indigenous marketing indicates no significant statistical difference (Table 7). Therefore, there is not enough evidence to suggest that being a household head influences the use of indigenous pest control strategies and indigenous marketing. Regarding the influence of age on the use of indigenous marketing, the average age between those who use and those who do not use indigenous marketing was statistically significantly different at 10 percent (Table 8).

Those smallholder farmers who do not practice indigenous marketing were significantly older than those who do use indigenous marketing. Thus, these results indicate that age does influence the practice of indigenous marketing in smallholder farming. This finding supports the assertion made by Dlamini and Kaya (2016) that age influences the implementation of indigenous practices and knowledge. The results show that smallholder farmers are actively applying and using the indigenous knowledge they have in their postharvest activities and operations, regardless of their age.

Table 8. Independent Samples t-test between the use of indigenous marketing and age

		Mean Age	**t significance level**
Indigenous Marketing (n-120)	Yes	52.848 (15.415)	0.097
	No	57.309 (12.306)	

Note: in brackets are standard deviations.

Table 9 shows the help obtained by smallholder farmers that receive agricultural extension services. Approximately 96.67 percent of smallholder farmers do not have access to agricultural extension services. Only 3.33 percent of smallholder farmers stated that they receive agricultural extension services or have access to agricultural extension services. In this study, smallholder farmers, regardless of whether or not they have access to agricultural extension, were using indigenous postharvest practices and technologies. Thus, this indicates that access to extension services or lack thereof does not influence the use of indigenous postharvest practices and technologies.

Table 9 shows that 3.3 percent of the smallholder farmers that receive agricultural extension services claimed to have received agricultural training from the agricultural extension officers,

1.7 percent said that they get advice about the best indigenous postharvest practices, 2.5 percent said they are provided with agricultural information, including indigenous information, 1.7 percent stated that agricultural extension provides them with access to indigenous or/and modern agricultural technology, and 1.7 percent said agricultural extension offers other services (mainly provide them with agricultural inputs such as seeds and tools).

Table 9. Services obtained by those respondents that receive agricultural extension

Agricultural extension service	**Percentage (n=120)**
Training (train me)	3.3
Advice about the best indigenous (and modern) postharvest practices	1.7
Provide agricultural information, including indigenous information	2.5
Provide access to indigenous or/and modern agricultural technology	1.7
Other, specify	1.7

4.6. The effects of using indigenous postharvest practices and technologies on household food security

Smallholder farmers use indigenous postharvest practices and technologies for several reasons, and these can have varying effects on agricultural productivity, the occurrence of postharvest losses, and food security. These indigenous practices and technologies are used to reduce the rate at which the harvested agricultural produce deteriorates at the postharvest phase, which in turn helps to ensure that food availability and supply are sustained at all times (Krishnan *et al.,* 2014; Phokele and Sylvester, 2015; Will *et al.,* 1998). The effects of using indigenous postharvest practices and technologies are presented and discussed below.

4.6.1. Effects on agricultural productivity

Figure 6 shows the effects of using indigenous postharvest practices and technologies on agricultural productivity. About 2.50 percent of smallholder farmers said that using indigenous postharvest practices and technologies greatly decreased their agricultural

productivity, while 20.83 percent said it moderately decreased their agricultural productivity. The use of indigenous postharvest practices and technologies had no effect, moderately increased, and greatly increased the agricultural productivity of 0.83 percent, 69.17 percent, and 4.17 percent of the interviewed smallholder farmers, respectively. It is evident from the results that the use of indigenous postharvest practices can have both negative and positive impacts on agricultural productivity; that is, the use can increase or decrease agricultural productivity depending on the context to which they are applied.

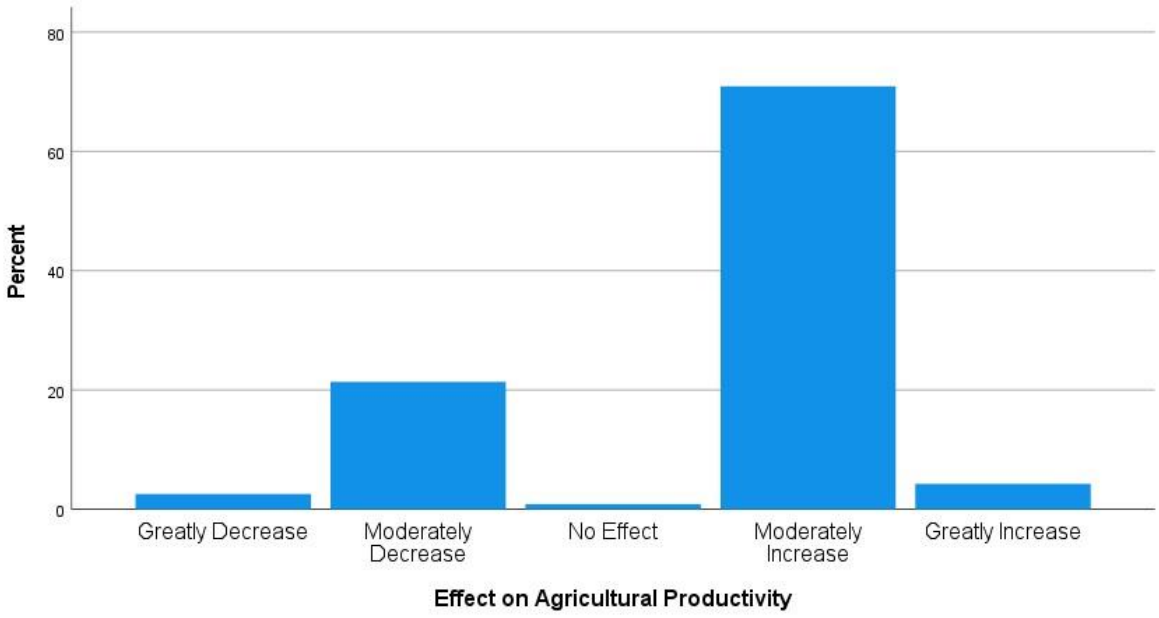

Figure 6. Effects of using indigenous postharvest practices and technologies on agricultural productivity

This, therefore, suggests that the use of indigenous postharvest practices and technologies can positively or negatively impact the livelihoods and household food security of those using them. But these results do not explain why some smallholder farmers have observed decreases in agricultural productivity while others have observed increases in agricultural productivity due to using indigenous postharvest practices and technologies. It should be highlighted that a significantly larger proportion of smallholder farmers observed increases in agricultural productivity than those who observed decreases due to using indigenous postharvest practices and technologies.

This means that these smallholder farmers observed higher agricultural output with little investments and inputs that could have freed some resources needed to meet other livelihood needs, such as purchasing different food types that the household does not produce and clothing. This freeing of household resources for example money would increase the household's economic access to food and other livelihood assets thereby increasing the food availability within these households, and may possibly improve food utilisation. Thereby positively impacting on household food security

Taiwo *et al.* (1997) wrote that the productivity of indigenous or traditional agricultural technologies and practices is low, which may explain why 23.33 percent of smallholder farmers in this study observed a decrease in their agricultural productivity due to using indigenous postharvest practices and technologies. Njomo *et al.* (2019) have noted that some indigenous postharvest practices contribute considerably to improving agricultural productivity as they contribute to the minimization of postharvest losses. Therefore, this can lead to indigenous postharvest practices contributing to enhanced food availability and stability of food supply since the harvested produce can be preserved for a more extended period.

Therefore, leading to improved food access for smallholder farmers who practice these indigenous practices contributes positively to enhanced food security. Although a significant proportion of smallholder farmers in the current study indicated that the use of indigenous postharvest practices and technologies had increased their agricultural productivity; a substantial proportion of them also stated that they had observed postharvest losses due to using these practices and technologies.

4.6.2. Effects on produce losses

The attainment of food security globally is continuously being challenged by the occurrence of postharvest losses (Njomo *et al*., 2019). Wills *et al*. (1998) stated that any attempt to improve the postharvest practices and technologies used by smallholder farmers must be preceded by an estimate of postharvest losses, which would help estimate the impact of using the postharvest methods and technologies, indigenous or otherwise, on food security. Figure 7 shows the proportion of smallholder farmers who have observed agricultural produce losses due to using indigenous postharvest practices and technologies.

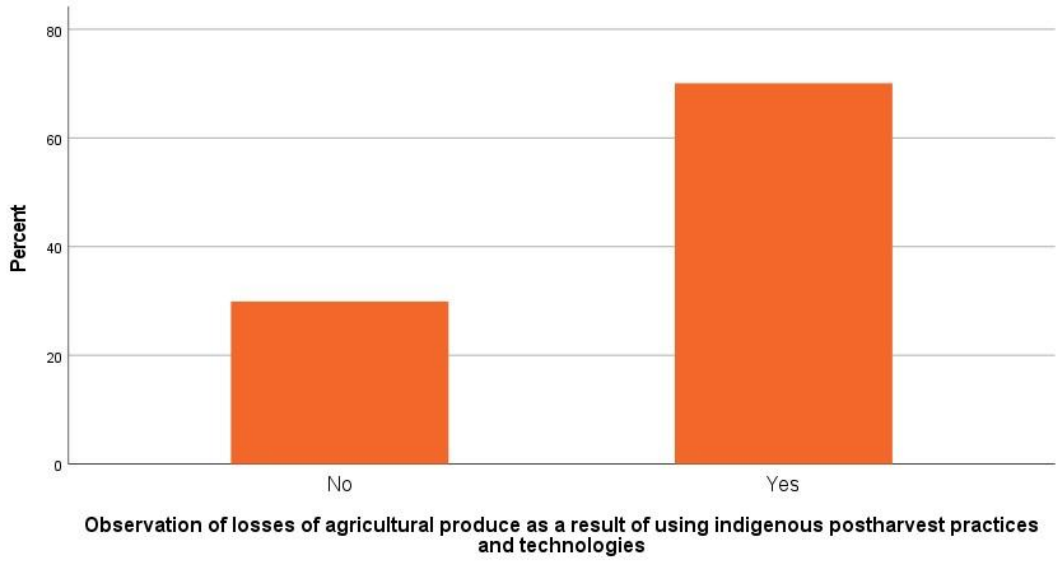

Figure 7. Proportion of smallholder farmers observing postharvest losses

Postharvest losses of agricultural produce resulting from using indigenous postharvest practices and technologies were experienced by 68.33 percent of smallholder farmers. In contrast, 29.17 percent of them did not experience any losses of agricultural produce. These results are consistent with the results obtained by Abass *et al.* (2014), who found that 70 percent of the smallholder farmers in their study observed and experienced postharvest losses. These results suggest that food availability and access are threatened at the household level by using indigenous postharvest practices and technologies due to the high postharvest losses associated with them. Therefore, this suggests that the use of indigenous postharvest practices and technologies can negatively impact food and nutrition security if no measures are employed to reduce postharvest losses.

The occurrence of postharvest losses resulting from the use of indigenous postharvest practices and technologies will undermine the target of promoting and ensuring sustainable food production systems and resilient agricultural practices that increase productivity and production by 2030 (United Nation Development Programme, 2015). Postharvest losses can also be reduced through improved marketing of the surplus agricultural produce enabling smallholder farmers to earn income, and thereby improving their household food security. Asogwa *et al.* (2017) and Njomo *et al.* (2019) wrote that, although the indigenous knowledge practices are useful, postharvest losses as a result of using indigenous preservation techniques were very high, and they identified the use of shelves, bags, and using raised

platforms rather than flat surfaces as the most appropriate indigenous preservation or postharvest techniques for minimizing post-harvest losses. Bags and raised surfaces such as tables, rooftops, and more were used by some of the smallholder farmers in this study (Appendix 4, 5, and 6). Mandisvika *et al.* (2015) also found; in a study about postharvest issues: rethinking technology for value-addition in food security and food sovereignty in Zimbabwe that the indigenous postharvest practices used in smallholder farming caused significant postharvest losses. Mandisvika *et al.* (2015) attributed the occurrence of postharvest losses to the lack of advanced postharvest technologies.

In this study, smallholder farmers identified several causes of postharvest losses emanating from the use of indigenous postharvest practices and technologies. These include the invasion and destruction of stored produce by rats, moles (*imvukuzane*), termites (*umuhlwa*), centipedes, chickens, warthogs, ants, monkeys, and birds, rotting and sprouting of produce in stored, heavy rains destroy naturally stored matured crops, and the overuse of pesticides (Appendix 6). The occurrence of postharvest losses can cause a reduction in food availability, and the stability of food supply may be negatively affected, which could lead to reduced agricultural incomes and food. This can reduce the physical and economic access to food for smallholder farmers and those who depend on them for food. Some smallholder farmers who observed losses resulting from using indigenous postharvest practices and technologies in this study indicated that losses occurred in three ways: quality, quantity and value.

During the use of traditional postharvest practices and technologies such as sun drying and storing produce on the floor, insect infestations can cause deteriorations and declines regarding the quality and quantity of stored produce and seeds (Asogwa *et al.,* 2017). This, therefore, suggests that through the use of these indigenous practices and if no measures are put in place to control for insect infestation, insect pests can negatively impact the food and nutrition security of smallholder farming households employing them because the availability of sufficiently good quality produce will decrease. The Chi-square test of independence between observing postharvest losses as a result of using indigenous postharvest practices and technologies and the use of indigenous marketing resulted in a statistically insignificant chi-square value. This, therefore, indicates that there is no significant statistical association between the number of those who have observed postharvest losses as a result of using

indigenous postharvest practices and technologies and those practicing indigenous marketing.

The Chi-square test of independence between observing postharvest losses due to using indigenous postharvest practices and technologies and the use of indigenous pest control resulted in the statistically significant chi-square value (Table 10). This indicates a significant statistical association between the number of those who have observed postharvest losses due to using indigenous postharvest practices and technologies and those using indigenous pest control strategies. However, the cross-tabulation results between observing postharvest losses due to using indigenous postharvest practices and technologies and indigenous pest control suggested that the proportions of those who have observed postharvest losses and those who did not whilst using indigenous pest control strategies was evenly distributed, that is 8.5 percent each (Table 10).

Table 10. Relationship between observing postharvest losses as a result of using indigenous postharvest practices and technologies and indigenous pest control

Observed postharvest losses as a result of using indigenous postharvest practices and technologies	**Indigenous Pest Control**			**Chi-Square Significance Level**
	No (Percent)	**Yes (Percent)**	**Total (Percent)**	
No	21.4	8.5	29.9	0.031
Yes	61.5	8.5	70.1	
Total	82.9	17.1	100.0	
n = 120				

4.6.3. Impact of using indigenous postharvest practices and technologies on household food security

Household food security is determined by several factors (Maziya *et al.,* 2017). The use of indigenous postharvest practices and technologies is said to impact food security (Kamwendo and Kamwendo, 2014; Mandisvika *et al.,* 2015; Njomo *et al.,* 2019). Food security is said to be threatened at postharvest (Mandisvika *et al.,* 2015). Njomo *et al*. (2019) has argued that the

use of indigenous postharvest practices and technologies can results in the attainment of many benefits, especially if they lead to the minimization of postharvest losses. The impacts of using indigenous postharvest practices and technologies on household food security are presented and discussed in detail below.

4.6.3.1. Household Food Insecurity Prevalence for 2020

Figure 8 shows the Household Food Insecurity Access Prevalence in Maqongqo. Approximately 11.67 percent of smallholder farmers were considered food secure, 12.50 percent were mildly food insecure, while 45.83 percent were moderately food insecure, and 30.00 percent were severely food insecure in terms of food access. Abass *et al.* (2014) found that in their study, between 71.3 percent and 80.5 percent of the smallholder farmers were food insecure or came from food insecure households. The above results on the Household Food Insecurity Access Prevalence contradict the arguments made by Kamwendo and Kamwendo (2014) and Phokele and Sylvester (2015) that the use of indigenous postharvest practices and technologies contributes positively to food access and food security.

These results also dispute the assertion by Taremwa *et al.* (2016) that considering and using the indigenous knowledge systems, practices, and technologies are likely to enhance the livelihoods of smallholder farmers through incomes from production, processing, and marketing of produce; and it was discussed above that the use of such practices can be attributed to high postharvest losses both in terms of quality and quantity. The smallholder farmers perceived the cause of food insecurity to be weather-related, mainly a change in weather (Abass *et al.,* 2014). In this study, the causes of household food insecurity were not investigated. However, a significant proportion of smallholder farmers from this study did indicate that they observed postharvest losses due to using the indigenous postharvest practices and technologies that may be undermining their access to food.

Asogwa *et al.* (2017) has noted that the observed high postharvest losses are constraints to the attainment of food and nutrition security in Africa; this also includes the developing Southern Africa. It is stated that the use of indigenous postharvest or food processing practices and technologies can help generate employment for women who are the primary custodians of IK; they can then earn an income (Asogwa *et al.,* 2017). This would enable women and their households to acquire modern technologies that would help improve their

agricultural productivity, reduce postharvest losses, enhance their economic access to food, and pay for the other household needs, and thereby improve the sustainability of their livelihoods and food security.

From the direct field observations, it was observed that the majority of smallholder farmers did not have any stored produce between two to three months after harvesting. This was attributed by the smallholder farmers to spoilage, loss, and low output, and has negative implications in terms of household food security as it affects food availability and access. This finding also indicates that food stability, from own production, has not been attained by the smallholder farmers in Maqongqo.

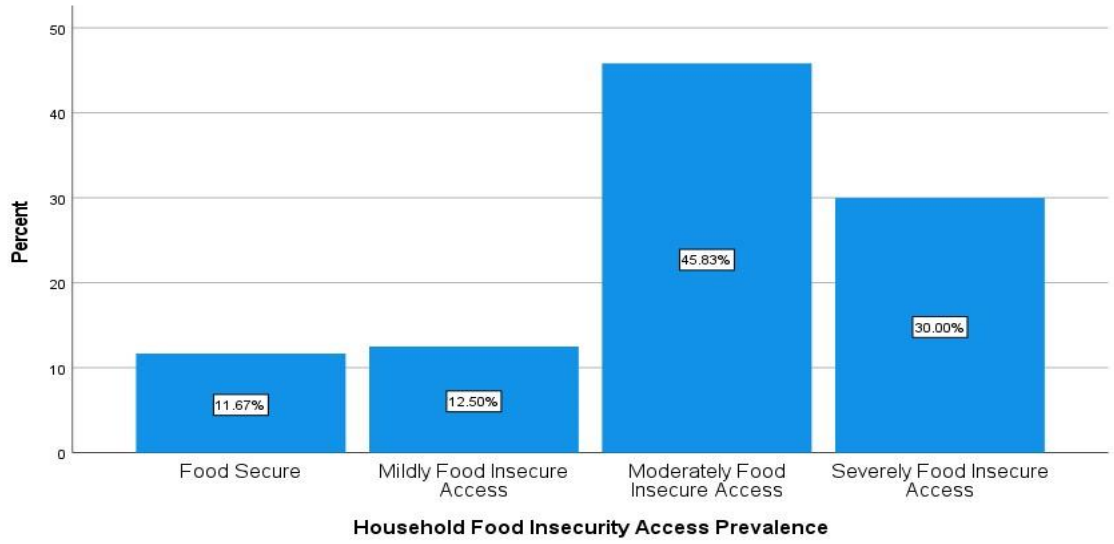

Figure 8. Household Food Insecurity Access Prevalence

4.6.3.2. Relationships between food security status and use of various indigenous postharvest practices and technologies

Several researchers have argued that indigenous postharvest systems' use contributes positively to food availability by increasing the quantity and quality of the harvested produce available for household consumption and selling at the markets (Asogwa *et al*., 2017; Phokele and Sylvester, 2015). The HFIAS scores were not statistically significantly different between those smallholder farmers who practice indigenous marketing and those who do not practice indigenous marketing (Table 11). Hence, this result shows that the use of indigenous marketing does not influence household food security in terms of food access.

The mean HFIAS scores between those who use and those who do not use indigenous pest control were not statistically significantly different (Table 11). The result shows that the use of indigenous pest control does not influence household food security in terms of food access. Thus, the use of these practices and technologies, particularly indigenous marketing and pest control does not lead to the attainment nor reduction of household food security, in terms of food access.

Table 11. Independent Samples t-test between the use of indigenous marketing, indigenous pest control, and HFIAS score

		Mean HFIAS Score	**t-test p - significance level**
Indigenous Marketing (n=117)	Yes	8.7 (5.2)	0.505
	No	7.9 (5.6)	
Indigenous Pest Control (n=117)	Yes	6.7 (5.4)	0.221
	No	8.4 (5.5)	

In brackets are standard deviations. n.s. – not statistically significant

Although there were no statistically significant differences and associations identified between the HFIAS scores of those using and those not using indigenous postharvest practices and technologies, particularly indigenous marketing and indigenous pest control; a significant proportion of those who use indigenous postharvest practices and technologies were food insecure to some extent (Table 12). In this study, of the smallholder farmers who used indigenous postharvest practices and technologies, a total of 85.9 percent of them were food insecure.

Table 12. Relationship between the use of indigenous postharvest practices and technologies, and Household Food Insecurity Access Prevalence

Use of Indigenous postharvest practices and technologies	Household Food Insecurity Access Prevalence					Cramer's V signif. level
	Food Secure (Percent)	Mildly Food Insecure Access (Percent)	Moderately Food Insecure Access (Percent)	Severely Food Insecure Access (Percent)	Total (Percent)	
Yes	11.7	12.5	44.2	29.2	97.5	0.790
No	0.0	0.0	1.7	0.8	2.5	
Total	11.7	12.5	45.8	30.0	100.0	
n = 120						

Cramer's V between the use of indigenous postharvest practice (adding paraffin to stored, dry produce) and the Household Food Insecurity Access prevalence resulted in an approximate significance of 0.018 (Table 12). This indicates that the prevalence of food insecurity is associated with paraffin's addition to stored dry produce in terms of food access. Thus, adding paraffin to stored dry produce affects HFIA prevalence**.** Therefore, the use of paraffin as an indigenous postharvest practice affects the food security of smallholder farmers and their households in terms of food access.

Some 4.2 percent of smallholder farmers who were using paraffin as an indigenous postharvest practice were food insecure (Table 13). Smallholder farmers in Maqongqo suggested that adding paraffin to stored dry produce helps prevent and reduce postharvest losses and extend the agricultural produce's shelf life. According to some smallholder farmers, paraffin use reduces spoilage and destruction of produce and stored seeds by pests. Kadende (2014) wrote that paraffin is used in some parts of Africa to repel pests and insects from crops, mainly beans and maize, on the field and during storage as well to treat and preserve seeds. Thus supporting the usage of paraffin in smallholder farming in Maqongqo. Although Kadende (2014) acknowledge the pest and insect repellent effect of paraffin, he cautions that different crops and seeds react in different ways to treatments with paraffin.

Table 13. Relationship between Household Food Insecurity Access Prevalence and use of indigenous postharvest practice[a]

Household Food Insecurity Access Prevalence	**Indigenous postharvest practice used[a]**			**Cramer's V Signif. Level**
	No (Percent)	**Yes (Percent)**	**Total (Percent)**	
Food Secure	10.0	1.7	11.7	0.018
Food Insecure	84.2	4.2	88.3	
Total	94.2	5.8	100	
n = 120				

[a]*Adding paraffin to stored, dry produce*

4.7. Summary

In this chapter, the findings of this study were presented and discussed. This chapter focussed on presenting and discussing the results of the study. The results were discussed in relation to the specific objectives and compared with findings from similar studies in the literature. There are a number of indigenous postharvest practices and technologies that are used in smallholder farming. Many factors influence the use of these indigenous postharvest practices and technologies; these are discussed in detail within the chapter. The use of indigenous postharvest practices and technologies has varying effects on agricultural productivity, the occurrence of postharvest losses, and household food security.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study aimed to investigate the Indigenous postharvest technologies and practices used in smallholder farming systems and their impact on food security. The researcher identified three specific objectives, which aided in achieving the aim of the study. These objectives were to identify the Indigenous postharvest practices and technologies used in smallholder farming systems across different crop types, to determine the factors that influence the use of indigenous postharvest practices and technologies, and to identify the effects of using indigenous postharvest practices and technologies and its impact on food security. In this study, indigenous postharvest practices and technologies were used mainly for the processing, preparation of produce for storage, for preserving the harvest, and for protecting stored harvest or produce from pests, which were mostly insects and rats.

There are many indigenous postharvest practices and technologies that are used by smallholder farmers, but the main practices used in Maqongqo are sun drying, winnowing, destalking, hand threshing, shelling, and natural field storage. Fermentation and the performance of postharvest celebrations were the least used of the identified postharvest practices that are being employed by smallholder farmers in Maqongqo. There are also a number of indigenous postharvest technologies that are used by smallholder farmers. The leading indigenous postharvest technologies used in Maqongqo are fibre bags, plastic buckets, and cool dry areas, mainly the floor. Pits were the least employed of the indigenous postharvest technologies that are used by smallholder farmers in Maqongqo. The indigenous postharvest practices and technologies used in Maqongqo were grouped into four categories to enable statistical analyses or tests. These categories were indigenous processing, indigenous storage, indigenous marketing, and indigenous pest control. The literature reviewed in this study revealed that there are many challenges and factors that influence the use of indigenous postharvest practices and technologies in smallholder farming.

The main factors that were identified as having an influence on the use of indigenous postharvest practices and technologies in this study were the familiarity of the indigenous postharvest practices and technologies, the confidence and faith in indigenous postharvest

practices and technologies, and the consideration of preharvest factors. The findings from the current study have shown that gender, having access to agricultural extension services, being a household head, Household income and education level does not have an influence on the use of indigenous postharvest practices, including indigenous marketing and indigenous pest control. However, the findings from this study show that more women than men participate in smallholder farming, which may explain why it may seem that more women than men participate in postharvest operations.

Based on the results of the independent samples (t) test statistic between indigenous marketing and age, and between indigenous pest control and age, age does not influence the use of indigenous pest control but age does influence the practice of indigenous marketing. The farming experience of smallholder farmers influences the use of indigenous postharvest practices and technologies. The South African government has recognised the need and importance of indigenous knowledge and has implemented the Indigenous Knowledge Systems policy. However, improvements in the policy's implementation are needed to ensure that the policy objectives are achieved. The custodians of this indigenous knowledge in South Africa need to be made aware of the implemented IKS Policy and the various ways through which they can benefit and contribute towards the attainment of its objectives.

Asogwa *et al*. (2017) concluded that the inclusion of indigenous knowledge of postharvest handling, food processing, and preservation into all programmes aiming to reduce food insecurity would boost smallholder farmers' confidence in them. In this study, indigenous information, including information about indigenous postharvest practices and technologies, was obtained mostly through local people in oral form. This study hypothesized that the use of indigenous postharvest practices and technologies can improve food security among smallholder farming households. However, the use of indigenous postharvest practices and technologies in Maqongqo did not lead to the attainment or improvement of food security among smallholder farming households. Hence, the hypothesis for this study is rejected or is not supported.

The majority of smallholder farmers who used indigenous postharvest practices and technologies in Maqongqo were mildly food insecure, moderately food insecure, and severely food insecure in terms of food access measured using the HFIAS. One has to question the

necessity of promoting the use of indigenous postharvest practices and technology in smallholder farming, especially since the findings from the study suggested that using indigenous postharvest practices and technologies has adverse effects on the household food security of smallholder farming households. As Myeza and Kaya (2016) have concluded, IK alone may not be enough to help local people. Therefore, there is a need to integrate indigenous and modern knowledge systems, technologies, and practices in order to achieve food security sustainably. Thus, the use of indigenous postharvest practices and technologies on their own is discouraged; rather, the integration of modern and indigenous postharvest practices and technologies is encouraged to account for the shortfalls of using indigenous postharvest practices and technologies, particularly regarding the occurrence of postharvest losses.

5.2. Recommendations

5.2.1. Recommendations for improving the use of indigenous postharvest practices and technologies in smallholder farming and its impact on household food security

- The integration of indigenous and modern knowledge systems, practices, and technologies is recommended to achieve food security among rural and urban farming households and ensure that the rural poor's livelihoods are sustainable.
- The education of agricultural extension officers about the various indigenous postharvest practices and technologies is highly recommended as they can be able to share the information about these practices and technologies with the smallholder farmers that need them, which may help them improve their postharvest handling practices. Thereby positively contributing to their livelihoods and food security.
- The formation of farmer groups and smallholder farmers' participation in farmer groups is also recommended. It would promote the interactions between smallholder farmers, which may promote the sharing of agricultural information, indigenous and modern, within and between communities.
- The integration of indigenous education in schools is highly recommended since it would ensure that indigenous information and knowledge is disseminated and distributed appropriately to the younger generations and is sustained. This could, in

turn, lead to further developments and improvement in terms of indigenous knowledge and its use, including but not limited to agriculture or smallholder farming.

- The development of policies that would promote the improvement and modernisation of the technologies used in rural smallholder farming, improving the market access of smallholder farmers and promote the development of niche markets for the indigenous and traditional crops produced in rural smallholder farming in South Africa is highly recommended. This would have positive implications for household food security through improved food production, processing and storage, and improved incomes.

5.2.2. Recommendations for improvement of the study

- The other three pillars of food security, particularly food utilization, should also be assessed to determine the impacts of using indigenous postharvest practices and technologies on smallholder farmers' nutrition and food security and their households in Maqongqo.
- A similar study could be conducted but using an increased sample size, which could improve the results' validity and generality. It would help avoid or reduce the shortfalls experienced in the study regarding data analysis using statistical tests because most of the data did not meet the requirements for conducting such analyses.

5.2.3. Recommendations for further study

- Further research is required to find reasons why smallholder farmers are experiencing food insecurity even though they have different socio-economic dynamics regardless of whether or not they are using indigenous postharvest practices and technologies.
- Further research should be conducted to identify the possible ways through which modern and indigenous postharvest practices could be integrated to maximise the impacts of smallholder farming on household food and nutrition security.
- Further research may be conducted to investigate the indigenous and modern postharvest technologies used by large-scale or commercial farmers.

- Research may be conducted to determine the indigenous technologies, tools and practices employed in smallholder farming systems before and during harvesting, and its impact on household food security
- Research may be conducted on the origins and evolution of the indigenous postharvest practices and technologies used in smallholder farming in South Africa.

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Appendix 1: Air drying of beans on the floor

Appendix 2: Pumpkin produce store on the rooftop

Appendix 3: A slightly elevated IK Silo made with corrugated iron used for storing agricultural produce

Appendix 4: Stored dry produce (maize) in a rondovel used as a storage facility

Appendix 5: Produce (beans) being sun dried on roof top

Appendix 6: <u>Focus Group Discussion with smallholder farmers</u>

Focus Group Discussion Results to questions about indigenous knowledge, indigenous postharvest practices and technologies, why indigenous postharvest practices were used, impacts of using indigenous postharvest practices on food security, and accessing information about indigenous postharvest practices.

What is your understanding of Indigenous Knowledge?

- Localised, traditional knowledge and information
- It's that information and knowledge about various things such as medicine, farming and more that was learnt from our homes, parents, friends and communities that we did not learn in school
- It's the knowledge possessed and used by local, rural people and that is practiced by us and people like us i.e. similar tribe, race etc. or by people living in similar conditions to ours
- "It's that type of knowledge that has been developed by us as indigenous African people through practices, observations and experiences of others
- "It is the knowledge of our forefathers that has been passed down from generation to generation, this encompasses a wide range of areas including farming and the various ways through which we handle crops and harvest"

Which other indigenous postharvest practices and technologies are used in this community?

- **Indigenous postharvest practices**
  - Adding orange peels to stored produce to prevent rotting,
  - Sun and air drying of produce such as maize and beans,
  - Shelling and grinding maize to make mealie meal and to produce poultry feed,
  - Hanging produce on roof (inside of rondavels and unused rooms) and/or avocado tree to keep it away from rats and dirt,
  - Cleaning and peeling of yams (*amadumbe*) before storage,

- Adding jeyes fluid to stored produce mainly to preserve seeds for the next growing season,
- Adding bicarbonate of soda to stored dry beans, and
- Soaking of produce (sorghum) for up to 7 days,

Indigenous postharvest technologies:

- Roof top,
- Metal drums,
- Ice cream tubs (2 litres),
- Bath tubs, and
- ➢ Tins (20 litres).

Why do you use indigenous postharvest practices and technologies in your community? (Which factors or reasons influence your choice to use or not use indigenous postharvest practices and technologies?)

- "To prepare harvest for storage and cooking or consumption"
- "They are efficient practices for processing harvest"
- "I do not know any other free or cheap ways for handling produce after harvesting"
- "To minimise losses and reduce the rate of spoilage"
- "To protect produce from rats and insects"
- "This is what and how I was taught to handle produce or harvest by my parents"
- "I'm familiar with these practices and technologies"
- "I'm confident of the efficiency of these practices and technologies"
- "These are common practices here in the community"
- "The best way I know of handling produce or harvest"
- "To prepare poultry feed"
- "To cheaply maximize produce"
- "The low household incomes due to unemployment and lack of adequate access to markets to generate better income led me or us to use indigenous postharvest

practices and technologies as opposed to expensive modern, mechanised practices and technologies" and

- The type of crop or produce being handled and processed

How does using or not using indigenous postharvest practices and technologies impact your agricultural productivity, farm incomes, food availability and food access within households and the community?

"These practices does not require any money to practice or use and hence frees some money for the household to buy other goods and food types that the household does not produce"

"The use of these practices helps us produce food for our families, and

The use of the floor (cool dry area, non-elevated) as a storage technology led to frequent postharvest losses because leaving produce on the floor exposes the produce to insects, rats, dirt and is highly prone to changes in temperature or weather conditions e.g. sudden but heavy rainfall.

What challenges exist in your community with regards to accessing and using indigenous postharvest information?

"Unwillingness of those who possess the indigenous knowledge to share it with us".

"Lack of formal channels through which information could be shared within our community such as smallholder farmer's meetings".

"Unwillingness of smallholder farmers to form and be part of farmer groups in the area limits our ability of obtaining indigenous and even new agricultural information".

"Lack of trust between us as smallholder farmers limits the extent to which communicate with each other and the relationships we form; and most of us only work (farm) and interact with smallholder farmers who live close to us (neighbours) or those who are our friends".

Bad politics that exist within the community has led to some smallholder farmers opting to not participate in cooperatives and farmer groups.

• The poor distribution and sharing of agricultural resources between smallholder farmers.

Appendix 7: Responses from question 21 and 45 of the questionnaire (Appendix 8)

Reasons why smallholder farmers performed postharvest celebrations?	**Views of smallholder farmers with regards to what can or should be done to improve the access and use of indigenous postharvest practices and technologies in smallholder farming?**
Postharvest celebrations involved the sharing of both cooked and raw agricultural produce with neighbours and friends which was done as a show of gesture or thanks to the ancestors	"Schools should start teaching people indigenous ways of living including about indigenous farming practices to ensure that we as rural people can produce adequate food for ourselves and possibly earn an income from it"
"To share with those who do not produce any agricultural produce and with the needy"	"Government should provide us with people who will teach us about ways of effectively handling produce and applying or using indigenous postharvest practice and technologies, and show us how we could effectively integrate modern postharvest practices and technologies to our indigenous practices".
"To show appreciation for the successful harvest and also show people that the land does provide"	

Appendix 8: Survey Questionnaire

University of KwaZulu-Natal

Questionnaire

All the information provided here will be treated as **STRICTLY CONFIDENTIAL**.

Name of interviewee……

Date: …….

Area……

Section A: Socio-economic demographics

1. **Gender**

1=Male	2=Female

2. **Age**

|__||__|

3. **Marital Status**

1=Single	2=Married	3=Divorced	4=Widowed

4. **Are you the household head?**

1=Yes	2=No

5. **Total size of household_____**
6. **Level of education (of the smallholder farmer)**

1=No Formal education	2=Primary	3=Secondary	4=Tertiary

7. **Employment status (of the smallholder farmer)**

1=Employed full time	2=Employed part time	3=Unemployed	4=Pensioner

8. **Total household income per month (including off-farm income)?**

1= Below R800	2= R801 – R1500	3= R1501-R3500	4= Above R3500

Section B: Smallholder farming

9. **How long have you been farming?**

1= 1 to 5 5 years	2= 6 to 10	3=11 to 15 years	4= 16 to 20 years	5=21 to 25 years	6= more than 25 years

10. Which crops do you produce?

1= Grains	2= roots and tubers	3= vegetables	4= fruits	5= Other (please specify)

11. When do you harvest? *Mark with an x*

1= Jan	2= Feb	3= March	4= April	5= May	6= June
7= July	8= Aug	9= Sep	10= Oct	11= Nov	12= Dec

12. Why do you farm?

1= To produce food for household consumption	2= For selling	3= Both consumption and selling	4=Traditional purposes	5= Other (Please specify)

13. Who owns the land that you farm on?

1= adult female	2= adult male	3= children	4= relatives

14. Who, from your household, works on the farm with you or on the land that you farm on?

1= adult female	2= adult male	3=children	4= all household members	5= no one (I work by myself)

<u>Section C: Indigenous postharvest and technologies practices employed</u>

15. Do you use any Indigenous postharvest practices and technologies?

1=Yes	2 = No

16. Why do you use indigenous postharvest practices and/or technologies?

_____
_____
_____

17. Which Indigenous postharvest practices do you use? *mark with an x*

1= Sun drying	2= Smoking	3= Salting	4=Sugar addition	5=Winnowing	6=Blanching	7=Fermentation
8=Shelling	9=Intercropping	10=Destalking	11=Using calcium carbide	12=Washing or cleaning	13=Pickling	14=Threshing

15= Natural or field storage	16=Other, specify _____

18. Which Indigenous postharvest technologies do you use? *mark with an x*

1= Pits	2= Nested packaging	3= Fibre bags	4=Wood ash	5=Clay pots	6=Barns	7=sand or coir baskets
8=IK Silos	11=Other, specify _____					

19. Where do you get most of the raw materials needed for your postharvest operations?

1= On farm (on my own land)	**2=** Free from nature	**3=** From other smallholder farmer's in the community	**4=** Purchase	**5=** other (specify)

20. Do you perform any postharvest celebrations (indigenous or otherwise?

1=Yes	2 = No

21. If yes, why?

_____

_____

22. What do those postharvest celebrations consist of?

_____

_____

23. Do you market or sell your agricultural produce (indigenously postharvested crops)?

1= Yes	**2**= No

24. If yes, to whom? _____

<u>Section D: Factors influencing use of indigenous postharvest practices and technologies</u>

25. Do you receive any agricultural extension services in your area?

1= Yes	**2**= No

26. If yes; how does the agricultural extension service that you receive help you? (you can choose more than 1 option)

1= teach me how	**2**= gives me advice about the best indigenous	**3**= Provide agricultural information including	**4**= provide access to indigenous and (modern)	**5**= other, please specify

to farm (train me)	postharvest practices	indigenous information	agricultural technology	

27. Which factors influenced your choice to adopt or not to adopt any indigenous postharvest practices and technologies your farming practices? *Mark with an x*

1= affordability and access to finance	**2**= the need to reduce risk	**3** = the need to maximize agric. production	**4=**Confidence and faith on IPP&T	**5=**IPP&T are effective and efficient	**6=** Familiarity of IPP&T	**7=** Consideration of preharvest factors
8= Other, specify_____						

28. Do you integrate indigenous and modern postharvest practices?

1= Yes	**2**= No

29. If yes, how?

_____

_____

30. Do you integrate indigenous technologies and modern postharvest practices?

1= Yes	**2**= No

31. If yes, how?

_____

_____

32. Do you integrate indigenous practices and modern postharvest technologies?

1= Yes	**2**= No

33. If yes, how?

_____

_____

Section E: Effects of using indigenous postharvest practices and technologies

34. What effect does the use of Indigenous postharvest practices and technologies have on your agricultural productivity?

1= Greatly Decrease	**2**= Moderately Decrease	3=No effect	4=Moderately Increase	5=Greatly increase

35. Has the use of indigenous postharvest practices and technologies been beneficial or harmful to your farming or agricultural production?

1= Beneficial	**2=** Harmful	**3=** No effect

36. Have you observed any losses from your agricultural produce as a result of using indigenous postharvest practices and technologies?

1= Yes	**2**= No

37. Do you think that using indigenous postharvest practices and technologies have an impact on your household's food security?

1= Yes	**2**= No

38. If yes, does it improve or decrease your household's food security?

1= Improve	**2**= Decrease

<u>Section F: Challenges smallholder farmers face with regards to accessing and using information about indigenous postharvest technologies and practices</u>

39. How did or do you access indigenous postharvest information?

1= from local people in the area	**2=** from a formal education facility including library	**3=** from newspapers and/or government publications	**4=** Social media and social groupings	**6=** from IKS database, centre or laboratory	**5=** Agricultural extension services	**6=** other, please specify

40. Do you own a cell phone?

1= Yes	**2**= No

41. Do you use it for accessing and sharing indigenous information (postharvest or otherwise)?

1= Yes	**2**= No

42. Do you think the government should employ policy measures to promote the access and use of indigenous postharvest practices and technologies in smallholder farming?

1= Yes	**2**= No

43. Are you aware that South Africa, in 2004, implemented an Indigenous knowledge Systems Policy which seeks to protect, sustain, promote and maintain IKS?

1= Yes	**2**= No

44. What do you think should be done to increase the use of indigenous postharvest practices and technologies in smallholder farming? <u>(you can choose more than 1 option)</u> *mark with an x*

1= provision of IKS education in my own indigenous language	**2**= Improve access to Indigenous information and technologies	3= Development of IKS libraries or centres within our communities so we can access and use them	**4**= promote sharing of indigenous postharvest information and technologies within or between communities	**5**= other, please specify

45. Do you have any other views (suggestions) with regards to what can or should be done to improve the access and use of indigenous postharvest practices and technologies in smallholder farming?

_____

_____

_____

Section G: Food Security Measurement (HFIAS)

No	Question	Response Options	How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)
1.	In the past four weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2) 1=Yes	....|___|
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	....|___|
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q4) 1 = Yes	....|___|
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q5) 1 = Yes	....|___|

5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q6) 1 = Yes	….|___|
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q7) 1 = Yes	….|___|
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 = No (skip to Q8) 1 = Yes	….|___|
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q9) 1 = Yes	….|___|
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (questionnaire is finished) 1 = Yes	….|___|

Appendix 9: Focus Group Discussion and Interview Guide

Investigating the indigenous postharvest practices and technologies used in smallholder farming systems and their impacts on food security: The case of Maqongqo, Mkhambathini Municipality, KwaZulu-Natal

1. What is your understanding of Indigenous Knowledge?
2. What do you think Indigenous postharvest practices are?
3. What do you think Indigenous Postharvest technologies are?
4. Which indigenous postharvest practices do you use; and why do you use them?
5. Which indigenous postharvest technologies are used in this community; and why are they used?
6. Which factors or reasons influence your choice to use or not use indigenous postharvest practices and technologies?
7. How does using or not using indigenous postharvest practices and technologies impact your agricultural productivity, farm income, food availability and access within household in the community?
8. What challenges exist in your community with regards to accessing and using indigenous postharvest information?
9. What do you think should be done to promote the use of indigenous postharvest practices and technologies in smallholder farming?

Appendix 10: Research Procedure - Provides a summary of the objectives, data collection tools, the type of data collected and the methods for data analysis employed

Objectives	Data to be collected	Data collection techniques & tools	Analysis
To identify the Indigenous postharvest practices used in smallholder farming systems across different crop types	• Indigenous postharvest technologies and practices • Identify the farming methods used by smallholder farmers	• Questionnaires • Observations • Focus group discussions (FGDs) • Semi-structured, unstructured and Key informant interviews	• Coding • Descriptive statistics (frequencies, means) • Content and theme analysis
To determine the factors that influence the use of indigenous postharvest practices	• To determine the reasons why smallholder farmers use the indigenous postharvest technologies and practices that they use • Household demographics • Smallholder farmer's socio-economic profile or situation • Cultural practices and belief • Perceptions and stereotypes with regards to the use of IKS in postharvest • Access to essential farm inputs and resources including water	• Focus group discussions • Interviews • Questionnaires	• Content analysis • Descriptive statistics (Correlations and Cross Tabulation) • Chi-square Tests • Cramer's V • Independent samples T-Test • Fisher's Exact Tests

To identify the effects of using indigenous postharvest practices, and its impact on food security	• Determine the impacts of the used IKS postharvest practices in smallholder farming systems • Observed crop and food losses or increases • Impact of use of IKS on the household's livelihood assets • Impact of use on the food security dimensions • Effect of use on Agricultural or crop Productivity	• Semi-structured, unstructured and Key informant interviews • Observations, and Questionnaires • FGDs • Household Food Insecurity Access Scale	• Coding • Descriptive statistics (Cross Tabulation, Descriptives and Frequencies) • Chi-square Tests • Cramer's V • Fisher's Exact Tests • Content analysis • Independent samples T-Test	

Appendix 11: Ethical Clearance Certificate

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

1 October 2018

Mr Wonder Ntokozo Ngubo 210553262
School of Agriculture, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Mrs Zuma

Protocol reference number: HSS/0966/018M
Project title: Investigating the indigenous postharvest technologies and practices used in smallholder farming systems, and their impact on food security: The case of Magongqo, Mkhambathini Municipality, KwaZulu-Natal

Full Approval – Expedited Application

In response to your application received 24 July 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

Professor Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committe

/pm

cc Supervisor: Dr Maxwell Mudhara
cc. Academic Leader Research: Professor Hussein Shimelis
cc. School Administrator: Ms Marsha Manjoo