PRESERVING TRADITIONAL LEAFY VEGETABLES USING INDIGENOUS KNOWLEDGE-BASED DRYING TECHNOLOGIES TO IMPROVE HOUSEHOLD FOOD SECURITY IN LIMPOPO PROVINCE, SOUTH AFRICA

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DECLARATION

I, **SINENHLANHLA NOMTHANDAZO NYEMBE** hereby certify that I am the sole author of this dissertation, except where indicated, this is my original work. The research reported or any part of it has not been submitted for any degree or examination at any other university.

I certify that, to the best of my knowledge, this dissertation does not infringe upon another author's copyright, unless specifically acknowledged in accordance with standard referencing practices.

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DEDICATION

To my precious angels, Chunkie and Yomusa

Always remember Jeremiah 11 verse 29

ABSTRACT

Collard greens and mustard greens are among several leafy vegetables grown in the Limpopo Province. They are good sources of nutrients and are available in abundance in rural communities. However, they are seasonal and highly perishable limiting their consistent supply and utilisation to contribute to food and nutrition security. Interventions that incorporate indigenous knowledge system (IKS)-based technology for processing, like drying, on traditional food items like the aforementioned traditional leafy vegetables (TLVs) may improve food and nutritional security and livelihood options of, particularly, the predominantly resource-poor rural households. Preservation of the TLVs by appropriate technologies could improve utilisation by availing TLVs off-season and providing an opportunity to earn higher income from the value added TLVs. However, the effects of the proposed preservation technologies on the quality, microbiological safety and consumer acceptability of the TLVs should be assessed.

Focus group discussions held with rural and urban participants, provided insights into consumer consumption patterns, perceptions and utilisation of TLVs. The focus group discussions indicated that the green colour of the TLVs was an important quality indicator for perceived high nutritional value. However, the consumption patterns of the TLVs were negatively affected by the stigma attached to the TLVs. Having the TLVs only available in the informal markets, at certain seasons, limited their wider utilisation, especially among the youth and urban consumers, because of no or very limited exposure to the TLVs.

The effects of the two preservation methods, the adapted indigenous method of blanching and sun-drying and the modern method of blanching and oven-drying, on the quality and microbiological safety of the TLVs were assessed by monitoring changes in their colour, texture, nutritional composition and microbiological content. The results indicated that the innovative IKS-based method of drying maintained colour better than the modern drying method, however, the opposite was true for texture. The different preservation methods had varying effects on the nutrient content of the two TVLs types. The total microbiological load and composition of the TLVs processed using the two preservation methods were generally within the acceptable limits.

Consumer panels of 28 rural and 34 urban dwellers participated in the study to rate the sensory attributes of the differently preserved TLVs on a 5-point pictorial hedonic scale. The rural dwellers found the aroma, texture and colour of sun-dried TLVs more acceptable than oven dried TLVs. Urban residents had differing preferences for the sensory attributes of the two processing methods, but, overall, the sun-dried TLVs were preferred over the oven-dried TLVs. The interfacing intervention of modern and indigenous processing technology was found to be acceptable to the consumers; this has positive implications for improving food and nutritional security and livelihood options of resource-poor rural households.

Keywords: Traditional leafy vegetables (TLVs); indigenous knowledge system (IKS)-based drying technology; altered IKS method; sun drying; oven drying; preservation.

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ABBREVIATIONS

AOAC	Association of Analytical Chemists
CG	Collard greens
EC	Eastern Cape
GDP	Gross Domestic Product
IKS	Indigenous Knowledge System
KZN	KwaZulu-Natal
LP	Limpopo
MG	Mustard greens
NGP	New Growth Path
NPCSA	National Planning Commission South Africa
OBCG	Oven-dried blanched collard greens
OBMG	Oven-dried blanched mustard greens
PHH	Post harvest handling
RBCG	Raw blanched collard greens
RBMG	Raw blanched mustard greens
RUCG	Raw untreated collard greens
RUMG	Raw untreated mustard greens
RRA	Rural Rapid Appraisal
SAGI	South African Government Information
SBCG	Sun-dried blanched collard greens
SBMG	Sun-dried blanched mustard greens
SUCG	Sun-dried untreated collard greens
SUMG	Sun-dried untreated mustard greens
TLV	Traditional Leafy Vegetable
UV	Ultraviolet

CHAPTER 1: STATEMENT OF THE PROBLEM

1.1 Background

In developing regions like Sub-Saharan Africa, agriculture is the main source of livelihood, however, this source is characterised by being poorly resourced (Voster *et al.* 2007). In South Africa, smallholder farmers have common wide ranging challenges that limit productivity. These include inadequate natural resources (land and water), limited access to credit and formal markets, poor local infrastructure and limited return on investment (Oni *et al.* 2010). Smallholder farmers therefore, tend to produce for their own consumption or at most, to sell at informal markets to sustain livelihoods (Lewu & Assefa 2009). Smallholder farmers also tend to produce as per seasons' market demands because it becomes unsustainable for them to produce crops that consumers will not buy.

Hunger and malnutrition are a problem for over 48% people living below poverty line[1] in South Africa (NPCSA 2013). The majority of malnourished households also have an undiversified diet and as such they lack daily intake of many essential micronutrients (Gupta & Prakash 2011). Malnutrition is rife among rural communities like those living in KwaZulu-Natal (KZN), Eastern Cape (EC) and Limpopo (Oni *et al.* 2011). The ideal solution would be finding socio-economically viable alternatives for supplying the deficient nutrients. The alternative could include obtaining the nutrients from the underutilised, nutrient-rich domesticated and wild plant foods through preservation methods that can bridge seasonal availability gaps (Ndawula *et al.* 2004; Misra *et al.* 2008; Sikora & Bodziarczyk 2012). More research into local, domesticated and wild leafy vegetables is essential because these underutilised plant foods could be used as alternate food sources to achieve food and nutrition security (Misra *et al.* 2008).

In South Africa, rural area dwellers use local, wild and domestically grown leafy vegetables as an addition to the main staples in order to diversify their diet (Misra *et al.* 2008; Voster *et al.* 2007). These leafy vegetables include cowpea leaves, pumpkin leaves, collard greens and mustard greens. The vegetables are an abundant and inexpensive source of micronutrients, but, they are seasonal and perishable. Hence people tend to depend on them to enrich their

[1] Poverty line of US$2 per day, 2008 statistics.

diets with essential vitamins and minerals only when they are in-season (Gupta & Prakash 2011; Masarirambi *et al.* 2010). The rural households usually store vegetables in a dried state in order to be able to use them during times when they are not readily available (Misra *et al.* 2008). This is additionally beneficial because the money saved from purchasing fresh vegetables can then be used for other needs (Oni *et al.* 2011). Traditional leafy vegetables (TLVs) like cowpea and pumpkin leaves have been found to have a higher nutritional value than the commonly utilized domesticated vegetables but their usage is limited by several factors like sensory properties, market availability of seeds or vegetables, consumers being uninformed about their nutritional value or preparation methods, consumers having negative perceptions of associating them with poverty, a perceived low cost-to-benefit ratio for the farmers and the limited use of indigenous knowledge of drying on them (Masarirambi *et al.* 2010; Voster *et al.* 2007).

Studies conducted in rural populations in Limpopo (LP) and KwaZulu-Natal (KZN) to identify commonly-consumed TLVs did not identify collard greens (*Brassica oleracea*) as commonly consumed and only one study identified mustard greens (*Brassica juncea*) as one of the most consumed leafy vegetables (Jansen van Rensburg *et al.* 2012; Ntuli *et al.* 2012; Makuse & Mbhenyane 2011; Faber *et al.* 2010). The two TLVs under study, collard greens and mustard greens, are underutilised vegetables that are cultivated domestically in the Limpopo province. The local communities in Limpopo grow several leafy vegetables other than the collard greens and mustard greens, such as cowpea leaves and pumpkin leaves for household consumption. Similar to other TLVs, collard greens and mustard greens are good sources of several nutrients, including vitamins, minerals and fibre; they are also a good source of other chemical components with effective anticancer, antiviral and antibacterial properties (Makuse & Mbhenyane 2011; Cartea *et al.* 2011). It is a common practice in Limpopo to dry vegetables such as cowpeas to prolong their shelf-life and then use them as a household safety net strategy (Voster *et al.* 2007). However, it has been noted that collard greens and mustard greens are not preserved through drying. It is not known why preservation by drying, which is common practice for preserving leafy vegetables, is not being applied on the two types of leafy vegetables, collard greens and mustard greens. Furthermore, there is a unique opportunity to explore the preservation of these vegetables using the traditional drying techniques and further interfacing them with modern drying techniques.

1.2 Problem statement and motivation for the study

South Africa has a burden of malnutrition and hunger; limited employment opportunities make it difficult for people to have purchasing power to meet their nutritional needs. The current socioeconomic conditions do not promote food and nutrition security at all levels. A state of food security is achieved when conditions that support the availability of food resources, access to such resources, adequate consumption and appropriate utilization of food in a nutritious and hygienic manner are attained at all times for all people (Baro and Deubel, 2006; Clover 2003). Without affordable and easily accessible interventions, the problem will escalate into a bigger socioeconomic issue for government and other food security relevant stakeholders.

For resource-poor rural households, purchasing fresh vegetables is costly in the long term as the vegetables are perishable whilst the cost of sourcing them (*i.e.* transport to and from markets) is high. Inadequate nutrition makes people susceptible to health problems, which in turn limits their potential for earning a living to provide for their basic needs. Climate change is also playing a significant role because the volatile and dry weather conditions make non-irrigated farming difficult, thus promoting the vulnerability of food production systems, underdevelopment and the persistence of poverty among the vulnerable smallholder farming households (Beddington *et al.* 2012). Yet, in parts of South Africa, such as the Limpopo province, there are abundant local, wild and home-grown leafy vegetables that are nutrient-rich and adapted to the predominantly harsh agro-climatic conditions (Sithole & Chitja 2011, Van der Walt *et al.* 2009). There is therefore a need to increase their utilisation by applying appropriate technologies to maximise the potential of these leafy vegetables.

There is little or no research focussed on the processing and marketing of TLVs to increase their utilisation. Innovative and appropriate technologies, including preservation by drying, for processing these vegetables into value added products could increase their utilization and thereby improve the livelihoods and food and nutrition security of these households. The household incomes could increase from the sale of the value added products in high-value formal markets and their nutritional security would also improve due to a rich, diversified diet comprised of these vegetables and other food types purchased with the increased income.

1.3 Aim of the study (General objective)

The aim of this study was to evaluate the potential of processing and preserving underutilised TLVs namely, collard greens and mustard greens, by interfacing indigenous and modern drying techniques to maximise their utilisation for enhanced household livelihood, food and nutrition security in Greater Tzaneen (Lenyenye township) and Greater Letaba (Mawa village) municipalities, Limpopo province of South Africa.

1.3.1 Objectives

1. To investigate the effects of sun and oven drying technologies on the nutritional and physical quality of collard greens and mustard greens.
2. To assess the microbiological quality and safety of the sun and oven dried collard and mustard greens.
3. To determine the effect of sun and oven drying on the consumer acceptability of collard greens and mustard greens.

1.3.2 Research questions

This study investigated the effects of two drying methods *(sun drying and oven drying)* on collard greens (*Brassica oleracae*) and mustard greens (*Brassica juncea*) vegetables, looking at drying effects on the quality (colour, texture and microbial) and nutritional content (proximate composition and minerals) to determine if the processed vegetables have potential to add value for farmers and consumers. The questions the study will be looking to answer include:

- Can collard greens and mustard greens vegetables be successfully preserved by drying?
- Will the drying process affect the quality and nutritional composition of the vegetables?
- Are the processed vegetables acceptable to the consumers familiar with the product?

1.4 Study Limits

This study cannot be generalised as the selected consumer sample would not be a true representation of the populations of the province. The cost of analysis limited the variety of tests that could be performed on the nutritional composition of the vegetables, the effect of processing on vitamins present in the vegetables were not included in the scope of analysis.

1.5 Assumptions

The following assumptions are of relevance for the purpose of this study and its validity

- The participants will be an acceptable representation of the population, would be willing to participate in the study and respond to questions honestly without bias.

1.6 Definition of Terms

Blanching: The heat pre-treatment of fruit and vegetables, which is meant to inactivate enzyme activity before processing through dehydration in order to inhibit some physiological processes that cause food deterioration through the development of undesirable colour, odour and flavour (Wen *et al*. 2010).

Dehydration: is a preservation technique where the product is exposed to heat conditions that will reduce its volume and weight through the decrease in moisture level (Afolabi 2014).

Food security: Is a state where all people at all times have economic and physical access to available of food resources, that are appropriate for nutritious and hygienic utilization, and are adequate for consumption in a manner that satisfies their food preferences.

Naturalised: are plant species that do not originate in the local region but their growth and widespread use in that region has rendered them to be considered endemic to that region (Jansen van Rensburg *et al.* 2012).

Post-harvest handling: the chain of processes carried out immediately from harvesting a plant until it reaches the consumer as a product. These processes include harvesting, handling, storage, processing and marketing.

Quality: is a measure of standard which denotes excellence or an acceptable level of the trait being evaluated either sensorially or instrumentally. The traits in the vegetables under study include colour, texture, aroma, appearance, nutritional value and microbial safety.

Traditional leafy vegetables: are the wild, indigenous or uncommon cultivated crops whose parts (*i.e.* leaves, shoots, seeds, flowers or fruits) are consumed either raw or cooked as vegetables by local communities, are naturalised to that region through use from generation to generation (Sithole & Chitja 2011).

1.7 Organisation of Dissertation

There are six chapters in this dissertation. The first chapter addresses the problem and its setting. Chapter two is focused on the review of literature that has informed the information gaps identified for the research questions. Chapter three outlines the conceptual framework, methodology and description of the study area. Chapter four and five discusses are research chapters presenting the findings. Chapter six concludes by summarising the outcome of the study findings and recommendations for future studies that would be of relevance.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction to food security in South Africa

South Africa is generally referred to as a middle-income developing country and is reported to be food secure at national level (NPCSA 2013). However, according to Oni *et al.* (2011), there is a significant food insecurity challenge at household level in both the rural and peri-urban areas. Most households lack access to sufficient food and adequate intake of micronutrients, which according to Gupta and Prakesh (2011), is not uncommon in developing countries. Over 48% of people in South Africa live below the poverty line[2] (NPCSA 2013). Adverse socioeconomic conditions, such as high levels of unemployment, high living cost (*i.e.* energy, food, transport), lack of stable income and poverty put pressure on households, rendering people less capable of providing themselves with basic needs (Beddington *et al.* 2012; Labadarios *et al.* 2011; Voster *et al.* 2007). Such conditions limit household production capacity and affect the ability to purchase nutritious food making them susceptible to disease and other social vulnerabilities (Oni *et al.* 2010). Although South Africa demonstrates a growth potential, having such a high number of vulnerable households limits the country's socioeconomic development potential.

Agriculture has an important socioeconomic role as it contributes 12% to the South African GDP, provides a livelihood to 16.6% of the workforce and many rural households (SAGI 2012). The sector has the potential to employ 33% of the country's labour force (Louw *et al.* 2008), accounting for South Africa's placement of agriculture in the New Growth Path as one of the drivers of economic growth through job creation in the smallholder and agro-processing sectors (SAGI 2012). However, it should be noted that environmental factors associated with global climate change are affecting agricultural production in South Africa through water shortages, unpredictable weather patterns and flooding. This maximises risk exposure for adaptation in local vulnerable households that mainly rely on agriculture as the source of livelihood (Beddington *et al.* 2012; Zhu & Ringler 2012; Quinn *et al.* 2011; Jensen *et al.* 2009).

There is a need for migration into food consumption habits that are highly adapted to environmental and socioeconomic effects. An example would be to adopt consumption of

[2] Poverty line of US$2 per day, 2008 statistics

wild vegetables, which are resistant to the effects of climate change, can be harvested in a short period and require minimal inputs for cultivation (Van Jaarsveld *et al.* 2014; Sikora & Bodziarczyk 2012; Schönfeldt and Pretorius 2011; Misra *et al.* 2008; Voster *et al.* 2007). This intervention should be complemented by preservation methods that could bridge seasonal availability gaps in food supply, faced by households (Ndawula *et al.* 2004). The wild, indigenous and domesticated cultivated plants, referred to as traditional leafy vegetables (TLV) in this study, are plants whose parts (*i.e.* leaves, shoots, seeds, flowers or fruits) are consumed either raw or cooked as vegetables by local communities and are naturalised to that region (Matenge *et al.* 2012; Sithole & Chitja 2011; WHO 2003). According to Schönfeldt and Pretorius (2011), there are over 7000 species of plants globally that can be categorised as TLVs. However, plants cultivated for human consumption and dietary research tend to overlook the value of wild and indigenous plants. This is a shortcoming because indigenous knowledge of consumable, medicinal and preparatory aspects of these wild plants remains neglected and could even be lost due to changing population dynamics in rural areas where such practices are commonly observed (Misra *et al.* 2008; Voster *et al.*, 2007).

2.2 Underutilised leafy vegetables

In South Africa any dark green leafy vegetable is collectively referred to as imifino (Nguni languages) or morogo (Sotho languages), there may be slight variations in spelling from the different Nguni/Sotho groups but the terms are the same (Jansen van Rensburg *et al.* 2012; Faber *et al.* 2010). The consumption habits of leafy vegetables tend to be confined to areas where these vegetables are grown and are thus determined by local perception, ethnic bias, tradition and common agricultural practices (van der Hoeven *et al.* 2013; Labadarios *et al.* 2011; Kahlon *et al.* 2008; Kayode *et al.* 2008). Faber *et al.* (2010) identified that a low intake of fruit and vegetables is a risk factor in the high mortality rates associated with diet-linked chronic diseases and micronutrient deficiency. Several international organisations like the World Health Organisation (WHO) and United States Department of Agriculture (USDA) recommend the consumption of fruit and vegetables to prevent diet-related illnesses (Jaarsvel *et al.* 2014). The USDA proposes that 1.5 to 2 cups of dark green vegetables, including collard greens and mustard greens, should be consumed per week (USDA 2013).

TLVs provide vitamins, minerals, essential nutrients and antioxidants necessary to promote human health and disease prevention (Khattak 2011; Sithole & Chitja 2011). Several studies have been conducted on TLVs owing to their perceived potential to contribute positively to improving household food security. Researchers believe that these vegetables are readily accessible in rural communities, have a high nutritional value and contain antioxidants and other compounds that are beneficial to health (Akeredolu & Adebajo 2013; Sikora & Bodziarczyk 2012; Cartea *et al.* 2011; Sithole & Chitja 2011; Kahlon *et al.* 2008).

Literature confirms that many green leafy vegetables, like *Brassica*, are less familiar and thus are among the underutilised vegetables (Cartea *et al.* 2011). They are a rich source of antioxidants and other nutrient compounds. Their natural composition has high levels of carotenoids, vitamins, iron, minerals, fibre and ascorbic acid, among others (Kim *et al.* 2013; Cartea *et al.* 2011). The two vegetables under study are cruciferous vegetables of the Brassicaceae family (Table 2.1) and they are called in different names depending on ethnic groups and geographical locations.

Table 2.1: Description of two TLVs under investigation in study

Common name	**Scientific name**	**Local name**	
Mustard Greens	*Brassica juncea rugosa*[3]	Pedi	Mokhwarepa (Tzaneen) MoChayina (Polokwane)
		Zulu	Masihlalisane
Collard Greens	*Brassica oleracea acephala*[4]	Pedi	Phophoroka
		Zulu	Ntileshi

Table 2.2 compares the micronutrient content of some exotic vegetables with those under study. The study vegetables are documented by Kahlon *et al.* (2008) to have higher fibre content than exotic vegetables.

[3] Source Cartea *et al.* (2011)
[4] Source Cartea *et al.* (2011) and Kahlon *et al.* (2008)

Table 2.2: Nutrient composition of Spinach, Cabbage, Collard greens and Mustard greens

	Dry matter %				
	Total dietary fibre	**Protein**	**Fat**	**Ash**	**Carbohydrates**
Mustard greens	34.0	40.9	3.9	16.7	38.5
Collard greens	36.3	21.3	5.8	16.3	56.6
Spinach	27.1	38.2	4.6	28.1	29.0
Cabbage	29.9	23.1	4.4	10.5	62.0

Source: Kahlon *et al.* (2008)

These vegetables are highly beneficial to the health of the consumer, not only due to their richness in antioxidants but also for their antimicrobial and medicinal properties (Kim *et al.* 2013). Van der Walt *et al.* (2009) reported on a link found between a high antioxidant protection, derived from supplement extracts of TLV compounds, with decreased incidents of cancer and chronic diseases. Smith and Eyzaguirre (2007) also reported that parts of the TLVs, like roots, are used in traditional medicines in rural communities because of their non-nutrient bioactive properties and phytochemicals.

2.3 Preservation of traditional leafy vegetables

It is common for households to devise means to adapt to unfavourable circumstances as a survival mechanism. For example, to overcome seasonal shortages, households apply an indigenous knowledge system (IKS)-based preservation technique of sun drying to preserve vegetables and other foods such as meat and fruits (Faber *et al.* 2010; Tembo *et al.* 2008; Muchoki *et al.* 2007). Preservation ensures that the biological activity is minimised in order to reduce the threat of microbial growth to the health of a consumer (Demarchi *et al.* 2013; Nguyen-The 2012). Findings by Voster *et al.* (2007) revealed that in rural households, dried vegetables form the basis of up to 80% of winter food consumption.

Masarirambi *et al.* (2010) has recognised that drying techniques require attention to detail in matters such as weather conditions and time frame necessary for optimal drying and this skill is passed on through generational knowledge transfer. There is a noticeable decline in indigenous knowledge transfer with a decrease in preservation and utilisation in some rural households. Older rural women continue to master the skill due to common practice and experience; however, there is seldom knowledge and skill transferred to younger generations. Researchers agree that the local knowledge existing in communities regarding these vegetables and other functional aspects perceived to be associated with parts of these vegetables, like health benefits, need to be documented (Ntuli *et al.* 2012; Makuse & Mbhenyane 2011).

2.3.1 Preservation techniques

Preservation through sun drying is the logical option for rural households that have limited resources because of the low the cost of such preservation. However, several research studies have identified that the sun drying method leads to high nutrient losses in the dehydrated vegetables while it also requires a longer drying period for appropriately reduced moisture content (Faber *et al.* 2010; Muchoki *et al.* 2007; Bankole *et al.* 2005). Since there is no even regulation of heat, vegetables can be over-dried or under-dried (Tembo *et al.* 2008). Sun drying also exposes vegetables to contaminants like dust and insects (Afolabi 2014). Lastly, direct ultraviolet (UV) exposure causes the vegetables to discolour and lose nutrients excessively (Tembo *et al.* 2008).

Apart from sun drying, there are other preservation technologies that households can employ for preservation. These technologies include solar-drying, oven-drying, freezing, canning or bottling, summarised in Table 2.3. Djuikwo *et al.* (2011) indicates that the commonly practiced preservation methods traditionally are boiling (canning) and sun drying.

Table 2.3: Summary of various preservation techniques

	Sun[5]	Solar[5]	Oven	Freeze[6]	Bottling/canning
Method	Expose food directly to the sun or in a shade to remove moisture	Expose food to the sun through covered solar panels to remove moisture	Expose food to high temperature that is constant to remove moisture	Package and freeze fresh food items in an airtight container	Apply heat to food items that are sealed in an airtight container
Input	None	Solar panels	Oven Electricity	Refrigerator Electricity Pre-freezing treatment	Heat resistant container Electricity/fire
Effect	Causes the highest loss of b-carotene, vitamin A and vitamin C content	Causes loss of some b-carotene, vitamin A and vitamin C content	Causes loss of some b-carotene, vitamin A and vitamin C content	Retains sensory and nutrient quality, losses are in the pre-treatment phase	Causes loss of some b-carotene, vitamin A and vitamin C content
Time	3***	3***	2**	1*	Unknown
Shelf-life	Up to 1 year	Up to 1 year	unknown	Less than 6 months	Unknown

Note on time: Preservation 1* is faster than 2**, which is faster than 3***

These techniques may not all be applicable to the rural situation, or even to some urban households, due to lack of resources. In a study by Van der Hoeven *et al.* (2013), researchers found that about 65% of participants did not have access to a fridge/freezer; hence preservation method options that could be applied by such households were limited. When taking into consideration the limited resources of households living in poverty, a method requiring minimal input becomes a sound choice for any intervention. Sun drying is an ideal method for poor households because it requires resources already accessible and is less time consuming as people can leave items to dry while attending to other domestic responsibilities.

On the other hand, solar drying is being studied as an alternative to sun drying. This is because the cover which prevents direct sun exposure has potential to reduce nutrient losses and other effects of direct UV exposure, and it is a more hygienic method. Seidu *et al.* (2012) found that it took 3 to 5 days to dry indigenous vegetables using solar panels, which is a relatively long period. It would be anticipated that due to a relatively good heat circulation in solar panels, the constant even distribution of heat would facilitate for more rapid drying. Mdziniso *et al.* (2006) found that oven drying, just like solar drying, retains more carotene than sun drying, it also reduces drying time, allows for even heat distribution and improves

[5] Adapted from Ndawula *et al* (2004).
[6] Adapted from Tosun & Yücecan (2007).

some sensory attributes like colour and texture. However, due to unaffordable inputs required with some of the preservation technologies, sun drying is the simplest, affordable and easily accessible means for poor households to preserve seasonal foods (Masarirambi *et al.*, 2010).

2.3.2 Effects of preservation by drying on the quality of leafy vegetables

Preservation is necessary for extending the shelf-life of a product and preventing post-harvest waste often associated with the seasonal abundance of low-value stock produce (Sagar & Suresh 2010). Of the various preservation technologies commonly applied, several authors have identified that sun drying causes greater loses of vitamin C (Faber *et al.* 2010; Muchoki *et al.* 2007; Ndawula *et al.* 2004). Table 2.4 shows different effects of preservation applications in terms of nutrient losses caused to food. As depicted in the table, drying causes the greatest loss in vitamin composition. A product that is dried and cooked looses more nutrients than a product that is frozen and cooked. This is however dependant on the type of food item, temperature, food dimensions and the time frame the food item is exposed to the preservation element (Mdziniso *et al.* 2006).

Table 2.4: Typical maximum nutrient losses (%) from processing compared to raw food

Vitamins	**Dry**	**Freeze**	**Cook**	**Cook+Drain**	**Reheat**
Vitamin A	50	5	25	35	10
Vitamin C	80	30	50	75	50
Vitamin B6	10	0	50	65	45
Vitamin B12	0	0	45	50	45
Alpha Carotene	50	5	25	35	10
Beta Carotene	50	5	25	35	10
Thiamin	30	5	55	70	40
Riboflavin	10	0	25	45	5
Minerals					
Calcium	0	5	20	25	0
Iron	0	0	35	40	0
Sodium	0	0	25	55	0
Zinc	0	0	25	25	0

Source: USDA (2003)

Processing affects the quality of the food product including attributes like nutrients, colour, texture and to some extent, flavour (Nyambaka & Ryley 2004). Therefore, the measure of an efficient preservation strategy is based on how much of the quality in terms of nutrients, colour, texture and flavour is retained after processing (Kaur *et al.* 2008).

There are several factors that contribute to the determination of product quality after processing. The main factor being the temperature under which the product was dried. This is because temperature has influence on the physiochemical composition which affects the final moisture content, nutritional composition, colour and texture of a product (Gamboa-Santos *et al.* 2014, Henriques *et al.* 2012). Other factors include the type of processing technique that was applied and duration of exposure to the processing method. According to Giri and Prasad (2009) and Sagar and Suresh (2010), the quality of food in terms of flavour, colour, texture, nutrient quality and microbiological safety is a key determinant of product acceptability by the consumers. Hence, it is critical to ensure that an acceptable level of quality in any processed food item is retained.

Texture and colour are important attributes for determining final product quality and appeal (Chen & Opara 2013; Toivonen & Brummell 2008). Controlling processing parameters in a manner that ensures that texture and colour are not adversely affected is important because the mechanical changes that affect these quality measures also influence the sensory quality of food (Guine & Barroca 2012).

Colour refers to the external appearance of a food item which generally influences its visual appeal. To a consumer, colour is the most visible trait that enables for an assessment of perceived quality (fresh, ripe, decay), and it is associated with specific nutritional benefits and flavour (Wu & Sun 2013; Guine & Barroca 2012). The green colour of vegetables is perceived to be an indication of richness in nutrients and antioxidants, containing compounds that act as a natural detoxing agent and the darker the colour, the more bitter the item is expected to be. For fresh green leafy vegetables, Toivonen and Brummell (2008) indicate several factors that can negatively affect appearance to a point where a consumer may reject the quality. These include post-harvest influences like washing which increases enzymatic activity, yellowing due to chlorophyll deterioration, browning due to wound effects, microbial colonies on vegetable surfaces and drying. Drying vegetables that are already displaying these factors will have a negative impact on the final product quality.

Texture refers to the structural attributes of a product that can be measured through subjective (human) and objective (equipment) methods (Chen & Opara 2013). According to Toivonen and Brummell (2008), texture in food items can be measured through crispness, hardness, softness and fracturability among others. Various factors contribute to the texture of a processed vegetable, these include the drying methods, length of exposure to the source of drying and the processing preparation techniques applied on the vegetable before drying (Sagar & Suresh 2010). In a study conducted on lettuce by Martin-Diana *et al.* (2006), researchers found that using the Kramer cell to measure the maximum load produced repeatable results for the measurement of the breaking and chewing traits of the leafy vegetable.

As mentioned in earlier sections, TLVs are a good source of vitamins, minerals and antioxidants necessary for a healthy diet and disease prevention. However, any form of processing such as harvest, washing, chopping, cooking, storage, temperature or preservation has an influence on the deterioration of vegetable quality and nutrient retention (Barrett *et al.* 2010). The method selected to dry leafy vegetables has an influence on the level of nutrient quality retained; generally, the lower the temperature used, the better the prospect of higher nutrient retention (Sagar & Suresh 2010). The degree to which vitamin C is retained in a dried product can be used as an indicator of quality of preserved product because this is a sensitive nutrient. If this nutrient is retained in a reasonable quantity then it implies that the rest of the not so sensitive nutrients are retained (Gamboa-Santos *et al.* 2014; Barrett *et al.* 2010).

As an acceptable measure of quality, dried products should also be free of pathogenic microbes commonly influenced by the moisture content of processed vegetables. This is because low-level moisture content can prevent the development of mould and other contaminating microorganisms (Bankole *et al.* 2005). An effective drying process reduces the moisture content in vegetables from 80% to a level below 10%; this should minimise bacterial and enzymatic activity to a level where their presence is almost not viable (Sagar & Suresh 2010). Microorganisms can exist on any structure or material, which makes contamination of food through handling, equipment, processing and storage a probable source of microbial contamination.. Some of these contaminants are already present in the soil, manure or water used to produce the food item. *Bacillus cereus*, *Escherichia coli* and

Salmonella are some examples of pathogens that can be present in food items which are as a result of contact with other inputs like soil, fertilisers and water, or transferred through contact with animal deposits (Nguyen-The 2012). The change from fresh to processed vegetables through the drying technology, according to Voster *et al.* (2007), commonly causes diarrhoea.

Storage conditions of a processed product have a vital role in maintaining conditions that inhibit microbial growth. Fungi for example, have an optimal growth environment at 30°C; thus, if dehydrated vegetables are kept at room temperature in a range of 25-30°C, this may be the optimum environment for their growth (Akeredolu & Adebajo 2013). This indicates how important it is to pay attention to, and control, environmental conditions like temperature and humidity during storage.

Blanching is a heat pre-treatment that inactivate enzymes before processing in order to inhibit activities that cause food deterioration. The IKS-based drying methods of households in places like Limpopo sometimes involve blanching vegetables before drying; however, this is not always the case (Voster *et al.*, 2007). In studies by Wen *et al.* (2010) and Oboh (2005), researchers found that blanching various vegetables, for 5 or 10 minutes respectively, caused the antioxidant activity to decrease, increase or remain, depending on the type of vegetable. In addition, Ndawula *et al.* (2004) found that blanching vegetables before drying them improved the retention of some vitamins. Even though the nutritional value is expected to be highest in raw vegetables (Masarirambi *et al.* 2010), Wen *et al.* (2010) reported that there are some vegetables that experience an increase in carotene and antioxidant activity as a result of blanching compared to the raw counterparts.

Blanching also has a positive impact on sensory attributes as it has a positive effect on colour, texture and flavour retention (Mdziniso *et al.* 2006). Furthermore, a study by Seidu *et al.* (2012) found that blanched samples preserved using solar-drying techniques had a higher percentage of weight reduction compared to non-blanched samples, indicating that drying is more effective in blanched samples. This then implies that non-blanched samples not only take longer to dry, but they may also have a moisture level that potentially encourages bacterial activity. This could explain the finding by Voster *et al.* (2007) that dried vegetables sometimes cause diarrhoea.

2.4 Effect of processing on consumer acceptability: *perception and sensory acceptability*

Human perception is the yardstick for any sensory measurement of quality in terms of product acceptability (Barrett *et al.* 2010). Individuals process sensory quality in different ways, hence it should be expected that their perception of the palatability of food products will be highly variable and will also have an influence on their food choices (Naish & Harris 2012). The acceptance and selection of a food product by the consumer is dependent on traits that are perceived to be related to a good quality measurement for palatability. These traits include visual appearance, texture, aroma and taste (van der Hoeven *et al.* 2013; Naish & Harris 2012; Giri & Prasad 2009). According to Guine and Barroca (2012), colour is the primary quality attribute that is evaluated by a consumer for determining acceptance. This notion is also supported by the findings of Wu and Sun (2013) who indicated that for market acceptability, colour is key because even if the presented food item contained all the known characteristics like aroma and flavour, a diversion from the expected colour will act as a deterrent to market acceptance, due to perception.

The stage of selection prior to processing for preservation also has an influence on the quality of nutrients retained (Barrett *et al.* 2010). Therefore, before a fresh food item is processed, it is important to determine selection criteria that will ensure efficient retention of the quality measures (Appiah *et al.* 2012). These criteria could include selection when the vegetable is still young and tender, unripe, ripe or over-ripe. Factors that measure quality of a product such as texture, appearance, sensory and their microbiological traits are important indicators in determining potential acceptability of a product by consumers (Giri & Prasad 2009).

The migration into studying indigenous vegetables is meant to address the nutrient deficiency problem. However, some research indicates that the adoption of these vegetables could be faced with perception challenges of being regarded as poverty vegetables, especially by the urban and youth consumers (Sithole & Chitja 2011; Faber *et al.* 2010; Narayanan & Kumar 2007). A study by Faber *et al.* (2010) concluded that since the TLVs are generally regarded as food for the poor, in promoting consumption of these vegetables, issues of cost should not be highlighted. However, according to Matenge *et al.* (2012), consumers accept products based on availability in formal markets, value-added benefits plus the sensory characteristics (taste, appearance, smell, etc.), instead of accepting based on the perception of association with poverty. Consumers are migrating toward seeking value-added solutions that are not only a good source of nutrition for health benefits, but are also economic (Khattak 2011).

2.5 The potential of preservation of underutilised leafy vegetables by drying to enhance rural household livelihood options, food and nutrition security

The collard greens and mustard greens are winter vegetables, hence their availability is seasonal and like all vegetables, they are perishable. The option of adding value to these vegetables by appropriate preservation and storage would make them available throughout the year (Akeredolu & Adebajo 2013; Seidu *et al.* 2012). The processing value of TLVs can only be achieved as a healthy alternative for consumers if the impact of the preservation process does not drastically interfere with the nutrient composition in comparison to the raw product (Nguyen-The 2012). If this is found to be the case, such leafy green vegetables could be ideally utilised in reducing high micronutrient malnutrition, associated nutritional disorders and the prevalence of degenerative diseases, as Gupta *et al.* (2005) believes these are the challenges faced by developing countries.

According to Viatla *et al.* (2009), rural livelihood development initiatives that focus on agriculture, like the interventions being studied in the current work, aim to improve and stabilise household incomes. A similar initiative on TLVs conducted in East Africa for smallholder farmers was found to address food security and income needs at household level. The farmers in that study indicated that TLVs are low in cost, usable during off-season through preservation and value-addition, generate income for women and their market availability increased demand for TLVs in Kenya and Tanzania (Muhanji *et al.* 2011). However, it took awareness campaigns targeted at both the farmers' and consumers' perceptions in some areas to achieve success. In another study by Chelang'a *et al.* (2013), researchers found that urban consumers in Eldoret, a town in Kenya, preferred, and were willing to pay a premium cost for, TLVs instead of exotic vegetables. Between 2003 and 2006, these researchers found that the consumption and farm gate value of TLVs increased from 31 tonnes (US$ 6 000) to 600 tonnes (US$ 142 000) respectively, drastically improving the income of smallholder farmers. Since there is trading of these TLVs in the informal markets in Limpopo and KZN, it indicates that there could be potential for commercial value.

2.6 Summary

Accelerated growth in the agricultural sector would be an effective means for reducing poverty because compared to other sectors of economic development; agriculture has a greater effect on poverty alleviation efforts as it provides a source of income, employment and livelihood for resource-poor households (Lyne *et al.* 2009). TLVs are an opportunity for a niche market or for smallholder farmers to supplement onto their livelihoods, but also for households to cultivate for domestic consumption as these vegetables are nutrient rich and require minimal input (Sikora and Bodziarczyk 2012). Seasonal availability presents an opportunity to add-value to these vegetables during times of abundance so that in a preserved form, they can be made available off-season. Drying as a technology is convenient for almost all households who are willing to attempt preservation. The challenge for research is to find ways to minimise the loss of nutrients that is associated with sun-drying technologies that the households may already be familiar with. Adding the blanching process for a period less than the 5-10 minutes presented in research (Wen *et al.* 2010; Oboh 2005) could yield more positive results for nutrient retention.

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CHAPTER 3: CONCEPTUAL FRAMEWORK, OUTLINE OF METHODOLOGY AND DESCRIPTION OF THE STUDY AREA

3. Introduction

In this chapter, the conceptual study framework, study design framework showing different methods used for collecting data and the ethical aspects are presented.

3.1 Conceptual framework

Collard greens and mustard greens are among several leafy vegetables grown in the Limpopo Province which are good sources of nutrients. To improve food and nutritional security in households, interventions that incorporate IKS based technology for processing, like drying, on traditional food items like the aforementioned TLVs are proposed. This could be the most feasible method because it has relatively low input costs and, the rural households are familiar with the practice as it has been passed through generations to prolong the shelf-life of similar food items. Researchers have however, reported that the traditional method of preservation depletes many nutrients and may negatively affect sensory properties of a product (Guine & Barroca 2012; Barrett *et al* 2010; Sagar & Suresh 2010). This provides a unique opportunity to investigate the potential of interfacing the modern and indigenous technologies to determine the method more effective in retaining the quality and safety of the processed vegetables. The modern technology interventions include oven-drying and blanching, the indigenous technology is sun-drying.

The effects of processing are major determinants of consumer acceptability, these are commonly measured through consumer perception and sensory attributes. If this interfacing intervention of modern and indigenous processing technology is found to be acceptable to the consumers, food and nutritional security could be improved as depicted in Figure 3.1.

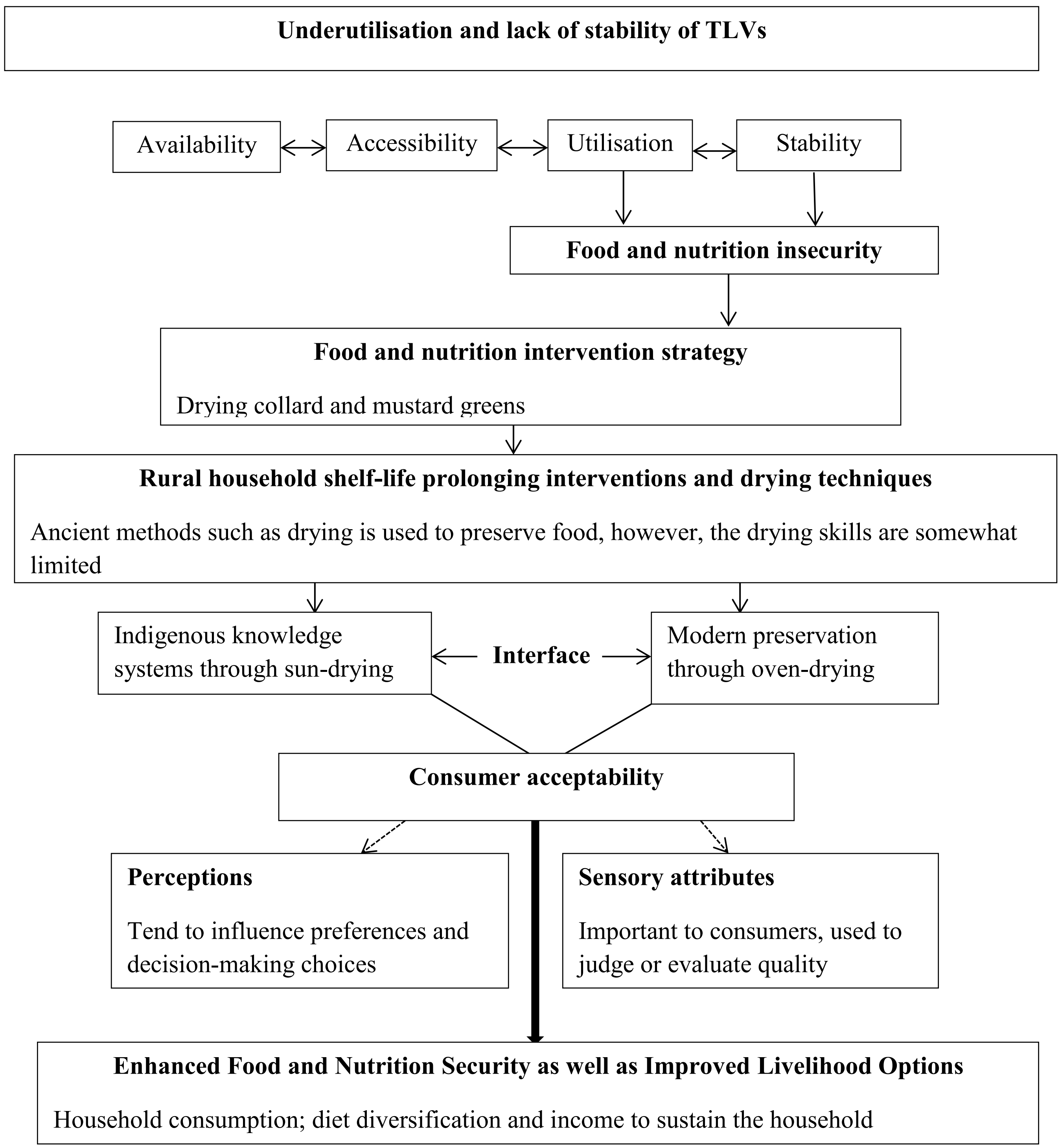

Figure 3.1: Study conceptual framework

3.2 Study design

Two TLVs, collard greens and mustard greens, were selected for this study. Several research studies conducted by Jansen van Rensburg *et al.* 2012; Ntuli *et al.* 2012; Makuse & Mbhenyane 2011 and Faber *et al.* 2010 in rural populations in Limpopo (LP) and KwaZulu-Natal (KZN) to identify commonly-consumed TLVs did not identify collard greens and mustard greens as commonly consumed leafy vegetables. Several types of leafy vegetables are cultivated in the Limpopo province for household consumption, and it is a common practice to dry vegetables to prolong their shelf-life. However, in the same province, unlike other similar leafy vegetables, collard greens and mustard greens are not preserved through drying. These two vegetables under study seem to be underutilised.

Two different processing (preservation) techniques (sun-drying and oven drying) were used to investigate the effects of the preservation technologies on the quality of the TLVs.

The study was a combination of quantitative and qualitative approaches through laboratory experiments and a field-study, respectively. In phase I, the Rapid Rural Appraisal (RRA) was conducted for learning and applying the indigenous-knowledge drying methods by observing and interviewing key informants who were local experts in drying TLVs. In phase II, an experimental laboratory approach which included laboratory drying, colour and texture analysis as well as nutritional composition determination was done following standard and referenced methods. Samples of the two vegetable types were processed by sun-drying (indigenous) and oven-drying (modern) technologies. The quality of processed vegetable samples was evaluated in terms of nutrient content, colour, texture and consumer acceptability. The microbiological quality and safety of the dried vegetables was also assessed. By focus group discussions, consumer perceptions about preserving the two vegetable types by drying were explored. The research design is represented in Figure 3.2.

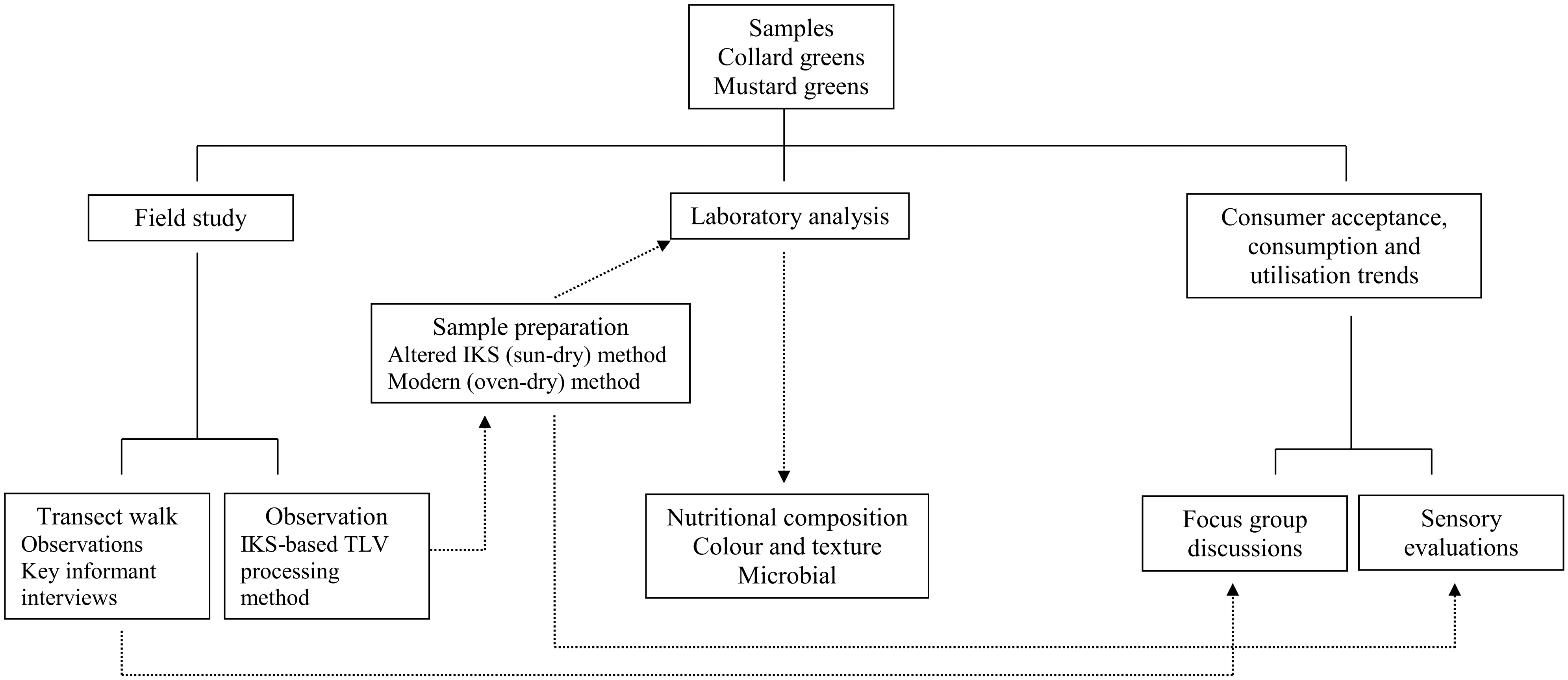

Figure 3.2 Summary depiction of the study research design

3.3 Description of the study area

In the Mopani District of the Limpopo province, leafy vegetables are a key component of the diet and the indigenous drying of vegetables is a common practice. This district is one of six in the Limpopo province. The three local municipalities in the Mopani district, namely Greater Giyani, Greater Letaba and Greater Tzaneen are strong in the area of agriculture and forestry amongst other things. The climatic conditions in the area are generally warm, dry, frost-free and sub-tropical with summer rainfall. About 50% of the horticultural income in the province in is earned in the Mopani district and unutilized agricultural land in this district is estimated at between 10 000 to 70 000 hectares (NDMC 2013).

Figure 3.3: Proximate map of the study locations, (A) Lenyenye, (B) Mawa and (C) Tzaneen
Source: http://www.newstrackindia.com/information/locations/South-Africa/2654856-city-lenyenye.htm & http://www.weather-forecast.com/place_maps/ma/Mawa-20.8.gif

The study only focused on the Greater Tzaneen municipality in a peri-urban area called Lenyeye and the Greater Letaba municipality in a rural village called Mawa. The researchers in the current study targeted this area due to the familiarity with both vegetables. In Polokwane markets for example, only mustard greens were sold. This was also confirmed through Rapid Rural Appraisal exercise conducted with Polokwane local people in order to obtain directions to other fruit and vegetable markets, locals did not know collard greens. According to StatsSA (2011), the Greater Tzaneen and Greater Letaba municipalities respectively have a 96% and 98.8% black population, 48% and 56.8% of households in the areas are headed by females, 41% and 14.4% of the population does not earn an income, and of those who earn an income in Greater Tzaneen, 45% earn below R1600 per month. This highlights that any intervention that could contribute to improving their food and nutrition security, and livelihood status is needed. Lenyenye is a peri-urban location with a population size of 10 634[1] and is approximately 22 km from Tzaneen. Mawa village is a rural area, approximately 80 kilometres (km) from Tzaneen and 160 km from Polokwane, the capital of the province (Fig 3.3). The population size in the village is 5 212, which is spread over three sections (8, 9 and 12)[7]. Basic supplies of water, sanitation, electricity and roads are still limited.

3.4 Ethical considerations and gaining entry to the community

All required approvals to conduct the study were obtained through written consent from the volunteering study participants for the sensory evaluation and focus group discussions (Appendix C). The Humanities and Social Sciences Research Ethics Committee of the University of KwaZulu-Natal granted approval for the conduct of the study (Approval Ref HSS/0719/014M in Appendix E); the local authority in the village also gave permission for the conduct of the study (Appendix F). The participants were orally reminded before beginning every session of their voluntary participations, anonymity and confidentiality.

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[7] Source: Department of water affairs
http://dwaf.gov.za/dir_ws/wsnis/toolbox/print.asp?curPerspectiveID=2&curReportID=205&nStn=pg_reports&currentPage=43&FilterSelection=true&AlphaChar=ALL&DMCode=&LMCode=&cid=3&cursecAuthorityCode=&curLinkID=&curYear=10&SearchStr=&SAID=&SASID=&Prov=LP&curlevelid=1

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CHAPTER 4: TRENDS IN THE CONSUMPTION AND UTILISATION OF TRADITIONAL LEAFY VEGETABLES (TLVs) BY URBAN AND RURAL CONSUMERS OF TZANEEN

4.1 Abstract

Traditional leafy vegetables (TLVs) are nutrient-rich food items and are available in abundance in rural communities. However, they are seasonal and highly perishable limiting their consistent supply and utilisation to contribute to food and nutrition security, and livelihood options. The two TLVs, collard greens and mustard greens in the Limpopo Province of South Africa, have a limited contribution to food and nutrition security due to their seasonality and perishability. The aim of this chapter was to assess consumer perceptions of the TLVs in Limpopo Province by assessing their consumption and utilisation. A Rapid Rural Appraisal (RRA) triangulated using observation and key informant interviews, a transect walk and seven focus group discussions conducted with rural and urban participants, who provided insight on consumer consumption patterns, perceptions and utilisation of TLVs. Collard and mustard greens were not dried but were only consumed cooked in its fresh form. Thus, they were strictly available during winter seasons. Consumers were of the opinion that drying compromised the quality of TLVs. Consequently, the green colour of TLVs was a fundamental quality indicator used to assess nutritional value and freshness. Generally, the consumption patterns of the TLVs have declined amongst youth and some urban dwellers due to stigmatisation based on negative perceptions. Limited availability in formal markets, the disappearance of indigenous knowledge transfer from generation to generation and monotony in preparation of TLVs were reported as reasons for the decline in consumption and utilisation. Interfacing modern with the traditional preservation methods, integrating TLVs into formal markets and updating preparation method could change the consumer perceptions thus increase the consumption and utilisation of TLVs among the youth and urban consumers.

Keywords: Consumer perceptions, Utilization, Consumption patterns, Traditional leafy vegetables.

4.2 Introduction

Leafy vegetables have a high nutritional value. The non-commercial vegetables that grow wildly, however, have been found to be higher in nutritional composition than the exotic commonly utilised vegetables. According to Kim *et al.* (2013), these vegetables are rich in nutrients and antioxidants, have antimicrobial properties and also have medicinal use. In rural areas where people have limited resources, they tend to use local, wild or domestically cultivated leafy vegetables in order to diversify their diet (Misra *et al.* 2008; Voster *et al.* 2007). These vegetables are commonly referred to as indigenous or traditional.

Collard greens and mustard greens are TLVs found in the Limpopo province of South Africa. Although these vegetables are not indigenous to the area, they are cultivated crops that have been naturalised in this region through widespread use. These vegetables are good sources of several nutrients, including vitamins, minerals and fibre; they are also a good source of other chemical components with anticancer, antiviral and antibacterial properties (Makuse & Mbhenyane 2011; Cartea *et al.* 2011). The utilisation of such traditional vegetables is often limited by several factors like sensory properties, market availability of seeds or vegetables, consumers being uninformed about their nutritional value or preparation methods, consumers having a negative perception of associating them with poverty and a low cost-to-benefit ratio for the farmers (Masarirambi *et al.* 2010; Voster *et al.* 2007).

Vegetables are not only seasonal but also purchasing fresh vegetables is costly in the long term as the vegetables are perishable whilst the cost of transport to acquire them from markets is high. Alternatives for supplying the nutrient-rich traditional plant foods and preservation methods that can cover seasonal availability gaps would increase their utilisation as a food source (Sikora & Bodziarczyk 2012; Misra *et al.* 2008; Ndawula *et al.* 2004). Rural households already preserve various types of vegetables by drying in order to be able to use them during times when they are not readily available (Misra *et al.* 2008). However, the TLVs collard greens and mustard greens, which are widely consumed by rural households in the Limpopo province, South Africa, are not preserved by drying. Several researchers have highlighted that processing greatly reduces the nutritional and sensory quality of vegetables (Barrett *et al.* 2010; Giri & Prasad 2009; Muchoki *et al.* 2007). Thus, the drying methods should be adapted by rural households in a manner that promotes high retention of nutritional and sensory quality attributes. The aim of this chapter was to assess consumer perceptions of the TLVs in Limpopo Province by assessing their consumption and utilisation.

4.3 Research Methodology

An RRA was conducted by the researcher. The researcher spent a week in the village to observe TLV production trends and practices and how the TLVs were processed and stored. This process was complemented with a transect walk and interaction with few farmers who acted as key informants and thus aided in providing the researcher with insight and further probing questions to be discussed through focus group discussions.

4.3.1 Rapid Rural Appraisal

In this study the RRA was used for various reasons such as to gain entry to the community (smallholder farmers); learn more about the topic understudy by observing how the household and smallholder farmers interacted on a daily basis; to identify the best way to collect data; and to identify gatekeepers to aid in further engagements with the community.

4.3.2 Transect walk

This is a systematic walk which was conducted with the smallholder farmers some of whom were also experts in TLV drying. The researcher used the transect walk to observe first hand and validate the information gathered through the RRA.

4.3.3 Focus group discussions

A series of seven focus group discussions were facilitated (3) in Mawa (rural area) and (4) in Lenyenye (urban area), composed of between 8-12 participants. Participants were recruited through random purposive sampling where they were called to a local community centre through word of mouth, targeting 60 participants in each location; however, due to the voluntary nature of participation, the targeted numbers could not be achieved. There were groups with small holder farmers who also happen to be consumers, there were groups with consumers only and also groups with a combination of both. The rural location had more smallholder farmers than the urban location.

At the beginning of the session, the facilitator introduced the research team and the purpose of the study, encouraging active participation. The audio data together with hand written notes were used to determine the main findings of the study.

4.3.4 Validity and trustworthiness

A trained facilitator assisted by three trained field workers conducted both the focus group discussions. Local language was used probing the issues of consumption and utilisation of TLVs. Triangulation of the RRA method, transect walk and focus group discussions provided a trustworthy data.

4.4 Results and discussion

4.4.1 Characteristics of the participants

A total of 62 respondents participated in the study, 61% were female and 39% were male. There were 29.1% youth aged 18- 20, young adults were 25.8% aged between25-35, adults were 14.5% aged 36-50 and the elders group aged above 50 were 30.6%.

4.4.2 Leafy vegetables seasonal availability

Farmers indicated that TLVs were the most popular crops in winter and summer seasons, as compared to the exotic vegetables that were available all year round (Figure 4.1). In the Limpopo province of South Africa, the two vegetables under study, collard greens and mustard greens, were planted in January and the first harvest would be in April. Generally, these TLVs were available until the end of August.

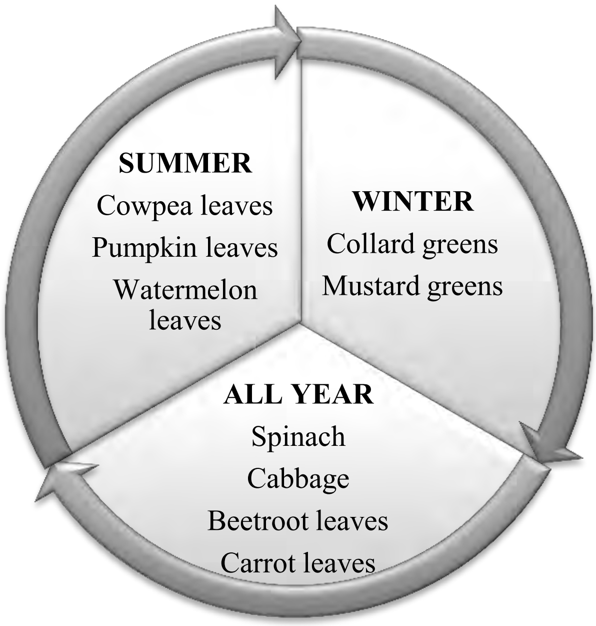

Figure 4.1: Cultivated TLVs and planting season

A transect walk exercise by the researcher observed that in most farms visited in the Mawa area and surrounding villages, there was an abundance of mustard greens, the few farms that did plant collard greens had depleted crops due to purchase and none of the local farms visited had planted the exotic vegetables which they describe as cultivated all year. The level of availability of TLVs at farm levels was an indicative of the popularity of these vegetables in the areas where they are consumed.

Collard and mustard greens were not dried; they were preferred fresh. According to the focus group discussions the drying process compromised the nutrient content. A study by Nguyen-The (2012) indicates that processing can be a healthy alternative for consumers provided the impact of preservation does not significantly alter the nutrient composition in comparison to the raw product. The preservation of cultivated TLVs into value added products can be a livelihood enhancer thereby increasing utilization to improve food and nutritional security.

4.4.3 Gender dynamics in consumption and production of TLVs

The TLVs were consumed by all household members regardless of the age and gender. There was a difference between field and homestead management, men managed the field production of TLVs while the TLVs from homestead gardens were primarily for household consumption. Women managed TLVs that were planted on homestead gardens, although some were sold to diversify the household income mainly as '*cash food*'. Faber *et al.* (2010) found that most cultivated TLVs in home or community gardens were managed by women because as Matenge *et al.* (2012) puts it, TLVs are regarded as women's crops in terms of utilisation and preparation responsibility. However, both men and women planted for both household consumption and selling.

4.4.4 Consumption and utilisation of TLVs

The consumption patterns of the TLVs were found to be varied in the two study areas. In the rural areas, they are consumed on a daily basis forming part of all the household meals from breakfast to supper. However, in urban areas these tend to be consumed less frequently, just twice a week (Table 4.1).

Table 4.1: Consumption patterns and utilisation of the TLVs

Factor/s	Rural Consumers	Urban consumers
Consumption pattern	Daily, part of all household meals	Twice a week
Utilisation & Consumption ***(Typical dish)***	Must contain tomatoes as the major ingredient Stiff porridge as the main complementary food Potatoes as a side dish, if available	Must contain tomatoes as the major ingredient Potatoes could be included in the TLV recipe Stiff porridge / rice as complementary foods Meat / insects / peanuts as a condiment

In both urban and rural areas, there is a decrease in the consumption of TLVs amongst the youth and children. Matenge *et al.* (2012) found similar results in their study; urbanisation had an influence on consumption patterns of indigenous food items like leafy vegetables. More especially among the youth who displayed lack of interest in indigenous knowledge because urbanisation breaks the traditional knowledge transfer between mothers and children due to work and lifestyle changes (Matenge *et al.* 2012).

4.4.5 Reasons for the preservation of TLVs

The rural participants were the ones who mainly practiced drying. The preservation was done for various reasons presented in Table 4.2.

Table 4.2: Reasons why the rural consumers preserved TLVs

Themes	Cooked and sun-dried
Convenience	Time saving and ready to serve Snack
Diet diversity	Eaten as a complement to 'pap' or stiff porridge, which is a meal that is eaten throughout the day by all household members
Food security	To enhance household food availability throughout the year
Livelihood options	Income generation *(sold when out of season)*

4.4.6 Perceptions towards the consumption of TLVs

There was a general view especially in the urban community that people who do not consume TLVs tended to look down upon those who consumed these vegetables. The assumption is that they are either 'poor', 'backwards' or of 'low income class'. Matenge *et al*. (2012) found similar sentiments from young adults who indicated that the lifestyle of consuming traditional foods was "old fashioned" and they preferred modern food. There were two identified drivers of these perceptions, the unavailability of the TLVs in the formal markets and the perception of prestige. The TLVs were mainly purchased in informal markets, which are generally perceived to be cheaper than formal markets. The fact that TLVs were available in informal markets made it seem as if it was an option only for those who had limited spending ability and could not afford to purchase vegetables in the formal markets.

Limited recipe variation of cooking and serving TLVs was mentioned as one of the causes of negative perceptions. Meat and tuber vegetables are regarded as prestigious food, whereas leafy vegetables are regarded as a *'poor man's food'*. Hence, people who consume these prestigious food items, especially in the urban areas, perceive themselves to be of a higher socio-economic class than those who do not consume such food frequently. Among the urban study participants, there was mention of adding potatoes in the preparation of the TLVs rather than as a side dish as is the case in the rural area. Also, the urban participants indicated that the preparation of the TLVs usually involved the addition of a protein source like meat, insects (local delicacy in the Limpopo province) or peanuts. In order to promote the utilisation of the TLVs by the youth, an appealing alternative could include incorporating the familiar prestigious food items, like potatoes or protein sources, which the urban consumers have adopted in their preparation technique.

4.4.7 Indigenous systems of evaluating quality of TLVs

It is commonly known that consumers mainly use the physical appearance to judge quality. For both urban and rural groups, the major indication of quality was colour; it signified the freshness the leafy vegetable (Table 4.3). The participants could depict the TLV freshness based on the shades of green.

Table 4.3: Key consumer quality indicators

Quality attributes	Rural	Urban
Physical appearance / Colour	Green Green colour indicated the nutritional content	Green Green colour indicated the nutritional content & freshness
Texture	Lightness and flakiness measures dryness	Softness after cooking
Smell	Able to detect fresh vs dried cooked TLVs	-
Cleanliness & palatability	Free of soil particles	Free of soil particles

The rural consumers acknowledged that the drying process resulted to the loss of the green colour which meant the loss of nutritional value. The findings of this study concur as seen in Figure 4.2, vegetables were dried on the same day under similar conditions, yet the effect of cooking and sun-drying as opposed to blanching and sun-drying made the indigenously preserved TLVs to lose the green colour. According to Guine and Barroca (2012), colour is the primary quality attribute that is evaluated by a consumer for determining acceptance. This notion is also supported by the findings of Wu and Sun (2013) who indicated that for market acceptability, a diversion from the expected colour will act as a deterrent to market acceptance despite the presented product containing all the known characteristics like aroma and taste.

Figure 4.2: Colour change on sun-dried TLVs, indigenous and altered preservation methods

Participants in all focus groups shared the sentiment that adding other ingredients not only enhanced flavour and to quote them '*to replenish lost nutrients, powdered peanuts are added during the recooking*'. Both urban and rural panels also indicated that the addition of tomato is for a similar purpose, they quoted that '*morogo (TLV) is not morogo without tomatoes*'; this was their traditional way of preparing TLVs. The current study was limited in that it did not compare the nutrient composition after the TLVs were reconstituted and cooked, to determine the actual impact of adding tomatoes or any other ingredients that consumer indicated they add to enhance the nutritional value.

Other quality indicators that the focus groups highlighted were that of texture, aroma and palatability. After drying, the rural groups indicated that a good indication that a TLV is thoroughly dried was that its texture must be light and flaky. The urban group on the other hand evaluated texture through softness after cooking. The rural groups indicated that there is a distinct aroma that they associate with TLVs, which enables them to differentiate between the freshly cooked and the dried and cooked TLVs. Hygiene was another quality indicator that both groups reflected on; there should be no soil particles for the TLV to be considered palatable. These are similar quality indicators that Naish and Harris (2012) reported on.

4.4.8 Indigenous storage of the TLVs

It was believed that TLVs stored in a sack could last up to a year and six months while dried and bottled TLVs had a short span on six months. The dried TLVs were stored in a sack (the sack has micro punctures that allow for air circulation), lifted off the floor through bricks and stored in the coolest room in the house to avoid sun exposure. The bottled ones were mainly used for immediate or short-term household consumption.

According to Voster *et al.* (2007), the transition from fresh to processed vegetables through the drying technology commonly caused diarrhoea. Microbial contaminants like *E. coli* and *Salmonella* which can cause diarrhoea are already present in the soil, manure or water. Also, in observing the indigenous preparation method, water is scarce and hence vegetables are not washed in running water but rather in buckets filled with water, hence blanching of the vegetables before drying could be more effective.

4.5 Conclusion

Currently, collard and mustard greens are strictly available during winter seasons. These vegetables are not found in any form during other seasons. Consumers are of the opinion that drying affects the nutritional content of these vegetables thus prefer to consume them fresh and not dry them. The green colour of TLVs was fundamental to the consumer as it was used as an indicator of nutritional value and freshness.

In the rural areas the TLVs are commonly consumed mainly by older generation. The TLVs were regarded as ‘delicacy’ food by older generation whilst it was perceived as ‘boring’ food by youth. Thus, there was a decline in the consumption of these vegetables in the urban areas. There is an even greater perceived decline in the consumption of these vegetables among the youth and some urban dwellers. The decline in consumption and utilisation in this consumer segments can be attributed to the disappearance of indigenous knowledge transfer from generation to generation, monotony in preparation of TLVs, stigmatisation and lack of availability of TLVs in formal markets. Modernising the TLVs by integrating them into formal markets and updating preparation method to include dishes that youth regard as prestigious can promote the consumption and utilisation of TLVs among the youth and urban consumers.

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CHAPTER 5: EFFECTS OF DIFFERENT DRYING METHODS ON THE NUTRITIONAL COMPOSITION, MICROBIAL SAFETY AND CONSUMER ACCEPTABILITY OF TRADITIONAL LEAFY VEGETABLES (TLVs)

5.1 Abstract

Two traditional leafy vegetables (TLVs), collard greens and mustard greens, are grown by smallholder farmers in the Limpopo province for informal markets and household consumption. These TLVs, just like many other leafy vegetables, are good sources of several nutrients. They are ideal for rural household food security because when they are in season they are very abundant and are affordable. However, due to perishability, seasonality and other limitations these vegetables are underutilised. Preservation of these TLVs by appropriate technologies, such as sun-drying could increase their utilisation as that would stabilise their access and availability. The effects of an innovative Indigenous Knowledge System (IKS)-based method of preserving by blanching and sun-drying on the quality and microbial safety of the TLVs was compared with a modern method of blanching and oven-drying. The effects of the two preservation methods on the quality were assessed by monitoring the changes in the colour and texture, nutritional composition and microbiological load and composition of the TLVs. The effects of an adapted indigenous method of blanching and sun-drying on the consumer acceptability of the TLVs were compared with the effects of a modern method of blanching and oven-drying. Sensory panels of 62 rural and urban consumers participated in the study to rate the sensory attributes of the differently preserved TLVs on a 5-point pictorial hedonic scale. The findings of this study indicated that the innovative IKS-based method of drying maintained colour better than the modern drying method, however, the opposite was true for texture. The total mineral content (ash) was higher in sun-dried vegetables than in the oven-dried vegetables. However, the effect of the different processing measures applied to the TLVs yielded different impacts on the nutrient composition in both vegetable types. The microbiological load and composition of the TLVs processed using the two preservation methods were generally within the acceptable limits. The rural consumers found the aroma, texture and colour of sun-dried TLVs more acceptable than oven dried TLVs. Urban consumers had differing preferences for the sensory attributes of the two processing methods, but, overall, the sun-dried TLVs were preferred over the oven-dried TLVs.

These findings reveal that both methods of preservation produce TLVs of acceptable quality and microbial safety; thus, the innovative IKS-based method has a potential for use by rural households and thereby contribute to the enhancement of their livelihood, food and nutrition security.

5.2 Introduction

Although at national level South Africa is considered food secure, a large proportion of its households, like in many other developing countries, have a burden of malnutrition and hunger. They are experiencing food and nutrition insecurity. Due to the slow economic growth, there are limited employment opportunities, high living costs and lack of stable income which make it difficult for resource-poor households to have purchasing power to provide for their nutritional needs (Beddington *et al.* 2012; Labadarios *et al.* 2011; Voster *et al.* 2007). Other factors such as environmental challenges and limited of resources (including land and input) are also contributing to the food and nutrition insecurity (Beddington *et al.* 2012; Quinn *et al.* 2011).

A state of food security is achieved when conditions that support the availability of food resources, access to such resources, adequate consumption and appropriate utilization of food in a nutritious and hygienic manner are attained at all times for all people (Baro & Deubel, 2006; Clover, 2003). However, current socio-economic conditions do not promote an environment that can assure food security at all levels and at all times. The majority of malnourished households have an undiversified diet and they lack daily intake of many essential micronutrients (Gupta & Prakesh 2011). This highlights the need for affordable and easily accessible nutritious food sources.

Food consumption habits need to be highly adapted to the current environmental and socio-economic conditions that households are faced with, whilst promoting a diversified nutritious diet (Voster *et al.* 2007). For convenience, agricultural produce is being supplemented by the growing market of processed foods. Thus there is a viable market for value added (processed) fruits and vegetables (Louw *et al.* 2008). In rural areas of Limpopo, like in most rural areas in sub-Saharan Africa, domesticated, indigenous or common, widely consumed (naturalised) leafy vegetables referred to here as traditional leafy vegetables (TLVs), such as collard greens and mustard greens, tend to be abundant when on-season and can be accessed at a low cost. These TLVs are consumed by the local communities either raw or cooked.

However, in most cases these TLVs are not integrated into the formal markets (Sithole & Chitja 2011; Matenge *et al.* 2012; WHO 2003). The TLVs have a potential to generate income for the local communities who are predominantly smallholder subsistence and semi-commercial farmers mainly because they are low value stock, thus informal traders prefer to buy these directly from farmers to minimise middleman costs that escalate the price (Ngiba *et al.* 2009; Misra *et al.* 2008).

Indigenous and/or traditional vegetables are the focus of various studies because of their potential in lessening the nutrient deficiency problem in areas where they are available abundantly and resources are scarce. However, some research indicates that the adoption of these vegetables could be faced with possible perception challenges of regarding them as poverty vegetables, especially by the urban and youth consumers (Sithole & Chitja 2011; Faber *et al.* 2010; Narayanan & Kumar 2007). Matenge *et al.* (2012) believes that perception is not an issue because consumers accept products based on their sensory qualities (appearance, texture, aroma and taste) and their integration into the commercial sector through formal markets and value-addition benefits like cleaning and chopping, which removes the inconvenience that may deter urban dwellers from adopting the TLVs. The sensory qualities are measures that are perceived to be related to, and used for acceptance and selection to determine, a good palatable quality product by the consumer (Naish & Harris 2012; Giri & Prasad 2009).

There is limited research which focuses on the processing and marketing of these vegetables to increase their utilisation. Appropriate technologies, for processing these vegetables into value added products, including preservation by drying, could benefit rural households by increasing their food and nutritional security through the consumption of these nutritious TLVs and improving their livelihoods through the sale of the value added products. Adding these TLVs into the modern diet would also reduce the loss of genetic diversity that has resulted from the over-use of a limited variety of commercial vegetables (Voster *et al.* 2008). From the available literature, it seems that collard greens and mustard greens are not preserved by the local rural communities and hence it is likely that large quantities of these vegetables are lost through deterioration during the season of their abundance. Yet, these communities preserve other leafy vegetables using indigenous methods, especially sun-drying. The aim of this investigation therefore was to evaluate the potential of preserving collard greens and mustard greens by sun-drying to enhance the livelihood, food and nutrition of the rural households of Limpopo. The specific objective of the investigation was to assess the effects of sun- and oven drying on the quality and microbial safety of collard greens and mustard greens and to assess these effects on consumer acceptability.

5.3 Materials and Methods

5.3.1 Vegetable samples

Fresh mustard green (*Brassica juncea*) and collard green (*Brassica oleracae*) vegetables were purchased from farmers in the Mawa village. Edible parts of the two TLVs were chopped and washed in buckets filled with tap water.

5.3.2 Drying of vegetables

Indigenous knowledge system (IKS-based drying method):
The TLV (collard greens and mustard greens) samples for sun-drying were boiled for 1 hour. Tomato skins were removed by hand after softening them in hot water, chopped and then, together with salt, added to the boiling TLVs. The TLV samples were then left to continue cooking for 30 minutes. The cooked TVLs were drained of the left cooking water, spread evenly on a metal surface that was raised one meter above the ground and then dried in the sun with periodical turning to ensure uniform drying. The vegetables dryness was determined through their lightness and flakiness when touched by hand.

Adaptation of the IKS-based drying method by interfacing it with the modern method:
Two preservation methods were used in this experiment: one method involved blanching and IKS-based sun drying and then other involved the modern method of blanching and drying. The two preservation methods are described as follows:

1. The TLV samples for sun-drying were blanched by placing it inside a sack which was then and immersed in hot water for three minutes and then in cold water for 30 seconds. The vegetable sample was removed from the sack and spread on a clean flat surface and left to dry in the sun with periodical turning to ensure uniform drying. The vegetable dryness was determined through the level of lightness and flakiness when touched by hand. Apart from the blanching step, this adapted IKS-based preservation method was different from the original IKS-based preservation method in that the vegetables were not cooked before drying.

Cooking was omitted to reduce product losses as reviewed earlier that the USDA (2003) reported reduction in mineral composition of between 20-35% (refer to table 2.4). And yet blanching has been reported to retain colour and reduce nutrient losses (Mdziniso *et al*. 2006; Ndawula *et al*. 2004).

2. The TLV samples for oven-drying were blanched by placing them on a sieve, immersed in hot water for three minutes, drained, immediately dipped in cold water for 30 seconds and then left to drain through a sieve. The vegetable samples were spread evenly on a tray lined with aluminium foil. The samples were then dried in a forced-air oven with periodical turning to ensure uniform drying. The samples were not cooked before drying.

Cooked and sun-dried mustard greens and collard greens were dry after 15 and 17 hours of sun exposure, respectively. Blanched, uncooked and sun-dried mustard greens and collard greens were dry after 24 hours of sun exposure. The vegetable samples were dried in two days between 8am and 10 pm. The temperature during the sun-drying period ranged from 10°C to 22°C, with an average of 16.6°C and average relative humidity of 35.6%. Blanched, uncooked and oven-dried TLVs were dried for 3 hours at 60°C, because that had been experimentally established to consistently reduce the moisture content of the vegetables to less than 10%. All the samples were packed in zip-lock plastic bags and stored at 4°C for further analyses.

Sample description

Raw untreated (RU) refers to fresh vegetables that have not been treated.

Raw blanched (RB) refers to fresh vegetables that have been treated through hot water blanching.

Sun-dried blanched (SB) refers to vegetables that have treated through hot water blanching and dried through direct sun exposure

Oven-dried blanched (OB) refers to vegetables that have treated through hot water blanching and dried through the oven.

5.3.3 Physical quality analysis

5.3.3.1 Colour

The HunterLab ColorFlex EZ Spectrophotometer (model 45/0, HunterLab, Reston, Virginia, United States of America) was used to measure the colour of the TLVs samples. The readings for each sample were taken by evenly spreading a portion of each sample to determine the CIE colour values for L* (lightness), a* (redness/greenness), and b* (yellowness/blueness). Three replicates of each TVL sample type, namely raw untreated (RU), raw blanched (RB), sun-dried blanched (SB) and oven-dried blanched (OB), were analysed.

5.3.3.2 Texture

The Kramer Shear Instron Universal Texture Analyser (model 2519-107, Instron, Illinois, USA) was used to determine the texture of the samples. Puncture probes with a maximum force of 500N and eight blades were used on the instrument; and the maximum penetration speed was 100mm/minute. The sample holder was filled with an even layer of each sample and the puncture probes were anchored onto the force transducer. The probe measured the maximum force required to penetrate the sample through 5mm, at a speed of 10mm/minute. Three replicates of each sample type (RU, RB, SB and OB) were analysed.

5.3.4 Nutritional analysis

The TVL sample type, namely raw untreated (RU), raw blanched (RB), sun-dried blanched (SB) and oven-dried blanched (OB), were analysed for their nutrient content by standard methods of the AOAC (AOAC 2005). The raw untreated (RU) and raw blanched (RB) samples were freeze dried before analysis. Crude fat was determined following the Soxhlett procedure of the AOAC official method 920.39 (AOAC 2005) using a Buchi 810 Soxhlett fat extractor. Fibre was determined as neutral detergent fibre (NDF) using the Dosi-fibre machine according to the AOAC official method 2002.04 (AOAC 2005), as described by Van Soest *et al*. (1991). Crude protein (Nx6.25) was measured with a LECO Truspec

Nitrogen analyser according to the Dumas Combustion method described in the AOAC official method 990.03 (AOAC 2005). The total mineral content of the samples was measured as ash using a muffle furnace set at a temperature of 550°C following the AOAC official method 942.05 (AOAC 2005). Individual minerals, calcium, magnesium, potassium, sodium, phosphorus, zinc, copper, manganese and iron, were determined by the AOAC method 6.1.2 (AOAC 1984).

5.3.5 Microbial quality and safety analysis

Accurately, 25 g of each sample type of the two TVLs (mustard greens and collard greens) was weighed and buffered peptone water was added to give a combined weight of 60 g in a flask. The sample was mixed thoroughly in a platform shaker. One millilitre (1 ml) aliquots of each sample were drawn using sterile pipettes and transferred into tubes with 9 ml saline water, and from this, serial dilutions of up to 10^{-3} were prepared.

The determination of yeast and mould was carried out following the SABS method (SABS ISO 7954:1987). Duplicate samples were plated into appropriately marked chloramphenicol agar plates using 0.1 ml of each sample serial dilutions described above. The plates were incubated at 25°C for 4 days.

The presence of the bacterium *L. monocytogenes* was determined following the ISO method (ISO 11290-2:1998). Serial dilutions (described above) of each sample type were plated in duplicate onto Chromogenica Listeria agar (clap) plates and incubated for 48 hours at 32°C. The presence of *B. cereus* was determined following the SANS method (SANS 7963:2005 ed. 2). Duplicate samples of the serial dilutions of each sample type were plated onto MYP agar plates and incubated at 30°C for 48 hours.

The presence of *E. coli* was determined following the SANS method (SANS 7251:2005 Ed. 2). Serial dilutions of each sample type, in duplicate, were inoculated onto appropriately marked Lauryl sulphate broth tubes and incubated at 37°C for 24 hours. The cultures were then inoculated in EC broth and incubated at 44°C for 24 hours. After, 0.5 ml of indole reagent was added to preheated (44°C) peptone water, mixed and examined.

The detection of the presence of *Salmonella* was carried out following the SANS method (SANS ISO 6579:2002). The samples remaining in buffered peptone water were incubated at 37°C overnight. Then 1 ml and 0.1 ml aliquots were transferred into the Muller Kauffmann tetrathionate and Vassiliadis peptone broths, respectively. These were then incubated at 37°C and 41.5°C also respectively, for 24 hours. The cultures from both broths were inoculated onto the Xylose lysine deoxycholate (XDL) agar and Brilliant green agar plates, incubated at 37°C for 24 hours.

5.3.6 Sensory evaluation

5.3.6.1 Sample preparation

Dried vegetable samples of collard greens and mustard greens were prepared under the guidance of a local informant who was an expert in TLV drying. A cup (250 ml) of the dried TLV sample was soaked in two cups of water for an hour. A single medium sized tomato was soaked in hot water to remove the skin, and then chopped into cubes. A sample of each of the two TLVs was cooked in the water it was soaked in on a stove set at medium heat for 30 minutes. The chopped tomato and a teaspoon of salt (5 g) were added and the heat was reduced. The vegetables were left to cook, stirring occasionally, until the water had evaporated. The raw, unblanched (fresh) vegetable was cooked in a similar manner, with the exception of soaking which was not conducted.

5.3.6.2 Sensory evaluation

The TLVs were analysed for the sensory quality by two different consumer panels, rural and urban, who were typical consumers of the TLVs. Both panels were from Tzaneen, Limpopo, recruited through random purposive sampling, whereby they were called to a local community centre through word of mouth, targeting 60 participants in each location. However, due to the voluntary nature of participation, the targeted number of participants could not be achieved. There were 28 non-trained participants recruited from Mawa village (rural panel) and 34 non-trained panellists recruited from The Resurrected Jesus Christ Church in Lenyenye Township (urban panel). The sensory quality of the TLV samples was rated on a 5 point pictorial hedonic rating scale, evaluating the degree of acceptability of the dried vegetables; the non-dried form of each TLV types served as a control. The panel evaluated three samples (fresh, oven-dried and sun-dried) of each of the two TLV types. Therefore, two sensory evaluation sessions were conducted. The samples blindly labelled with 3-digit codes and randomly served to each panellist. The texture, aroma, colour and overall acceptability of the vegetable samples were rated. The taste acceptability of the samples was not evaluated because their microbial safety had not been determined.

5.3.7 Data analysis

The Statistical Package for Social Sciences (SPSS) was used for statistical analysis of collected data. Descriptive statistics techniques were used to compute means and standard deviations; replicate values and percentages were used to assess the trends in sensory acceptability of the differently processed TVL samples. The LSD test was used to analyse for differences in physical quality attributes (colour and texture) and nutrient content due to the different processing methods, at 95% ($P<0.05$) statistical significance. Microbial quality and safety data were compared with standard values obtained from the literature.

5.4 Results and discussion

5.4.1 Effect of drying methods on the physical quality of TLVs

The processing of vegetables changed their colour and texture (Figure 5.1). After the blanching, the vegetables shrank in size, their bright green colour changed to a darker green when compared with the unprocessed vegetables and the texture became softer. However, after drying, the leaves became flaky and crisp. In the oven-dried samples, the mustard green leaves appeared lighter than the unprocessed leaves and the collard green leaves appeared darker.

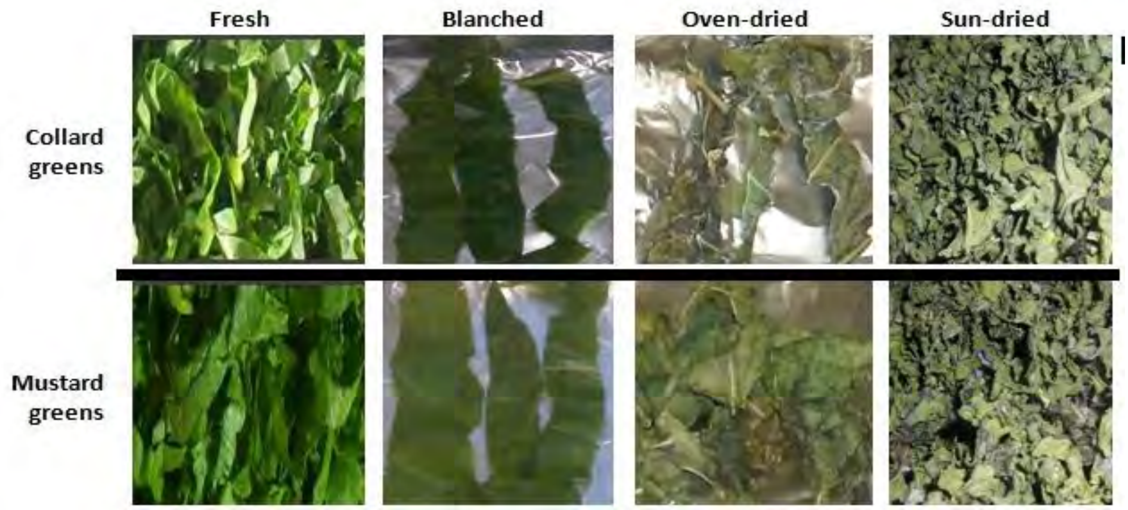

Figure 5.1 Physical changes observed on the dried collard and mustard greens

The quantitative changes in the colour and texture of the vegetables are shown in Table 5.1 and Figure 5.2, respectively.

5.4.1.1 Colour changes as indicated by Hunter Lab values due to processing

The effect of different processing techniques on the colour of the leafy vegetables is shown in Table 5.1.

Table 5.1: Effect of different drying methods on the colour of TLVs

CIE colour values	Collard greens		Mustard greens	
	Sample code	**Mean[1,2] (STDEV)**	**Sample code**	**Mean[1,2] (STDEV)**
L values	RUCG	40.55 (0.73)^{y}	RUMG	45.13 (1.45)^{y}
	RBCG	36.21 (0.46)^{x}	RBMG	37.66 (2.90)^{x}
	OBCG	25.53 (0.64)^{w}	OBMG	28.92 (2.69)^{w}
	SBCG	36.93 (1.04)^{x}	SBMG	34.43 (1.19)^{x}
a values	RUCG	-8.79 (0.14)^{x}	RUMG	-10.46 (0.51)^{x}
	RBCG	-13.69 (0.82)^{w}	RBMG	-14.00 (0.89)^{w}
	OBCG	1.31 (0.25)^{z}	OBMG	1.59 (0.72)^{z}
	SBCG	-3.70 (0.37)^{y}	SBMG	-2.20 (0.70)^{y}
b values	RUCG	19.83 (0.59)^{y}	RUMG	26.00 (3.30)^{x}
	RBCG	22.77 (1.29)^{z}	RBMG	22.64 (2.24)^{x}
	OBCG	13.27 (0.47)^{w}	OBMG	12.91 (1.32)^{w}
	SBCG	16.96 (0.38)^{x}	SBMG	15.66 (1.16)^{w}

[1] Mean value (n=3) and standard deviation in brackets

[2] For each CIE colour value, the means in the same column which are marked with different letters are significantly different (P<0.05), determined by LSD test. Means with the same letter in the same column represents means with no statistical difference

L = measure of lightness (0 = black to 100 = white)

a = measure of redness (+a = redness; -a = greenness)

b = measure of yellowness (+b = yellowness; -b = blueness)

RU = raw untreated; RB = raw blanched; OB = oven-dried blanched; SB = sun-dried blanched; CG = collard greens; MG = mustard greens

Blanching enhanced the green colour significantly (P<0.05) on both vegetables, making the vegetables to appear richer in colour as depicted by the lower Hunter L values. Sun-drying process retained the green colour of both TVL types was retained during drying. However, oven-drying caused the vegetables to be slightly redder and this processing method gave the lowest L value, indicating that the colour became darker.

The observed changes to the green hue of the vegetables were statistically significant (P<0.05). Considering that colour is an important quality attribute for consumer acceptability, control of handling and processing steps prior to preservation is essential for maintaining quality. Toivonen and Brummell (2008) indicate several factors associated with handling that impact on colour, including washing which increases enzymatic activity, chlorophyll deterioration which causes yellowing, wound effects which cause browning. Therefore, the control of environmental parameters like time of harvest, washing, chopping, temperature and preservation method are critical factors for maintaining acceptable colour (Barrett *et al.* 2010).

5.4.1.2 Changes in texture as detected by the texture analyser

The effect of different processing techniques on the texture of the leafy vegetables is shown in Figure 5.2.

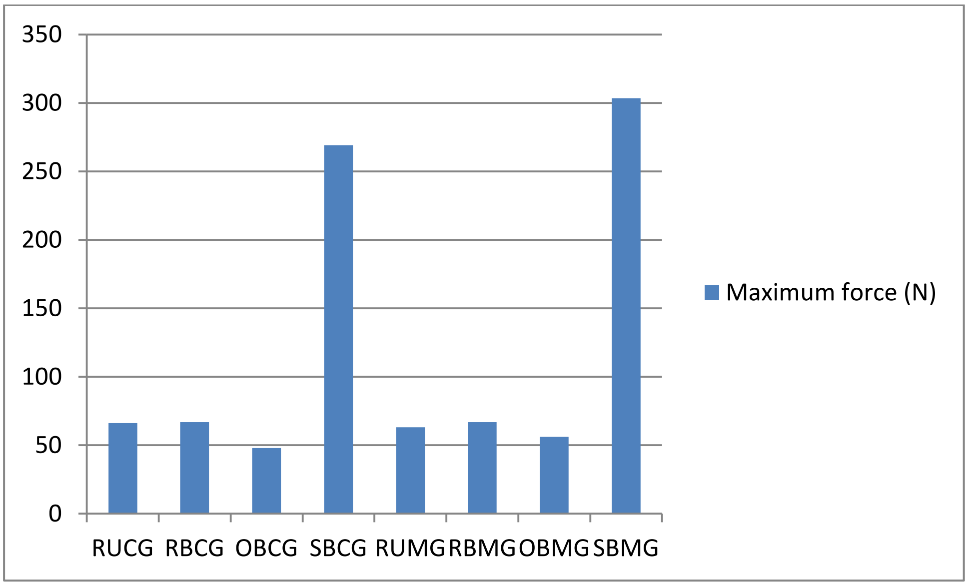

Figure 5.2: Effect of sun and oven drying methods on the texture of TLVs

Note: RU = raw untreated; RB = raw blanched; OB = oven-dried blanched; SB = sun-dried blanched; CG = collard greens; MG = mustard greens

Blanching did not significantly alter the texture of the TLVs. Oven-drying reduced the hardness/firmness the vegetables, however, not significantly. Sun-drying significantly increased the hardness/firmness of both vegetable types.

Several factors could have contributed to the changes in the texture of the sun-dried samples. Due to the thin layer of leafy vegetables, direct exposure to the sun has a negative effect on texture through UV radiation (Constantin & Manuela 2010). There is also no control of temperature during drying; the temperature tends to fluctuate. According to Henriques *et al.* (2012), temperature has an impact on the texture of a dried vegetable. Gamboa-Santos *et al.* (2014) concurs by stating that temperature is one of the factors that cause hardness and shrinkage in preservation by drying. A review by Afolabi (2014) found that if the sun dries the vegetables rapidly, the outer cell layer may harden. As discussed in the earlier sections, the temperature during sun-drying ranged from 10°C to 22°C, with an average of 16.6°C and average humidity level of 35.6%. Low temperature and high humidity may have had an impact on the texture quality.

5.4.2 Effect of different drying methods on the nutritional composition of TLVs

The effects of different processing methods on the nutritional composition of the leafy vegetables are depicted in Table 5.2, Figures 5.3 and 5.4. The study tested the dry weight composition percentages in the vegetable for the proximate composition of fat, fibre and protein. The minerals tested for included calcium, magnesium, potassium, sodium and phosphorus (A) and zinc, copper, manganese and iron (B).

Table 5.2: Effect of different drying methods on proximate composition

Proximate composition (% dry weight)	**Collard greens**		**Mustard greens**	
	Sample code	**Mean[1,2] (STDEV)**	**Sample code**	**Mean[1,2] (STDEV)**
Fat values	RUCG	3.23 (0.56)^{w}	RUMG	3.52 (0.18)^{w}
	RBCG	4.23 (0.21)^{x}	RBMG	5.05 (0.17)^{y}
	SUCG	2.91 (0.05)$^{v, w}$	SUMG	2.13 (0.12)^{v}
	OBCG	4.35 (0.06)^{x}	OBMG	4.08 (0.17)^{x}
	SBCG	2.65 (0.13)^{v}	SBMG	2.17 (0.08)^{v}
NDF[3] values	RUCG	21.12 (0.78)^{v}	RUMG	22.21 (0.41)^{w}
	RBCG	20.69 (0.63)^{v}	RBMG	19.78 (0.51)^{v}
	SUCG	34.70 (0.91)^{x}	SUMG	38.83 (0.60)^{y}
	OBCG	42.05 (0.78)^{y}	OBMG	37.74 (0.27)^{x}
	SBCG	26.81 (0.52)^{w}	SBMG	22.72 (0.41)^{w}
Crude protein values	RUCG	41.34 (0.14)^{x}	RUMG	34.50 (0.18)^{y}
	RBCG	42.77 (0.25)^{z}	RBMG	34.28 (0.15)$^{x, y}$
	SUCG	30.61 (0.16)^{v}	SUMG	27.74 (0.23)^{v}
	OBCG	42.17 (0.16)^{y}	OBMG	33.87 (0.41)^{x}
	SBCG	31.41 (0.41)^{w}	SBMG	28.87 (0.42)^{w}

[1] Mean value (n=3) and standard deviation in brackets

[2] For each CIE colour value, the means in the same column which are marked with different letters are significantly different (P<0.05), determined by LSD test. Means with the same letter in the same column represents means with no statistical difference

[3] NDF = Neutral Detergent Fibre

RU = raw untreated; RB = raw blanched; OB = oven-dried blanched; SB = sun-dried blanched; CG = collard greens; MG = mustard greens

Blanching enhanced the protein and fat content in the TLVs, and slightly reduced fibre content. A significant proportion of the nutrients in both TVL types were retained during sun-drying. The indigenous knowledge system (IKS)-based drying method resulted in an increase in the fibre content of both TVL types compared to the corresponding unprocessed TVLs samples. The results could be attributed to the addition of tomato and salt during processing. Interestingly, oven drying resulted in slightly higher nutrient in the dried TVL content compared to the unprocessed forms. It seems that controlled uniform heating resulted in increased availability of nutrients and thereby making them more assayable. According to Henriques *et al.* (2012), oven drying is the preferred method in preserving agricultural produce because the even drying temperature retains aesthetic physical quality attributes. However, their research indicated that nutritional composition of vegetables was adversely affected by the high temperature drying temperature.

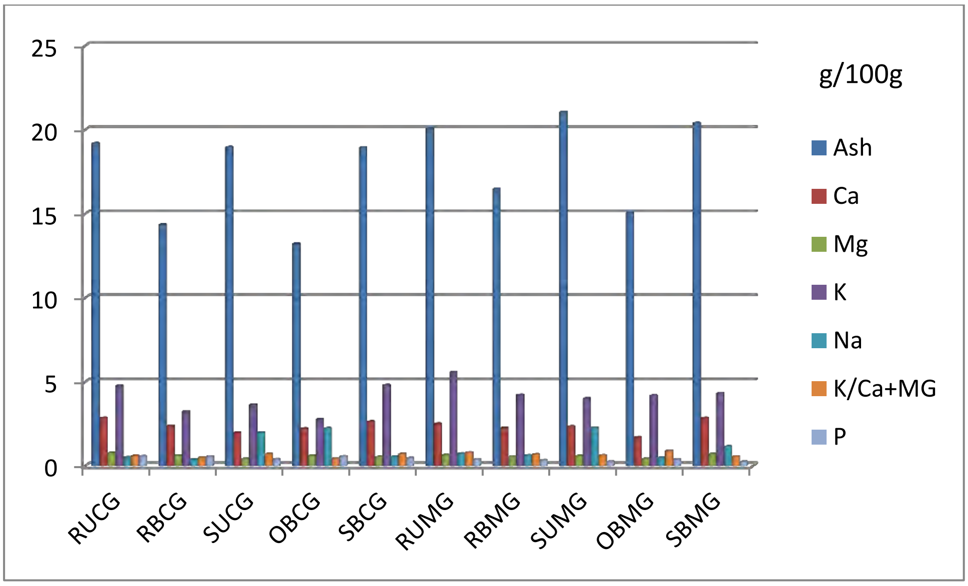

Figure 5.3: Effect of different drying methods on the mineral content (A)[1]

[1] Mean value (n=3)

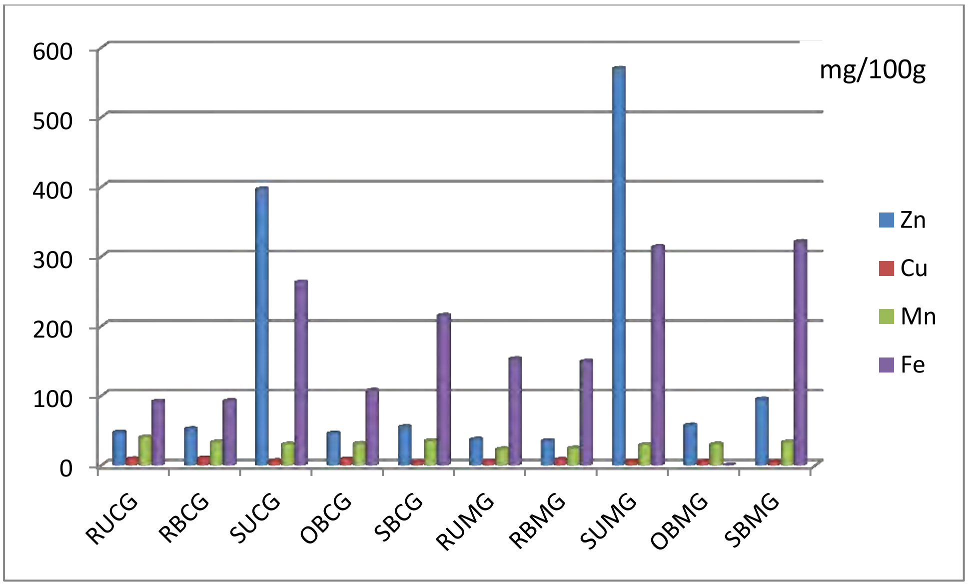

Figure 5.4: Effect of different drying methods on the mineral content (B)[1]

[1] Mean value (n=3)

Overall, blanching reduced the total mineral content significantly (P<0.05). There was notable reduction in most minerals, however, the zinc, copper and iron increased in CG and the copper and manganese increased in MG. The indigenous method of preservation (SUCG/SUMG) significantly reduced (P<0.05) calcium, magnesium, potassium and phosphorus in both TVLs types; copper and manganese only decreased in CG but in MG manganese content increased with no change observed in copper levels. Sodium, zinc and iron content significantly increased in both TVLs types. Sun-drying had a lower reduction effect on calcium, potassium and manganese than oven-drying. Sun-drying increased the sodium, zinc and iron content in both TVLs types. Oven drying increased of sodium and iron content in CG and zinc, manganese and iron in MG.

Several researchers have reported that drying resulted in the reduction of several nutrients, the extent of the loss was, however, dependent on the type of vegetable (Tembo *et al.* 2008; Muchoki *et al.* 2007). All the methods used had a variable impact, either positive or negative, on the minerals, however, the total mineral content (ash) was higher in sun-dried than in oven-dried vegetable samples. There is indigenous belief that adding tomatoes or other ingredients enhances the nutritional value. The results of Figures 5.3 and 5.4 seem to contradict some of the findings reported by the USDA (2003) in which cooking reportedly depletes over 20% of some minerals like sodium, iron, zinc and calcium. In preserving these vegetables using the indigenous method, tomatoes are added, which could explain why there is either a less than expected decrease or an increase in some nutrient contents.

Based on these results, the ideal preservation method would need to be determined in combination with other quality measures. The increase in iron, sodium and zinc content of TLV types during processing by the IKS-based method could have been due to the addition of salt and tomato during preparation. Further investigations are needed to determine the influence of adding tomato before preservation on the nutrient of the TLVs.

5.4.3 Microbial quality and safety

The effects of different processing methods on the microbial quality of the leafy vegetables are depicted in Table 5.3.

The yeast, mould and *B. cereus* levels were all below the standard limits in all vegetable samples. Mould could not be detected in both TLVs types (collard greens and mustard greens) after oven-drying. The *L. monocytogenes* were detected in the sun-dried collard greens and the raw mustard greens. The *E. coli* and *Salmonella* were detected in all TLVs samples processed by different methods.

Table 5.3: Microbial content of TLVs preserved by different drying methods

Microbial type	RUCG	OBCG	SBCG	RUMG	OBMG	SBMG	*Standard limit
Yeast (cfu/g)	4.7×10^2	7.5×10^3	1.1×10^4	$>1.5 \times 10^3$	10	$>1.5 \times 10^3$	*** 10^5
Mould (cfu/g)	30	<10	80	2.4×10^2	<10	85	*** 10^5
Salmonella / 25g	present	present	present	present	present	present	** Absence
***Listeria monocytogenes* (cfu/g)**	<100	<100	5.5×10^2	1.3×10^4	<100	<100	** 100
***Bacillus cereus* (cfu/g)**	4.5×10^2	6.0×10^2	5.0×10^2	8.0×10^2	<100	3.5×10^2	*** 10^4
Presumptive *Escherichia coli* / 0.1g	present	present	present	present	present	present	*** 10^3

(<) = less than

(>) = greater than

cfu/g = colony forming units / gram

* The standard limit represents the maximum acceptable levels prior to cooking the dried vegetables.

** Source: CBI market information database. EU legislation: Microbiological contamination of food.

*** Source: Stannard *et al.* (1997), Development and use of microbiological criteria for foods.

RU = raw untreated; RB = raw blanched; OB = oven-dried blanched; SB = sun-dried blanched; CG = collard greens; MG = mustard greens

Oven drying reduced moulds in vegetables more than did sun drying. However, both drying methods were effective reducing mould levels to significantly below the standard limit. Yeasts were not very sensitive to sun drying as dried samples of both TVLs types had an equal or higher level of yeast than their unprocessed and oven-dried counterparts. The presence of *E. coli* and *B. cereus* in the unprocessed TLVs was as expected because according to Muchoki (2007), these bacteria are common in raw vegetables. With the exception of oven-dried MG, processing did not make a significant reduction in the levels of *B. cereus*; *E. coli* could not be quantified due to the limited sample size. The levels of *B. cereus* in the dried TLVs were below the standard limit indicating that this bacterium would not harm the consumers. The presence of *Salmonella* in the dried TVLs samples is of concern as this bacterium is highly pathogenic. However, Salmonella is easily killed by ordinary cooking temperatures and therefore it may not be risky to consume the dried vegetables if they are cooked properly. Yet, it is critical that the drying methods studied are improved to eliminate this pathogen completely. Constantin and Manuela (2010) found similar lower sensitivity of yeasts to sun drying; however, the bacteria were more sensitive. Based on the findings of several researchers, the expectation was that there would be high levels of microbial contamination of the sun-dried TLVs, which was not the case. The conditions they listed as contributors to microbial contamination of sun dried vegetables included poor hygiene, dust, environmental contaminants due to industrialisation, and infestation by pests, rodents or livestock (Afolabi 2014; Akeredolu & Adebajo 2013). These contributors to microbial contamination seem not to have been significant this study. Overall, with the exception of *Salmonella spp.*, the microbiological quality and safety of the processing techniques used in this study was within acceptable limits.

5.4.4 Sensory quality

A total of 62 respondents participated in the study, 61% were female and 39% were male. From this total of respondents, 29.1% were youths aged below 25 years, 25.8% young adults (25-35 years old), 14.5% adults aged between 36-50 and 30.6% elders aged above 50 years.

5.4.4.1 Sensory acceptability of the vegetable samples

The results of the sensory acceptability evaluation of collard green TLVs that were cooked either fresh (control), oven dried or sun dried are shown in Table 5.4. The sum of the responses under good and very good for each attribute indicated a percentage of an acceptable finding. A neutral response indicated an undecided finding and the sum of the responses under bad and very bad indicated an unacceptable finding

Table 5.4: Sensory rating of collard greens by rural and urban dwellers (Rural N = 28, Urban N = 34)

Sensory Attribute	Rating	**Fresh** (n%)		**Oven dried** (n%)		**Sun dried** (n%)	
		Rural	Urban	Rural	Urban	Rural	Urban
Texture	Very good	7 (25.0)	12 (35.2)	5 (17.8)	4 (11.7)	6 (21.4)	7 (20.5)
	Good	10 (35.7)	12 (35.2)	4 (14.2)	12 (35.2)	14 (50.0)	14 (41.1)
	Neutral	5 (17.8)	6 (17.6)	10 (35.7)	9 (26.4)	6 (21.4)	9 (26.4)
	Bad	5 (17.8)	1 (2.9)	6 (21.4)	5 (14.7)	0 (0)	1 (2.9)
	Very bad	0 (0)	1 (2.9)	1 (3.5)	1 (2.9)	0 (0)	0 (0)
	No result	1 (3.5)	2 (5.8)	2 (7.1)	3 (8.8)	2 (7.1)	3 (8.8)
Aroma	Very good	5 (17.8)	8 (23.5)	7 (25.0)	3 (8.8)	3 (10.7)	6 (17.6)
	Good	9 (32.1)	16 (47.0)	10 (35.7)	12 (35.2)	16 (57.1)	22 (64.7)
	Neutral	11 (39.2)	4 (11.7)	7 (25.0)	13 (38.2)	5 (17.8)	2 (5.8)
	Bad	1 (3.5)	1 (2.9)	4 (14.2)	3 (8.8)	2 (7.1)	2 (5.8)
	Very bad	0 (0)	1 (2.9)	0 (0)	0 (0)	0 (0)	0 (0)
	No result	2 (7.1)	4 (11.7)	0 (0)	3 (8.8)	2 (7.1)	2 (5.8)
Colour	Very good	8 (28.5)	11 (32.3)	6 (21.4)	6 (17.6)	5 (17.8)	11 (32.3)
	Good	13 (46.4)	14 (41.1)	10 (35.7)	12 (35.2)	14 (50.0)	10 (29.4)
	Neutral	5 (17.8)	5 (14.7)	5 (17.8)	9 (26.4)	5 (17.8)	8 (23.5)
	Bad	2 (7.1)	1 (2.9)	6 (21.4)	3 (8.8)	1 (3.5)	2 (5.8)
	Very bad	0 (0)	1 (2.9)	0 (0)	1 (2.9)	1 (3.5)	1 (2.9)
	No result	0 (0)	2 (5.8)	1 (3.5)	3 (8.8)	2 (7.1)	2 (5.8)
Overall acceptability	Very good	6 (21.4)	10 (29.4)	9 (32.1)	5 (14.7)	9 (32.1)	8 (23.5)
	Good	14 (50.0)	14 (41.1)	7 (25.0)	14 (41.1)	8 (28.5)	17 (50.0)
	Neutral	3 (10.7)	6 (17.6)	10 (35.7)	10 (29.4)	8 (28.5)	6 (17.6)
	Bad	2 (7.1)	1 (2.9)	1 (3.5)	2 (5.8)	0 (0)	1 (2.9)
	Very bad	0 (0)	1 (2.9)	1 (3.5)	0 (0)	1 (3.5)	0 (0)
	No result	3 (10.7)	2 (5.8)	0 (0)	3 (8.8)	2 (7.1)	2 (5.8)

Over 60% of both urban and rural dwellers found the texture of sun-dried collard greens acceptable (good and very good). A significant proportion of consumers from the rural location were either undecided (35.7%) or disliked (24.9%) the texture of oven-dried collards, the urban residents (46.9%), however, found them acceptable. The aroma and colour of sun-dried collards was the most preferred processed TLV compared to oven-dried counterparts in both study locations. Consistently, over 45% of respondents in both locations preferred the fresh TLVs over both the processed forms of TLVs.

The results of the evaluation of sensory acceptability of mustard green TLVs cooked either fresh (control), oven dried or sun dried are shown in Table 5.5

Table 5.5: Sensory rating of mustard greens by rural and urban dwellers (Rural N = 28, Urban N = 34)

Sensory Attribute	**Rating**	**Fresh** (n%)		**Oven dried** (n%)		**Sun dried** (n%)	
		Rural	Urban	Rural	Urban	Rural	Urban
Texture	Very good	8 (28.5)	14 (41.1)	3 (10.7)	12 (35.2)	7 (25.0)	6 (17.6)
	Good	11 (39.2)	16 (47.0)	12 (42.8)	9 (26.4)	9 (32.1)	12 (35.2)
	Neutral	4 (14.2)	2 (5.8)	6 (21.4)	9 (26.4)	7 (25.0)	11 (32.3)
	Bad	3 (10.7)	0 (0)	6 (21.4)	4 (11.7)	4 (14.2)	2 (5.8)
	Very bad	0 (0)	0 (0)	1 (3.5)	0 (0)	0 (0)	2 (5.8)
	No result	2 (7.1)	2 (5.8)	0 (0)	0 (0)	1 (3.5)	1 (2.9)
Aroma	Very good	10 (35.7)	18 (52.9)	6 (21.4)	12 (35.2)	8 (28.5)	8 (23.5)
	Good	9 (32.1)	11 (32.3)	8 (28.5)	10 (29.4)	6 (21.4)	9 (26.4)
	Neutral	3 (10.7)	3 (8.8)	8 (28.5)	9 (26.4)	11 (39.2)	8 (23.5)
	Bad	4 (14.2)	0 (0)	4 (14.2)	1 (2.9)	1 (3.5)	6 (17.6)
	Very bad	1 (3.5)	0 (0)	0 (0)	2 (5.8)	1 (3.5)	1 (2.9)
	No result	1 (3.5)	2 (5.8)	2 (7.1)	0 (0)	1 (3.5)	2 (5.8)
Colour	Very good	10 (35.7)	13 (38.2)	6 (21.4)	10 (29.4)	6 (21.4)	11 (32.3)
	Good	12 (42.8)	18 (52.9)	11 (39.2)	14 (41.1)	13 (46.4)	10 (29.4)
	Neutral	4 (14.2)	1 (2.9)	8 (28.5)	5 (14.7)	8 (28.5)	9 (26.4)
	Bad	1 (3.5)	1 (2.9)	2 (7.1)	5 (14.7)	0 (0)	3 (8.8)
	Very bad	0 (0)	0 (0)	1 (3.5)	0 (0)	0 (0)	0 (0)
	No result	1 (3.5)	1 (2.9)	0 (0)	0 (0)	1 (3.5)	1 (2.9)
Overall acceptability	Very good	8 (28.5)	16 (47.0)	6 (21.4)	10 (29.4)	6 (21.4)	6 (17.6)
	Good	14 (50.0)	12 (35.2)	12 (42.8)	13 (38.2)	13 (46.4)	10 (29.4)
	Neutral	5 (17.8)	4 (11.7)	7 (25.0)	8 (23.5)	5 (17.8)	13 (38.2)
	Bad	0 (0)	0 (0)	2 (7.1)	2 (5.8)	2 (7.1)	4 (11.7)
	Very bad	0 (0)	0 (0)	0 (0)	1 (2.9)	0 (0)	0 (0)
	No result	1 (3.5)	2 (5.8)	1 (3.5)	0 (0)	2 (7.1)	1 (2.9)

The texture of oven-dried vegetables was more preferable to urban residents than the sun-dried vegetables. However, in the rural location, the consumers preferred the texture of sun-dried TLVs over that of oven-dried ones. The aroma of mustard greens was equally acceptable (good and very good) to the rural dwellers (49.9%) for both oven- and sun-dried TLVs, the urban consumers, however, preferred the oven-dried (64.6%). An appreciable proportion of urban dwellers (20.5%) found the sun-dried TLVs aroma unacceptable (bad and very bad). The colour of processed TLVs was acceptable to the panellists in both locations. For all the sensory attributes evaluated, urban residents, overall, found sun-dried mustards less acceptable than oven-dried ones, whereas rural residents found them to be comparatively acceptable, although sun-dried forms were to a small degree preferred. However, over 67% of the panellists in both locations consistently preferred the fresh TLVs over both the processed forms of TLVs in terms of all the sensory attributes evaluated.

Of the processed vegetables, rural dwellers preferred the sun-dried vegetables of both TLVs types over the oven-dried counterparts in terms of all the sensory attributes evaluated. The urban dwellers, overall, preferred the sun-dried collard greens and the oven-dried mustard greens. The focus group discussions revealed that for consumers, colour was an important attribute for determining acceptability, which concurs with what is documented in the literature that colour is associated with specific nutritional benefits and flavour which influence acceptability (Wu & Sun 2013; Guine & Barroca 2012). The colour of sun-dried TLVs samples retained the green hue as mentioned in the preceding chapter (Table 4.1), whereas the oven-dried TVLs samples became reddish. This explains why overall the sun-dried TLVs were more acceptable than the oven-dried TLVs. Panellists also stated that there is a distinct smell that is associated with TLVs. Over 67% of respondents in both urban and rural panels had a consistent preference of fresh vegetables to the processed ones even though the vegetables were marked in codes and randomly served. The literature indicates that aroma and texture are also important determinants of sensory acceptability (Giri & Prasad 2009). Urban residents preferred the aroma and texture of oven-dried mustard greens, whereas rural residents preferred the texture and aroma of sun-dried vegetables. Rural residents are familiar with preservation through sun-drying of other similar leafy vegetables; this is likely to be the reason for their preference of the aroma of the sun-dried TLVs as found in this study.

5.5 Conclusion

The findings of this study indicate that s blanching, sun drying and oven had both similar and different effects on the quality and microbial safety of the two TLVs, collard greens and mustard greens. Sun drying retained the colour of the TVLs better than oven drying; however, the latter drying method maintained texture better than the former. The nutrient composition of the sun dried and oven dried TLVs samples- notably; the total mineral content (ash) was higher in sun-dried vegetables than in the oven-dried or blanched vegetables. With the exception of *Salmonella* levels, indicators of the microbiological quality and safety of the processing techniques used in this study were within acceptable limits. Consumers that are familiar with TLVs are willing to consume processed forms of the two TLVs. What is essential to the consumers about the preserved TLVs is that they retain their quality. This they judge by the green colour of the vegetables, which indicates nutrient retention levels. The innovative indigenous method of blanching and sun-drying, met this requirement and the sensory acceptability results indicated preference of this preservation method in terms of most of the sensory quality attributes evaluated. Overall, both sun drying and oven drying resulted in TVLs of fairly acceptable quality although sun-drying achieved better sensory quality of the TVLs.

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CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study aimed to investigate the potential of processing and preserving the underutilised TLVs to maximise their utilisation for enhanced household livelihood, food and nutrition security, especially, of the predominantly resource-poor households. This was achieved though assessing the effects of different drying technologies on the nutritional composition, physical quality, consumer acceptability and microbiological safety of two TLVs types, mustard greens and collard greens.

Sun drying maintained TLV colour better than oven drying, however, the latter maintained texture better. Nutrient content varied between the two processes; however, the total mineral content (ash) was higher in sun-dried vegetables than in the oven-dried or blanched vegetables. The microbiological contents of the TLVs preserved by the different methods, with the exception of *Salmonella,* were within acceptable limits. Both these processing methods maintain an acceptable quality. However, based on literature findings that colour gives a perception of good nutritional value to the consumer, the innovative indigenous method of blanching and sun-drying, fulfilled this requirement. The TLVs samples preserved by blanching and sun-drying were more acceptable to the consumers than the TLVs samples preserved by blanching and oven drying. This seems to confirm what is documented in the literature that consumers perceive brighter green vegetables with higher nutritional value and as a result tend to prefer them. As stated earlier, the TLVs samples preserved by sun-drying had a brighter green colour than the oven-dried samples.

There is a perceived decline in consumption patterns in the urban areas, more so among the youth. These can be attributed to stigma and declining familiarity with both the traditional food and the indigenous way of preparing the food. The TLVs could be modernised to promote utilisation by integrating them into the formal markets and updating preparation method to include food that the youth regards as prestigious, like potatoes and protein.

South Africa aims to achieve the eradication of hunger, malnutrition and food insecurity as part of its Millennium Development Goal targets. Current socioeconomic challenges of economic and physical availability and access to nutritious food choices limit the government's response to challenges faced by households. The findings of this study indicate that innovative IKS-based methods could be easy to implement in resource-poor households in Limpopo as most of them are already familiar with the common practice of drying and the input required is minimal. Over and above that, the dried food products would be economically accessible due to low cost, nutritious due to retention of nutritional value and provide food safety-nets due to prolonged shelf-life.

6.2 Recommendations

The selected consumer sample in the current study had limited representation of the populations of the Limpopo and the country of South Africa. Future studies could be extended to other provinces in the country to identify their familiarity with the practice of drying for preservation, their common methods of preservation, their familiarity with the TLVs and their willingness to consume dried TLVs. To address the issue of familiarity among the youth, programmes aimed at integrating TLVs into common food like cereals during nutritional feeding programmes, adding TLVs in food parcels during nutritious food utilisation campaigns and introducing TLV consumption in the basic food basket could be implemented. Commercial farmers regard such vegetables as low value stock; therefore such interventions could be of benefit for smallholder farmers. In rural homesteads, these interventions could promote the use of land, enabling households to improve livelihoods through income generation.

Similar studies in future could be improved through investigating two additional criteria that were not covered by the scope of this study. Consumers in the focus group discussions indicated inconsistencies in their perception on the shelf-life of dried TLVs. They also had perceptions on storage that differ from literature in that the TLVs are kept at room temperature which is an optimal growth environment for some microorganisms known for food borne infections. Studies on the control of temperature and humidity during storage and how these impact the shelf-life have implications on the usability of TLVs to promote food and nutrition security.

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APPENDICES

Appendix A: Statistical analysis on the effect of different drying methods

Table A1: Effect of different drying methods on texture

Maximum force (N)[2]	**Collard greens**		**Mustard greens**	
	Sample code	**Mean**[1] **(STDEV)**	**Sample code**	**Mean**[1] **(STDEV)**
Maximum force values	RUCG	66.21 (6.99)[w]	RUMG	63.08 (2.94)[w]
	RBCG	66.82 (10.27)[w]	RBMG	66.95 (18.65)[w]
	OBCG	48.04 (19.17)[w]	OBMG	56.17 (32.74)[w]
	SBCG	269.04 (94.86)[x]	SBMG	303.52 (12.90)[x]

Table A2: Effect of different drying methods on mineral composition

Mineral composition[2] **(% dry weight)**	**Collard greens**		**Mustard greens**	
	Sample code	**Mean**[1] **(STDEV)**	**Sample code**	**Mean**[1] **(STDEV)**
Ash (g/100g)	RUCG	19.19 (0.01)[y]	RUMG	20.07 (0.10)[x]
	RBCG	14.36 (0.13)[w]	RBMG	16.47 (0.09)[w]
	SUCG	18.97 (0.20)[x, y]	SUMG	21.04 (0.12)[z]
	OBCG	13.22 (0.08)[v]	OBMG	15.07 (0.33)[v]
	SBCG	18.93 (0.12)[x]	SBMG	20.40 (0.05)[y]
Calcium (g/100g)	RUCG	2.85 (0.04)[z]	RUMG	2.52 (0.03)[y]
	RBCG	2.38 (0.02)[x]	RBMG	2.27 (0.01)[w]
	SUCG	1.97 (0.02)[v]	SUMG	2.34 (0.01)[x]
	OBCG	2.22 (0.03)[w]	OBMG	1.71 (0.01)[v]
	SBCG	2.63 (0.01)[y]	SBMG	2.85 (0.06)[z]
Magnesium (g/100g)	RUCG	0.77 (0.01)[y]	RUMG	0.65 (0.01)[y]
	RBCG	0.61 (0.01)[x]	RBMG	0.54 (0.00)[w]
	SUCG	0.42 (0.01)[v]	SUMG	0.58 (0.02)[x]
	OBCG	0.60 (0.00)[x]	OBMG	0.41 (0.01)[v]
	SBCG	0.52 (0.01)[w]	SBMG	0.71 (0.01)[z]
Potassium (g/100g)	RUCG	4.76 (0.08)[y]	RUMG	5.57 (0.08)[y]
	RBCG	3.24 (0.03)[w]	RBMG	4.23 (0.05)[w, x]
	SUCG	3.64 (0.02)[x]	SUMG	4.01 (0.03)[v]
	OBCG	2.77 (0.01)[v]	OBMG	4.18 (0.04)[w]
	SBCG	4.80 (0.04)[y]	SBMG	4.32 (0.04)[x]
Sodium (g/100g)	RUCG	0.51 (0.02)[w]	RUMG	0.73 (0.01)[w]
	RBCG	0.38 (0.01)[v]	RBMG	0.63 (0.01)[w]
	SUCG	1.97 (0.03)[x]	SUMG	2.27 (0.16)[y]
	OBCG	2.24 (0.01)[y]	OBMG	0.49 (0.02)[v]
	SBCG	0.54 (0.03)[w]	SBMG	1.15 (0.01)[x]

Phosphorus (g/100g)	RUCG	0.57 (0.06)$^{x, y}$	RUMG	0.37 (0.00)^{x}
	RBCG	0.55 (0.01)^{x}	RBMG	0.34 (0.01)^{w}
	SUCG	0.39 (0.00)^{v}	SUMG	0.24 (0.00)^{v}
	OBCG	0.56 (0.00)^{y}	OBMG	0.39 (0.01)^{y}
	SBCG	0.46 (0.00)^{w}	SBMG	0.24 (0.00)^{v}
Zinc (mg/100g)	RUCG	47.33 (1.53)$^{v, w}$	RUMG	32.00 (0.00)^{v}
	RBCG	52.00 (0.00)^{w}	RBMG	35.00 (0.00)^{v}
	SUCG	396.33 (5.51)^{y}	SUMG	569.67 (7.57)^{y}
	OBCG	45.67 (1.15)^{v}	OBMG	57.33 (6.51)^{w}
	SBCG	55.00 (0.00)^{x}	SBMG	94.67 (1.15)^{x}
Copper (mg/100g)	RUCG	9.00 (0.00)^{x}	RUMG	6.00 (0.00)^{w}
	RBCG	10.00 (0.00)^{y}	RBMG	8.00 (0.00)^{x}
	SUCG	6.33 (0.58)^{w}	SUMG	6.00 (0.00)^{w}
	OBCG	8.67 (0.58)^{x}	OBMG	5.33 (0.58)^{v}
	SBCG	5.00 (0.00)^{v}	SBMG	5.00 (0.00)^{v}
Manganese (mg/100g)	RUCG	40.00 (0.00)	RUMG	23.00 (0.00)^{v}
	RBCG	33.00 (0.00)	RBMG	24.33 (1.15)^{v}
	SUCG	30.00 (0.00)	SUMG	29.00 (0.00)$^{v, w}$
	OBCG	31.00 (0.00)	OBMG	30.00 (8.89)$^{v, w}$
	SBCG	35.00 (0.00)	SBMG	33.00 (0.00)^{w}
Iron (mg/100g)	RUCG	91.67 (1.15)^{v}	RUMG	152.67 (0.58)^{v}
	RBCG	92.33 (2.08)^{v}	RBMG	149.00 (30.32)^{v}
	SUCG	262.67 (7.51)^{y}	SUMG	313.33 (5.03)$^{v, w}$
	OBCG	107.33 (1.15)^{w}	OBMG	4083.67 (4621.81)^{w}
	SBCG	215.00 (4.36)^{x}	SBMG	321.00 (29.51)$^{v, w}$

REFERENCE DATA

Table A3: LSD Comparison on Hunter Lab L-value for colour of collard greens

(I) Lightness	(J) Lightness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	4.3400*	.6109	.000	2.931	5.749
	3.00	15.0133*	.6109	.000	13.605	16.422
	4.00	3.6200*	.6109	.000	2.211	5.029
2.00	1.00	-4.3400*	.6109	.000	-5.749	-2.931
	3.00	10.6733*	.6109	.000	9.265	12.082
	4.00	-.7200	.6109	.272	-2.129	.689
3.00	1.00	-15.0133*	.6109	.000	-16.422	-13.605

	2.00	-10.6733*	.6109	.000	-12.082	-9.265
	4.00	-11.3933*	.6109	.000	-12.802	-9.985
4.00	1.00	-3.6200*	.6109	.000	-5.029	-2.211
	2.00	.7200	.6109	.272	-.689	2.129
	3.00	11.3933*	.6109	.000	9.985	12.802

*. The mean difference is significant at the 0.05 level.

Table A4: LSD Comparison on Hunter Lab a-value for colour of collard greens

(I) Greenness	(J) Greenness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	4.90333*	.38504	.000	4.0154	5.7912
	3.00	-10.10000*	.38504	.000	-10.9879	-9.2121
	4.00	-5.09000*	.38504	.000	-5.9779	-4.2021
2.00	1.00	-4.90333*	.38504	.000	-5.7912	-4.0154
	3.00	-15.00333*	.38504	.000	-15.8912	-14.1154
	4.00	-9.99333*	.38504	.000	-10.8812	-9.1054
3.00	1.00	10.10000*	.38504	.000	9.2121	10.9879
	2.00	15.00333*	.38504	.000	14.1154	15.8912
	4.00	5.01000*	.38504	.000	4.1221	5.8979
4.00	1.00	5.09000*	.38504	.000	4.2021	5.9779
	2.00	9.99333*	.38504	.000	9.1054	10.8812
	3.00	-5.01000*	.38504	.000	-5.8979	-4.1221

*. The mean difference is significant at the 0.05 level.

Table A5: LSD Comparison on Hunter Lab b-value for colour of collard greens

(I) Yellowness	(J) Yellowness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-2.94000*	.62776	.002	-4.3876	-1.4924
	3.00	6.56000*	.62776	.000	5.1124	8.0076
	4.00	2.87000*	.62776	.002	1.4224	4.3176
2.00	1.00	2.94000*	.62776	.002	1.4924	4.3876
	3.00	9.50000*	.62776	.000	8.0524	10.9476
	4.00	5.81000*	.62776	.000	4.3624	7.2576
3.00	1.00	-6.56000*	.62776	.000	-8.0076	-5.1124
	2.00	-9.50000*	.62776	.000	-10.9476	-8.0524
	4.00	-3.69000*	.62776	.000	-5.1376	-2.2424
4.00	1.00	-2.87000*	.62776	.002	-4.3176	-1.4224
	2.00	-5.81000*	.62776	.000	-7.2576	-4.3624
	3.00	3.69000*	.62776	.000	2.2424	5.1376

*. The mean difference is significant at the 0.05 level.

Table A6: LSD Comparison on Hunter Lab L-value for colour of mustard greens

(I) Lightness	(J) Lightness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	7.47000*	1.78679	.003	3.3497	11.5903
	3.00	16.21667*	1.78679	.000	12.0963	20.3370
	4.00	10.70333*	1.78679	.000	6.5830	14.8237
2.00	1.00	-7.47000*	1.78679	.003	-11.5903	-3.3497
	3.00	8.74667*	1.78679	.001	4.6263	12.8670
	4.00	3.23333	1.78679	.108	-.8870	7.3537
3.00	1.00	-16.21667*	1.78679	.000	-20.3370	-12.0963
	2.00	-8.74667*	1.78679	.001	-12.8670	-4.6263
	4.00	-5.51333*	1.78679	.015	-9.6337	-1.3930
4.00	1.00	-10.70333*	1.78679	.000	-14.8237	-6.5830
	2.00	-3.23333	1.78679	.108	-7.3537	.8870
	3.00	5.51333*	1.78679	.015	1.3930	9.6337

*. The mean difference is significant at the 0.05 level.

Table A7: LSD Comparison on Hunter Lab a-value for colour of mustard greens

(I) Greenness	(J) Greenness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	3.53667*	.58591	.000	2.1855	4.8878
	3.00	-12.05333*	.58591	.000	-13.4045	-10.7022
	4.00	-8.26000*	.58591	.000	-9.6111	-6.9089
2.00	1.00	-3.53667*	.58591	.000	-4.8878	-2.1855
	3.00	-15.59000*	.58591	.000	-16.9411	-14.2389
	4.00	-11.79667*	.58591	.000	-13.1478	-10.4455
3.00	1.00	12.05333*	.58591	.000	10.7022	13.4045
	2.00	15.59000*	.58591	.000	14.2389	16.9411
	4.00	3.79333*	.58591	.000	2.4422	5.1445
4.00	1.00	8.26000*	.58591	.000	6.9089	9.6111
	2.00	11.79667*	.58591	.000	10.4455	13.1478
	3.00	-3.79333*	.58591	.000	-5.1445	-2.4422

*.The mean difference is significant at the 0.05 level.

Table A8: LSD Comparison on Hunter Lab b-value for colour of mustard greens

(I) Yellowness	(J) Yellowness	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	3.35667	1.77847	.096	-.7445	7.4578

	3.00	13.08667*	1.77847	.000	8.9855	17.1878
	4.00	10.34000*	1.77847	.000	6.2388	14.4412
2.00	1.00	-3.35667	1.77847	.096	-7.4578	.7445
	3.00	9.73000*	1.77847	.001	5.6288	13.8312
	4.00	6.98333*	1.77847	.004	2.8822	11.0845
3.00	1.00	-13.08667*	1.77847	.000	-17.1878	-8.9855
	2.00	-9.73000*	1.77847	.001	-13.8312	-5.6288
	4.00	-2.74667	1.77847	.161	-6.8478	1.3545
4.00	1.00	-10.34000*	1.77847	.000	-14.4412	-6.2388
	2.00	-6.98333*	1.77847	.004	-11.0845	-2.8822
	3.00	2.74667	1.77847	.161	-1.3545	6.8478

*. The mean difference is significant at the 0.05 level.

Table A9: LSD Comparison on maximum force of penetration for texture of collard greens

(I) Texture	(J) Texture	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.60667	39.83227	.988	-92.4600	91.2467
	3.00	18.17333	39.83227	.660	-73.6800	110.0267
	4.00	-202.82333*	39.83227	.001	-294.6767	-110.9700
2.00	1.00	.60667	39.83227	.988	-91.2467	92.4600
	3.00	18.78000	39.83227	.650	-73.0734	110.6334
	4.00	-202.21667*	39.83227	.001	-294.0700	-110.3633
3.00	1.00	-18.17333	39.83227	.660	-110.0267	73.6800
	2.00	-18.78000	39.83227	.650	-110.6334	73.0734
	4.00	-220.99667*	39.83227	.001	-312.8500	-129.1433
4.00	1.00	202.82333*	39.83227	.001	110.9700	294.6767
	2.00	202.21667*	39.83227	.001	110.3633	294.0700
	3.00	220.99667*	39.83227	.001	129.1433	312.8500

*. The mean difference is significant at the 0.05 level.

Table A10: LSD Comparison on maximum force of penetration for texture of mustard greens

(I) Texture	(J) Texture	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-3.86667	16.30474	.819	-41.4655	33.7321
	3.00	6.91333	16.30474	.683	-30.6855	44.5121
	4.00	-240.43333*	16.30474	.000	-278.0321	-202.8345
2.00	1.00	3.86667	16.30474	.819	-33.7321	41.4655
	3.00	10.78000	16.30474	.527	-26.8188	48.3788
	4.00	-236.56667*	16.30474	.000	-274.1655	-198.9679

3.00	1.00	-6.91333	16.30474	.683	-44.5121	30.6855
	2.00	-10.78000	16.30474	.527	-48.3788	26.8188
	4.00	-247.34667*	16.30474	.000	-284.9455	-209.7479
4.00	1.00	240.43333*	16.30474	.000	202.8345	278.0321
	2.00	236.56667*	16.30474	.000	198.9679	274.1655
	3.00	247.34667*	16.30474	.000	209.7479	284.9455

*. The mean difference is significant at the 0.05 level.

Table A11: LSD Comparison on proximate composition of Fat in collard greens

(I) FAT	(J) FAT	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-1.00000*	.22479	.001	-1.5009	-.4991
	3.00	.32667	.22479	.177	-.1742	.8275
	4.00	-1.11333*	.22479	.001	-1.6142	-.6125
	5.00	.58667*	.22479	.026	.0858	1.0875
2.00	1.00	1.00000*	.22479	.001	.4991	1.5009
	3.00	1.32667*	.22479	.000	.8258	1.8275
	4.00	-.11333	.22479	.625	-.6142	.3875
	5.00	1.58667*	.22479	.000	1.0858	2.0875
3.00	1.00	-.32667	.22479	.177	-.8275	.1742
	2.00	-1.32667*	.22479	.000	-1.8275	-.8258
	4.00	-1.44000*	.22479	.000	-1.9409	-.9391
	5.00	.26000	.22479	.274	-.2409	.7609
4.00	1.00	1.11333*	.22479	.001	.6125	1.6142
	2.00	.11333	.22479	.625	-.3875	.6142
	3.00	1.44000*	.22479	.000	.9391	1.9409
	5.00	1.70000*	.22479	.000	1.1991	2.2009
5.00	1.00	-.58667*	.22479	.026	-1.0875	-.0858
	2.00	-1.58667*	.22479	.000	-2.0875	-1.0858
	3.00	-.26000	.22479	.274	-.7609	.2409
	4.00	-1.70000*	.22479	.000	-2.2009	-1.1991

*. The mean difference is significant at the 0.05 level.

Table A12: LSD Comparison on proximate composition of NDF in collard greens

(I) NDF	(J) NDF	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	.43000	.60340	.492	-.9145	1.7745
	3.00	-13.58000*	.60340	.000	-14.9245	-12.2355
	4.00	-20.93333*	.60340	.000	-22.2778	-19.5889

	5.00	-5.68667*	.60340	.000	-7.0311	-4.3422
2.00	1.00	-.43000	.60340	.492	-1.7745	.9145
	3.00	-14.01000*	.60340	.000	-15.3545	-12.6655
	4.00	-21.36333*	.60340	.000	-22.7078	-20.0189
	5.00	-6.11667*	.60340	.000	-7.4611	-4.7722
3.00	1.00	13.58000*	.60340	.000	12.2355	14.9245
	2.00	14.01000*	.60340	.000	12.6655	15.3545
	4.00	-7.35333*	.60340	.000	-8.6978	-6.0089
	5.00	7.89333*	.60340	.000	6.5489	9.2378
4.00	1.00	20.93333*	.60340	.000	19.5889	22.2778
	2.00	21.36333*	.60340	.000	20.0189	22.7078
	3.00	7.35333*	.60340	.000	6.0089	8.6978
	5.00	15.24667*	.60340	.000	13.9022	16.5911
5.00	1.00	5.68667*	.60340	.000	4.3422	7.0311
	2.00	6.11667*	.60340	.000	4.7722	7.4611
	3.00	-7.89333*	.60340	.000	-9.2378	-6.5489
	4.00	-15.24667*	.60340	.000	-16.5911	-13.9022

*. The mean difference is significant at the 0.05 level.

Table A13: LSD Comparison on proximate composition of protein in collard greens

(I) CRUDE PROTEIN	(J) CRUDE PROTEIN	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.43333*	.19910	.000	-1.8770	-.9897
	3.00	10.73000*	.19910	.000	10.2864	11.1736
	4.00	-.83333*	.19910	.002	-1.2770	-.3897
	5.00	9.93000*	.19910	.000	9.4864	10.3736
2.00	1.00	1.43333*	.19910	.000	.9897	1.8770
	3.00	12.16333*	.19910	.000	11.7197	12.6070
	4.00	.60000*	.19910	.013	.1564	1.0436
	5.00	11.36333*	.19910	.000	10.9197	11.8070
3.00	1.00	-10.73000*	.19910	.000	-11.1736	-10.2864
	2.00	-12.16333*	.19910	.000	-12.6070	-11.7197
	4.00	-11.56333*	.19910	.000	-12.0070	-11.1197
	5.00	-.80000*	.19910	.002	-1.2436	-.3564
4.00	1.00	.83333*	.19910	.002	.3897	1.2770
	2.00	-.60000*	.19910	.013	-1.0436	-.1564
	3.00	11.56333*	.19910	.000	11.1197	12.0070
	5.00	10.76333*	.19910	.000	10.3197	11.2070
5.00	1.00	-9.93000*	.19910	.000	-10.3736	-9.4864
	2.00	-11.36333*	.19910	.000	-11.8070	-10.9197

	3.00	.80000*	.19910	.002	.3564	1.2436
	4.00	-10.76333*	.19910	.000	-11.2070	-10.3197

*. The mean difference is significant at the 0.05 level.

Table A14: LSD Comparison on proximate composition of Fat in mustard greens

(I) FAT	(J) FAT	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.53333*	.12070	.000	-1.8023	-1.2644
	3.00	1.38333*	.12070	.000	1.1144	1.6523
	4.00	-.56333*	.12070	.001	-.8323	-.2944
	5.00	1.34667*	.12070	.000	1.0777	1.6156
2.00	1.00	1.53333*	.12070	.000	1.2644	1.8023
	3.00	2.91667*	.12070	.000	2.6477	3.1856
	4.00	.97000*	.12070	.000	.7011	1.2389
	5.00	2.88000*	.12070	.000	2.6111	3.1489
3.00	1.00	-1.38333*	.12070	.000	-1.6523	-1.1144
	2.00	-2.91667*	.12070	.000	-3.1856	-2.6477
	4.00	-1.94667*	.12070	.000	-2.2156	-1.6777
	5.00	-.03667	.12070	.768	-.3056	.2323
4.00	1.00	.56333*	.12070	.001	.2944	.8323
	2.00	-.97000*	.12070	.000	-1.2389	-.7011
	3.00	1.94667*	.12070	.000	1.6777	2.2156
	5.00	1.91000*	.12070	.000	1.6411	2.1789
5.00	1.00	-1.34667*	.12070	.000	-1.6156	-1.0777
	2.00	-2.88000*	.12070	.000	-3.1489	-2.6111
	3.00	.03667	.12070	.768	-.2323	.3056
	4.00	-1.91000*	.12070	.000	-2.1789	-1.6411

*. The mean difference is significant at the 0.05 level.

Table A15: LSD Comparison on proximate composition of NDF in mustard greens

(I) NDF	(J) NDF	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	2.43333*	.36905	.000	1.6110	3.2556
	3.00	-16.61333*	.36905	.000	-17.4356	-15.7910
	4.00	-15.52333*	.36905	.000	-16.3456	-14.7010
	5.00	-.50667	.36905	.200	-1.3290	.3156
2.00	1.00	-2.43333*	.36905	.000	-3.2556	-1.6110
	3.00	-19.04667*	.36905	.000	-19.8690	-18.2244
	4.00	-17.95667*	.36905	.000	-18.7790	-17.1344

	5.00	-2.94000*	.36905	.000	-3.7623	-2.1177
3.00	1.00	16.61333*	.36905	.000	15.7910	17.4356
	2.00	19.04667*	.36905	.000	18.2244	19.8690
	4.00	1.09000*	.36905	.014	.2677	1.9123
	5.00	16.10667*	.36905	.000	15.2844	16.9290
4.00	1.00	15.52333*	.36905	.000	14.7010	16.3456
	2.00	17.95667*	.36905	.000	17.1344	18.7790
	3.00	-1.09000*	.36905	.014	-1.9123	-.2677
	5.00	15.01667*	.36905	.000	14.1944	15.8390
5.00	1.00	.50667	.36905	.200	-.3156	1.3290
	2.00	2.94000*	.36905	.000	2.1177	3.7623
	3.00	-16.10667*	.36905	.000	-16.9290	-15.2844
	4.00	-15.01667*	.36905	.000	-15.8390	-14.1944

*. The mean difference is significant at the 0.05 level.

Table A16: LSD Comparison on proximate composition of protein in mustard greens

(I) CRUDE PROTEIN	(J) CRUDE PROTEIN	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.22000	.24346	.387	-.3225	.7625
	3.00	6.76000*	.24346	.000	6.2175	7.3025
	4.00	.63000*	.24346	.027	.0875	1.1725
	5.00	5.63333*	.24346	.000	5.0909	6.1758
2.00	1.00	-.22000	.24346	.387	-.7625	.3225
	3.00	6.54000*	.24346	.000	5.9975	7.0825
	4.00	.41000	.24346	.123	-.1325	.9525
	5.00	5.41333*	.24346	.000	4.8709	5.9558
3.00	1.00	-6.76000*	.24346	.000	-7.3025	-6.2175
	2.00	-6.54000*	.24346	.000	-7.0825	-5.9975
	4.00	-6.13000*	.24346	.000	-6.6725	-5.5875
	5.00	-1.12667*	.24346	.001	-1.6691	-.5842
4.00	1.00	-.63000*	.24346	.027	-1.1725	-.0875
	2.00	-.41000	.24346	.123	-.9525	.1325
	3.00	6.13000*	.24346	.000	5.5875	6.6725
	5.00	5.00333*	.24346	.000	4.4609	5.5458
5.00	1.00	-5.63333*	.24346	.000	-6.1758	-5.0909
	2.00	-5.41333*	.24346	.000	-5.9558	-4.8709
	3.00	1.12667*	.24346	.001	.5842	1.6691
	4.00	-5.00333*	.24346	.000	-5.5458	-4.4609

*. The mean difference is significant at the 0.05 level.

Table A17: LSD Comparison on mineral composition of Ash in collard greens

(I) ASH	(J) ASH	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	4.83333*	.10013	.000	4.6102	5.0564
	3.00	.22333*	.10013	.050	.0002	.4464
	4.00	5.97333*	.10013	.000	5.7502	6.1964
	5.00	.26000*	.10013	.027	.0369	.4831
2.00	1.00	-4.83333*	.10013	.000	-5.0564	-4.6102
	3.00	-4.61000*	.10013	.000	-4.8331	-4.3869
	4.00	1.14000*	.10013	.000	.9169	1.3631
	5.00	-4.57333*	.10013	.000	-4.7964	-4.3502
3.00	1.00	-.22333*	.10013	.050	-.4464	-.0002
	2.00	4.61000*	.10013	.000	4.3869	4.8331
	4.00	5.75000*	.10013	.000	5.5269	5.9731
	5.00	.03667	.10013	.722	-.1864	.2598
4.00	1.00	-5.97333*	.10013	.000	-6.1964	-5.7502
	2.00	-1.14000*	.10013	.000	-1.3631	-.9169
	3.00	-5.75000*	.10013	.000	-5.9731	-5.5269
	5.00	-5.71333*	.10013	.000	-5.9364	-5.4902
5.00	1.00	-.26000*	.10013	.027	-.4831	-.0369
	2.00	4.57333*	.10013	.000	4.3502	4.7964
	3.00	-.03667	.10013	.722	-.2598	.1864
	4.00	5.71333*	.10013	.000	5.4902	5.9364

*. The mean difference is significant at the 0.05 level.

Table A18: LSD Comparison on mineral composition of Calcium in collard greens

(I) CALCUIM	(J) CALCUIM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.47333*	.01897	.000	.4311	.5156
	3.00	.87667*	.01897	.000	.8344	.9189
	4.00	.62667*	.01897	.000	.5844	.6689
	5.00	.22000*	.01897	.000	.1777	.2623
2.00	1.00	-.47333*	.01897	.000	-.5156	-.4311
	3.00	.40333*	.01897	.000	.3611	.4456
	4.00	.15333*	.01897	.000	.1111	.1956
	5.00	-.25333*	.01897	.000	-.2956	-.2111
3.00	1.00	-.87667*	.01897	.000	-.9189	-.8344
	2.00	-.40333*	.01897	.000	-.4456	-.3611

	4.00	-.25000*	.01897	.000	-.2923	-.2077
	5.00	-.65667*	.01897	.000	-.6989	-.6144
4.00	1.00	-.62667*	.01897	.000	-.6689	-.5844
	2.00	-.15333*	.01897	.000	-.1956	-.1111
	3.00	.25000*	.01897	.000	.2077	.2923
	5.00	-.40667*	.01897	.000	-.4489	-.3644
5.00	1.00	-.22000*	.01897	.000	-.2623	-.1777
	2.00	.25333*	.01897	.000	.2111	.2956
	3.00	.65667*	.01897	.000	.6144	.6989
	4.00	.40667*	.01897	.000	.3644	.4489

*. The mean difference is significant at the 0.05 level.

Table A19: LSD Comparison on mineral composition of Magnesium in collard greens

(I) MAGNESIUM	(J) MAGNESIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.15667*	.00699	.000	.1411	.1722
	3.00	.35000*	.00699	.000	.3344	.3656
	4.00	.16667*	.00699	.000	.1511	.1822
	5.00	.24667*	.00699	.000	.2311	.2622
2.00	1.00	-.15667*	.00699	.000	-.1722	-.1411
	3.00	.19333*	.00699	.000	.1778	.2089
	4.00	.01000	.00699	.183	-.0056	.0256
	5.00	.09000*	.00699	.000	.0744	.1056
3.00	1.00	-.35000*	.00699	.000	-.3656	-.3344
	2.00	-.19333*	.00699	.000	-.2089	-.1778
	4.00	-.18333*	.00699	.000	-.1989	-.1678
	5.00	-.10333*	.00699	.000	-.1189	-.0878
4.00	1.00	-.16667*	.00699	.000	-.1822	-.1511
	2.00	-.01000	.00699	.183	-.0256	.0056
	3.00	.18333*	.00699	.000	.1678	.1989
	5.00	.08000*	.00699	.000	.0644	.0956
5.00	1.00	-.24667*	.00699	.000	-.2622	-.2311
	2.00	-.09000*	.00699	.000	-.1056	-.0744
	3.00	.10333*	.00699	.000	.0878	.1189
	4.00	-.08000*	.00699	.000	-.0956	-.0644

*. The mean difference is significant at the 0.05 level.

Table A20: LSD Comparison on mineral composition of Potassium in collard greens

(I) POTASSIUM	(J) POTASSIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

1.00	2.00	1.52333*	.03694	.000	1.4410	1.6056
	3.00	1.12667*	.03694	.000	1.0444	1.2090
	4.00	1.99000*	.03694	.000	1.9077	2.0723
	5.00	-.04000	.03694	.304	-.1223	.0423
2.00	1.00	-1.52333*	.03694	.000	-1.6056	-1.4410
	3.00	-.39667*	.03694	.000	-.4790	-.3144
	4.00	.46667*	.03694	.000	.3844	.5490
	5.00	-1.56333*	.03694	.000	-1.6456	-1.4810
3.00	1.00	-1.12667*	.03694	.000	-1.2090	-1.0444
	2.00	.39667*	.03694	.000	.3144	.4790
	4.00	.86333*	.03694	.000	.7810	.9456
	5.00	-1.16667*	.03694	.000	-1.2490	-1.0844
4.00	1.00	-1.99000*	.03694	.000	-2.0723	-1.9077
	2.00	-.46667*	.03694	.000	-.5490	-.3844
	3.00	-.86333*	.03694	.000	-.9456	-.7810
	5.00	-2.03000*	.03694	.000	-2.1123	-1.9477
5.00	1.00	.04000	.03694	.304	-.0423	.1223
	2.00	1.56333*	.03694	.000	1.4810	1.6456
	3.00	1.16667*	.03694	.000	1.0844	1.2490
	4.00	2.03000*	.03694	.000	1.9477	2.1123

*. The mean difference is significant at the 0.05 level.

Table A21: LSD Comparison on mineral composition of Sodium in collard greens

(I) SODIUM	(J) SODIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.13000*	.01764	.000	.0907	.1693
	3.00	-1.46000*	.01764	.000	-1.4993	-1.4207
	4.00	-1.72667*	.01764	.000	-1.7660	-1.6874
	5.00	-.03000	.01764	.120	-.0693	.0093
2.00	1.00	-.13000*	.01764	.000	-.1693	-.0907
	3.00	-1.59000*	.01764	.000	-1.6293	-1.5507
	4.00	-1.85667*	.01764	.000	-1.8960	-1.8174
	5.00	-.16000*	.01764	.000	-.1993	-.1207
3.00	1.00	1.46000*	.01764	.000	1.4207	1.4993
	2.00	1.59000*	.01764	.000	1.5507	1.6293
	4.00	-.26667*	.01764	.000	-.3060	-.2274
	5.00	1.43000*	.01764	.000	1.3907	1.4693
4.00	1.00	1.72667*	.01764	.000	1.6874	1.7660
	2.00	1.85667*	.01764	.000	1.8174	1.8960
	3.00	.26667*	.01764	.000	.2274	.3060

	5.00	1.69667*	.01764	.000	1.6574	1.7360
5.00	1.00	.03000	.01764	.120	-.0093	.0693
	2.00	.16000*	.01764	.000	.1207	.1993
	3.00	-1.43000*	.01764	.000	-1.4693	-1.3907
	4.00	-1.69667*	.01764	.000	-1.7360	-1.6574

*. The mean difference is significant at the 0.05 level.

Table A22: LSD Comparison on mineral composition of Phosphorus in collard greens

(I) PHOSPHORUS	(J) PHOSPHORUS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.01667	.02231	.472	-.0330	.0664
	3.00	.18000*	.02231	.000	.1303	.2297
	4.00	.01000	.02231	.664	-.0397	.0597
	5.00	.11000*	.02231	.001	.0603	.1597
2.00	1.00	-.01667	.02231	.472	-.0664	.0330
	3.00	.16333*	.02231	.000	.1136	.2130
	4.00	-.00667	.02231	.771	-.0564	.0430
	5.00	.09333*	.02231	.002	.0436	.1430
3.00	1.00	-.18000*	.02231	.000	-.2297	-.1303
	2.00	-.16333*	.02231	.000	-.2130	-.1136
	4.00	-.17000*	.02231	.000	-.2197	-.1203
	5.00	-.07000*	.02231	.011	-.1197	-.0203
4.00	1.00	-.01000	.02231	.664	-.0597	.0397
	2.00	.00667	.02231	.771	-.0430	.0564
	3.00	.17000*	.02231	.000	.1203	.2197
	5.00	.10000*	.02231	.001	.0503	.1497
5.00	1.00	-.11000*	.02231	.001	-.1597	-.0603
	2.00	-.09333*	.02231	.002	-.1430	-.0436
	3.00	.07000*	.02231	.011	.0203	.1197
	4.00	-.10000*	.02231	.001	-.1497	-.0503

*. The mean difference is significant at the 0.05 level.

Table A23: LSD Comparison on mineral composition of Zinc in collard greens

(I) ZINC	(J) ZINC	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-4.66667	2.12916	.053	-9.4107	.0774
	3.00	-349.00000*	2.12916	.000	-353.7441	-344.2559
	4.00	1.66667	2.12916	.452	-3.0774	6.4107
	5.00	-7.66667*	2.12916	.005	-12.4107	-2.9226

2.00	1.00	4.66667	2.12916	.053	-.0774	9.4107
	3.00	-344.33333*	2.12916	.000	-349.0774	-339.5893
	4.00	6.33333*	2.12916	.014	1.5893	11.0774
	5.00	-3.00000	2.12916	.189	-7.7441	1.7441
3.00	1.00	349.00000*	2.12916	.000	344.2559	353.7441
	2.00	344.33333*	2.12916	.000	339.5893	349.0774
	4.00	350.66667*	2.12916	.000	345.9226	355.4107
	5.00	341.33333*	2.12916	.000	336.5893	346.0774
4.00	1.00	-1.66667	2.12916	.452	-6.4107	3.0774
	2.00	-6.33333*	2.12916	.014	-11.0774	-1.5893
	3.00	-350.66667*	2.12916	.000	-355.4107	-345.9226
	5.00	-9.33333*	2.12916	.001	-14.0774	-4.5893
5.00	1.00	7.66667*	2.12916	.005	2.9226	12.4107
	2.00	3.00000	2.12916	.189	-1.7441	7.7441
	3.00	-341.33333*	2.12916	.000	-346.0774	-336.5893
	4.00	9.33333*	2.12916	.001	4.5893	14.0774

*.The mean difference is significant at the 0.05 level.

Table A24: LSD Comparison on mineral composition of Copper in collard greens

(I) COPPER	(J) COPPER	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-1.00000*	.29814	.007	-1.6643	-.3357
	3.00	2.66667*	.29814	.000	2.0024	3.3310
	4.00	.33333	.29814	.290	-.3310	.9976
	5.00	4.00000*	.29814	.000	3.3357	4.6643
2.00	1.00	1.00000*	.29814	.007	.3357	1.6643
	3.00	3.66667*	.29814	.000	3.0024	4.3310
	4.00	1.33333*	.29814	.001	.6690	1.9976
	5.00	5.00000*	.29814	.000	4.3357	5.6643
3.00	1.00	-2.66667*	.29814	.000	-3.3310	-2.0024
	2.00	-3.66667*	.29814	.000	-4.3310	-3.0024
	4.00	-2.33333*	.29814	.000	-2.9976	-1.6690
	5.00	1.33333*	.29814	.001	.6690	1.9976
4.00	1.00	-.33333	.29814	.290	-.9976	.3310
	2.00	-1.33333*	.29814	.001	-1.9976	-.6690
	3.00	2.33333*	.29814	.000	1.6690	2.9976
	5.00	3.66667*	.29814	.000	3.0024	4.3310
5.00	1.00	-4.00000*	.29814	.000	-4.6643	-3.3357
	2.00	-5.00000*	.29814	.000	-5.6643	-4.3357
	3.00	-1.33333*	.29814	.001	-1.9976	-.6690

	4.00	-3.66667*	.29814	.000	-4.3310	-3.0024

*. The mean difference is significant at the 0.05 level.

Table A25: LSD Comparison on mineral composition of Iron in collard greens

(I) IRON	(J) IRON	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	-.66667	3.31327	.845	-8.0491	6.7158
	3.00	-171.00000*	3.31327	.000	-178.3824	-163.6176
	4.00	-15.66667*	3.31327	.001	-23.0491	-8.2842
	5.00	-123.33333*	3.31327	.000	-130.7158	-115.9509
2.00	1.00	.66667	3.31327	.845	-6.7158	8.0491
	3.00	-170.33333*	3.31327	.000	-177.7158	-162.9509
	4.00	-15.00000*	3.31327	.001	-22.3824	-7.6176
	5.00	-122.66667*	3.31327	.000	-130.0491	-115.2842
3.00	1.00	171.00000*	3.31327	.000	163.6176	178.3824
	2.00	170.33333*	3.31327	.000	162.9509	177.7158
	4.00	155.33333*	3.31327	.000	147.9509	162.7158
	5.00	47.66667*	3.31327	.000	40.2842	55.0491
4.00	1.00	15.66667*	3.31327	.001	8.2842	23.0491
	2.00	15.00000*	3.31327	.001	7.6176	22.3824
	3.00	-155.33333*	3.31327	.000	-162.7158	-147.9509
	5.00	-107.66667*	3.31327	.000	-115.0491	-100.2842
5.00	1.00	123.33333*	3.31327	.000	115.9509	130.7158
	2.00	122.66667*	3.31327	.000	115.2842	130.0491
	3.00	-47.66667*	3.31327	.000	-55.0491	-40.2842
	4.00	107.66667*	3.31327	.000	100.2842	115.0491

*. The mean difference is significant at the 0.05 level.

Table A26: LSD Comparison on mineral composition of Ash in mustard greens

(I) ASH	(J) ASH	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	3.60000*	.13753	.000	3.2936	3.9064
	3.00	-.97000*	.13753	.000	-1.2764	-.6636
	4.00	5.00667*	.13753	.000	4.7002	5.3131
	5.00	-.32333*	.13753	.041	-.6298	-.0169
2.00	1.00	-3.60000*	.13753	.000	-3.9064	-3.2936
	3.00	-4.57000*	.13753	.000	-4.8764	-4.2636
	4.00	1.40667*	.13753	.000	1.1002	1.7131
	5.00	-3.92333*	.13753	.000	-4.2298	-3.6169
3.00	1.00	.97000*	.13753	.000	.6636	1.2764

	2.00	4.57000*	.13753	.000	4.2636	4.8764
	4.00	5.97667*	.13753	.000	5.6702	6.2831
	5.00	.64667*	.13753	.001	.3402	.9531
4.00	1.00	-5.00667*	.13753	.000	-5.3131	-4.7002
	2.00	-1.40667*	.13753	.000	-1.7131	-1.1002
	3.00	-5.97667*	.13753	.000	-6.2831	-5.6702
	5.00	-5.33000*	.13753	.000	-5.6364	-5.0236
5.00	1.00	.32333*	.13753	.041	.0169	.6298
	2.00	3.92333*	.13753	.000	3.6169	4.2298
	3.00	-.64667*	.13753	.001	-.9531	-.3402
	4.00	5.33000*	.13753	.000	5.0236	5.6364

*. The mean difference is significant at the 0.05 level.

Table A27: LSD Comparison on mineral composition of Calcium in mustard greens

(I) CALCUIM	(J) CALCUIM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.25000*	.02271	.000	.1994	.3006
	3.00	.17333*	.02271	.000	.1227	.2239
	4.00	.81000*	.02271	.000	.7594	.8606
	5.00	-.33667*	.02271	.000	-.3873	-.2861
2.00	1.00	-.25000*	.02271	.000	-.3006	-.1994
	3.00	-.07667*	.02271	.007	-.1273	-.0261
	4.00	.56000*	.02271	.000	.5094	.6106
	5.00	-.58667*	.02271	.000	-.6373	-.5361
3.00	1.00	-.17333*	.02271	.000	-.2239	-.1227
	2.00	.07667*	.02271	.007	.0261	.1273
	4.00	.63667*	.02271	.000	.5861	.6873
	5.00	-.51000*	.02271	.000	-.5606	-.4594
4.00	1.00	-.81000*	.02271	.000	-.8606	-.7594
	2.00	-.56000*	.02271	.000	-.6106	-.5094
	3.00	-.63667*	.02271	.000	-.6873	-.5861
	5.00	-1.14667*	.02271	.000	-1.1973	-1.0961
5.00	1.00	.33667*	.02271	.000	.2861	.3873
	2.00	.58667*	.02271	.000	.5361	.6373
	3.00	.51000*	.02271	.000	.4594	.5606
	4.00	1.14667*	.02271	.000	1.0961	1.1973

*. The mean difference is significant at the 0.05 level.

Table A28: LSD Comparison on mineral composition of Magnesium in mustard greens

(I) MAGNESIUM	(J) MAGNESIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	.10667*	.00816	.000	.0885	.1249
	3.00	.06667*	.00816	.000	.0485	.0849
	4.00	.23333*	.00816	.000	.2151	.2515
	5.00	-.06000*	.00816	.000	-.0782	-.0418
2.00	1.00	-.10667*	.00816	.000	-.1249	-.0885
	3.00	-.04000*	.00816	.001	-.0582	-.0218
	4.00	.12667*	.00816	.000	.1085	.1449
	5.00	-.16667*	.00816	.000	-.1849	-.1485
3.00	1.00	-.06667*	.00816	.000	-.0849	-.0485
	2.00	.04000*	.00816	.001	.0218	.0582
	4.00	.16667*	.00816	.000	.1485	.1849
	5.00	-.12667*	.00816	.000	-.1449	-.1085
4.00	1.00	-.23333*	.00816	.000	-.2515	-.2151
	2.00	-.12667*	.00816	.000	-.1449	-.1085
	3.00	-.16667*	.00816	.000	-.1849	-.1485
	5.00	-.29333*	.00816	.000	-.3115	-.2751
5.00	1.00	.06000*	.00816	.000	.0418	.0782
	2.00	.16667*	.00816	.000	.1485	.1849
	3.00	.12667*	.00816	.000	.1085	.1449
	4.00	.29333*	.00816	.000	.2751	.3115

*. The mean difference is significant at the 0.05 level.

Table A29: LSD Comparison on mineral composition of Potassium in mustard greens

(I) POTASSIUM	(J) POTASSIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	1.34667*	.04185	.000	1.2534	1.4399
	3.00	1.56000*	.04185	.000	1.4668	1.6532
	4.00	1.39333*	.04185	.000	1.3001	1.4866
	5.00	1.25667*	.04185	.000	1.1634	1.3499
2.00	1.00	-1.34667*	.04185	.000	-1.4399	-1.2534
	3.00	.21333*	.04185	.000	.1201	.3066
	4.00	.04667	.04185	.291	-.0466	.1399
	5.00	-.09000	.04185	.057	-.1832	.0032
3.00	1.00	-1.56000*	.04185	.000	-1.6532	-1.4668
	2.00	-.21333*	.04185	.000	-.3066	-.1201
	4.00	-.16667*	.04185	.003	-.2599	-.0734

	5.00	-.30333*	.04185	.000	-.3966	-.2101
4.00	1.00	-1.39333*	.04185	.000	-1.4866	-1.3001
	2.00	-.04667	.04185	.291	-.1399	.0466
	3.00	.16667*	.04185	.003	.0734	.2599
	5.00	-.13667*	.04185	.008	-.2299	-.0434
5.00	1.00	-1.25667*	.04185	.000	-1.3499	-1.1634
	2.00	.09000	.04185	.057	-.0032	.1832
	3.00	.30333*	.04185	.000	.2101	.3966
	4.00	.13667*	.04185	.008	.0434	.2299

*. The mean difference is significant at the 0.05 level.

Table A30: LSD Comparison on mineral composition of Sodium in mustard greens

(I) SODIUM	(J) SODIUM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	.10667	.05873	.099	-.0242	.2375
	3.00	-1.54000*	.05873	.000	-1.6709	-1.4091
	4.00	.24667*	.05873	.002	.1158	.3775
	5.00	-.42000*	.05873	.000	-.5509	-.2891
2.00	1.00	-.10667	.05873	.099	-.2375	.0242
	3.00	-1.64667*	.05873	.000	-1.7775	-1.5158
	4.00	.14000*	.05873	.038	.0091	.2709
	5.00	-.52667*	.05873	.000	-.6575	-.3958
3.00	1.00	1.54000*	.05873	.000	1.4091	1.6709
	2.00	1.64667*	.05873	.000	1.5158	1.7775
	4.00	1.78667*	.05873	.000	1.6558	1.9175
	5.00	1.12000*	.05873	.000	.9891	1.2509
4.00	1.00	-.24667*	.05873	.002	-.3775	-.1158
	2.00	-.14000*	.05873	.038	-.2709	-.0091
	3.00	-1.78667*	.05873	.000	-1.9175	-1.6558
	5.00	-.66667*	.05873	.000	-.7975	-.5358
5.00	1.00	.42000*	.05873	.000	.2891	.5509
	2.00	.52667*	.05873	.000	.3958	.6575
	3.00	-1.12000*	.05873	.000	-1.2509	-.9891
	4.00	.66667*	.05873	.000	.5358	.7975

*. The mean difference is significant at the 0.05 level.

Table A31: LSD Comparison on mineral composition of Phosphorus in mustard greens

(I) PHOSPHORUS	(J) PHOSPHORUS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	.03333*	.00298	.000	.0267	.0400

	3.00	.13000*	.00298	.000	.1234	.1366
	4.00	-.01667*	.00298	.000	-.0233	-.0100
	5.00	.13000*	.00298	.000	.1234	.1366
2.00	1.00	-.03333*	.00298	.000	-.0400	-.0267
	3.00	.09667*	.00298	.000	.0900	.1033
	4.00	-.05000*	.00298	.000	-.0566	-.0434
	5.00	.09667*	.00298	.000	.0900	.1033
3.00	1.00	-.13000*	.00298	.000	-.1366	-.1234
	2.00	-.09667*	.00298	.000	-.1033	-.0900
	4.00	-.14667*	.00298	.000	-.1533	-.1400
	5.00	.00000	.00298	1.000	-.0066	.0066
4.00	1.00	.01667*	.00298	.000	.0100	.0233
	2.00	.05000*	.00298	.000	.0434	.0566
	3.00	.14667*	.00298	.000	.1400	.1533
	5.00	.14667*	.00298	.000	.1400	.1533
5.00	1.00	-.13000*	.00298	.000	-.1366	-.1234
	2.00	-.09667*	.00298	.000	-.1033	-.0900
	3.00	.00000	.00298	1.000	-.0066	.0066
	4.00	-.14667*	.00298	.000	-.1533	-.1400

*. The mean difference is significant at the 0.05 level.

Table A32: LSD Comparison on mineral composition of Zinc in mustard greens

(I) ZINC	(J) ZINC	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-3.00000	3.66970	.433	-11.1766	5.1766
	3.00	-537.66667*	3.66970	.000	-545.8433	-529.4901
	4.00	-25.33333*	3.66970	.000	-33.5099	-17.1567
	5.00	-62.66667*	3.66970	.000	-70.8433	-54.4901
2.00	1.00	3.00000	3.66970	.433	-5.1766	11.1766
	3.00	-534.66667*	3.66970	.000	-542.8433	-526.4901
	4.00	-22.33333*	3.66970	.000	-30.5099	-14.1567
	5.00	-59.66667*	3.66970	.000	-67.8433	-51.4901
3.00	1.00	537.66667*	3.66970	.000	529.4901	545.8433
	2.00	534.66667*	3.66970	.000	526.4901	542.8433
	4.00	512.33333*	3.66970	.000	504.1567	520.5099
	5.00	475.00000*	3.66970	.000	466.8234	483.1766
4.00	1.00	25.33333*	3.66970	.000	17.1567	33.5099
	2.00	22.33333*	3.66970	.000	14.1567	30.5099
	3.00	-512.33333*	3.66970	.000	-520.5099	-504.1567
	5.00	-37.33333*	3.66970	.000	-45.5099	-29.1567

5.00	1.00	62.66667*	3.66970	.000	54.4901	70.8433
	2.00	59.66667*	3.66970	.000	51.4901	67.8433
	3.00	-475.00000*	3.66970	.000	-483.1766	-466.8234
	4.00	37.33333*	3.66970	.000	29.1567	45.5099

*. The mean difference is significant at the 0.05 level.

Table A33: LSD Comparison on mineral composition of Copper in mustard greens

(I) COPPER	(J) COPPER	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-2.00000*	.21082	.000	-2.4697	-1.5303
	3.00	.00000	.21082	1.000	-.4697	.4697
	4.00	.66667*	.21082	.010	.1969	1.1364
	5.00	1.00000*	.21082	.001	.5303	1.4697
2.00	1.00	2.00000*	.21082	.000	1.5303	2.4697
	3.00	2.00000*	.21082	.000	1.5303	2.4697
	4.00	2.66667*	.21082	.000	2.1969	3.1364
	5.00	3.00000*	.21082	.000	2.5303	3.4697
3.00	1.00	.00000	.21082	1.000	-.4697	.4697
	2.00	-2.00000*	.21082	.000	-2.4697	-1.5303
	4.00	.66667*	.21082	.010	.1969	1.1364
	5.00	1.00000*	.21082	.001	.5303	1.4697
4.00	1.00	-.66667*	.21082	.010	-1.1364	-.1969
	2.00	-2.66667*	.21082	.000	-3.1364	-2.1969
	3.00	-.66667*	.21082	.010	-1.1364	-.1969
	5.00	.33333	.21082	.145	-.1364	.8031
5.00	1.00	-1.00000*	.21082	.001	-1.4697	-.5303
	2.00	-3.00000*	.21082	.000	-3.4697	-2.5303
	3.00	-1.00000*	.21082	.001	-1.4697	-.5303
	4.00	-.33333	.21082	.145	-.8031	.1364

*. The mean difference is significant at the 0.05 level.

Table A34: LSD Comparison on mineral composition of Manganese in mustard greens

(I) MANGANESE	(J) MANGANESE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.33333	3.27278	.692	-8.6255	5.9589
	3.00	-6.00000	3.27278	.097	-13.2922	1.2922
	4.00	-7.00000	3.27278	.058	-14.2922	.2922
	5.00	-10.00000*	3.27278	.012	-17.2922	-2.7078
2.00	1.00	1.33333	3.27278	.692	-5.9589	8.6255

	3.00	-4.66667	3.27278	.184	-11.9589	2.6255
	4.00	-5.66667	3.27278	.114	-12.9589	1.6255
	5.00	-8.66667*	3.27278	.024	-15.9589	-1.3745
3.00	1.00	6.00000	3.27278	.097	-1.2922	13.2922
	2.00	4.66667	3.27278	.184	-2.6255	11.9589
	4.00	-1.00000	3.27278	.766	-8.2922	6.2922
	5.00	-4.00000	3.27278	.250	-11.2922	3.2922
4.00	1.00	7.00000	3.27278	.058	-.2922	14.2922
	2.00	5.66667	3.27278	.114	-1.6255	12.9589
	3.00	1.00000	3.27278	.766	-6.2922	8.2922
	5.00	-3.00000	3.27278	.381	-10.2922	4.2922
5.00	1.00	10.00000*	3.27278	.012	2.7078	17.2922
	2.00	8.66667*	3.27278	.024	1.3745	15.9589
	3.00	4.00000	3.27278	.250	-3.2922	11.2922
	4.00	3.00000	3.27278	.381	-4.2922	10.2922

*. The mean difference is significant at the 0.05 level.

Table A35: LSD Comparison on mineral composition of Iron in mustard greens

(I) IRON	(J) IRON	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	3.66667	1687.71751	.998	-3756.8023	3764.1356
	3.00	-160.66667	1687.71751	.926	-3921.1356	3599.8023
	4.00	-3931.00000*	1687.71751	.042	-7691.4690	-170.5310
	5.00	-168.33333	1687.71751	.923	-3928.8023	3592.1356
2.00	1.00	-3.66667	1687.71751	.998	-3764.1356	3756.8023
	3.00	-164.33333	1687.71751	.924	-3924.8023	3596.1356
	4.00	-3934.66667*	1687.71751	.042	-7695.1356	-174.1977
	5.00	-172.00000	1687.71751	.921	-3932.4690	3588.4690
3.00	1.00	160.66667	1687.71751	.926	-3599.8023	3921.1356
	2.00	164.33333	1687.71751	.924	-3596.1356	3924.8023
	4.00	-3770.33333*	1687.71751	.050	-7530.8023	-9.8644
	5.00	-7.66667	1687.71751	.996	-3768.1356	3752.8023
4.00	1.00	3931.00000*	1687.71751	.042	170.5310	7691.4690
	2.00	3934.66667*	1687.71751	.042	174.1977	7695.1356
	3.00	3770.33333*	1687.71751	.050	9.8644	7530.8023
	5.00	3762.66667*	1687.71751	.050	2.1977	7523.1356
5.00	1.00	168.33333	1687.71751	.923	-3592.1356	3928.8023
	2.00	172.00000	1687.71751	.921	-3588.4690	3932.4690
	3.00	7.66667	1687.71751	.996	-3752.8023	3768.1356
	4.00	-3762.66667*	1687.71751	.050	-7523.1356	-2.1977

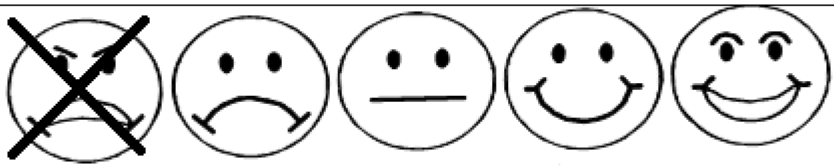
*. The mean difference is significant at the 0.05 level.

Appendix B: Sensory evaluation of processed Collard and Mustard green leafy vegetables

Instructions:

- Please rinse your mouth with water before starting.
- Please rinse your mouth with water after tasting each sample.
- Please taste the samples of processed vegetables in the order presented, from left to right.
- Please rate the taste, texture, aroma, colour and overall acceptability of the samples by putting a cross on the picture that best describes that sample.
- You may re-taste the sample if you wish.

Example :

Aroma	 Very bad Bad Average Good Very good

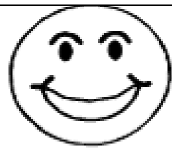
Sensory evaluation of processed Collard and Mustard green leafy vegetables

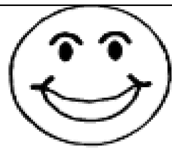
Gender: Male Female

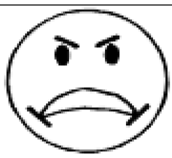
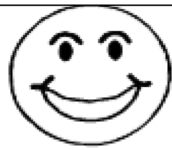
Age: ____

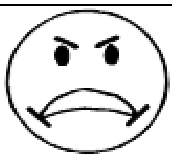
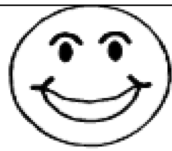
Number: _____

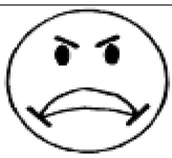
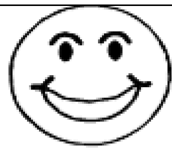
Sample number: ______

Taste				
				
Very bad	**Bad**	**Average**	**Good**	**Very good**

Texture				
				
Very bad	**Bad**	**Average**	**Good**	**Very good**

Aroma				
				
Very bad	**Bad**	**Average**	**Good**	**Very good**

Colour				
				
Very bad	**Bad**	**Average**	**Good**	**Very good**

Overall acceptability				
				
Very bad	**Bad**	**Average**	**Good**	**Very good**

Appendix C: Consent form for participants

I am currently a part-time student at the University of KwaZulu-Natal, doing my MSc in Food Security. The aim of my research is to test the effect of different drying technologies on two leafy vegetables under study. I would like to find out if sun-drying and oven-drying have an impact on the sensory attributes of the vegetables. The participants will be required to taste samples of collard greens and mustard greens and rate the samples using a simple picture scale. There will be no discomforts or hazards to participants who agree to participate in this study.

- The researcher's name is Sinenhlanhla Nyembe (BSc Microbiology/Genetics, BScHons Genetics), who is from the African Centre for Food Security at the University of KwaZulu- Natal. Contact details for the researcher are as follows 079-2918038 or chunkza@webmail.co.za.
- For further information regarding the study, you may contact Dr Mthulisi Siwela, who is the project supervisor. Contact details: 033-2605459 or siwelam@ukzn.ac.za.
- All the data collected from this study will remain confidential and will only be used for the purpose of this research project. All participants will remain anonymous.
- Participation in this study is completely voluntary. All participants may leave the study at any time they wish, without any negative consequences.
- There are no potential benefits from participating in this study. No participants will receive any payments or financial reimbursements for participating in this research project.
- Audio recordings from the focus group discussions will be used for the purpose of this study and will be stored appropriately.
- All data will be destroyed when it is no longer needed.

Declaration:

I ____ (full name and surname) hereby confirm that the questionnaire has been clearly explained to me and I understand the purpose of this research project and how the information will be collected. I consent to participating in the research project.

I understand that participation is voluntary and I can leave the study if I desire.

____________________________ ____________________

Signature Date

Appendix D: Focus group guiding questions

1. What kind of <u>leafy vegetables</u> do you plant?
    a. Probe on when they are planted and harvested using a seasonal calendar
    b. Also on the seasonal calendar indicate when they do preservation on what vegetables
    c. Who plants and who harvests and how the vegetables are stored (shelf life when fresh and shelf life when preserved)
2. What kind of <u>preservation methods</u> are used for leafy vegetables?
    a. Probe on the reasons why the methods for specific vegetables
    b. Why do they dry ULVs
    c. Where did they learn how to do the method
    d. How do take they take measure of hygiene and safety
3. What <u>criteria or even characteristics do you use to select</u> dried ULVs for meal preparation?
    a. How would they assess the proper dried leafy vegetable
    b. How do they measure microbial safety
    c. Is microbial safety important or even known
    d. How long do they keep the dried leafy vegetables for, how do they keep them
    e. What is perceived as quality ULVs?
4. Do you sell fresh ULVs or dried ULVs?
    a. Reasons why or not sell
5. Would you like to sell fresh or dried ULVs?
    a. Where, for how much
    b. How would you maintain that you supply the market consistently?
6. What do you consume ULVs with?
    a. Dishes
    b. Recipes
    c. How it is eaten, when and by whom?

Appendix E: Ethical clearance letter

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

1 September 2014

Ms Sinenhlanhla Nyembe 2015[illegible]
School of Agriculture, Earth and Environmental Sciences
Pietermaritzburg Campus

Dear Ms Nyembe

Protocol reference number: HSS/0719/014M
Project title: Improving household food security in the Limpopo Province of South Africa through processing of underutilised wild leafy vegetables into value added products by drying technologies

Full Approval – Expedited

This letter serves to notify you that your application in connection with the above has now been granted **Full Approval**

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach/Methods must be reviewed and approved through an amendment /modification prior to its implementation. Please quote the above reference number for all queries relating to this study. PLEASE NOTE: Research data should be securely stored in the school/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.

Best wishes for the successful completion of your research protocol

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Science Research Ethics Committee

/pm

cc Supervisor: Dr Muthulisi Siwela, Dr Unathi Kolanisi & Ebrany Sempio
cc Academic Leader: Professor D Mutanga
cc School Admin: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: [illegible]@ukzn.ac.za / [illegible]@ukzn.ac.za / [illegible]@ukzn.ac.za
Website: www.ukzn.ac.za

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Appendix F: Gatekeeper permission letter

GATEKEEPER PERMISSION LETTER

Mawa
Bolobedu
PO Box 4306
Ga-Kgapane, 0828
20/July/2014

Private Bag X01
Scottsville
3209

To whom it may concern

Re: University of KwaZulu Natal Research Project

Title: Improving household food security in the Limpopo province of South Africa through processing of underutilised wild leafy vegetables into value added products by drying technologies

Names of researchers
Student: Sinenhlanhla Nyembe
Supervisors: Dr Unathi Kolanisi, Dr Mthulisi Siwela and Ms Grany Senyolo.

Permission to conduct a sensory evaluation from a panel of untrained consumers in Mopani District, Limpopo, has been granted to the afore-mentioned researchers.

As the Chief at MAWA, I give my permission to the researchers to conduct a sensory evaluation from a panel of willing local participants in Mopani District, Limpopo in this area.

Name of permission-giver: MOHALE M [illegible]

Signature of permission-giver: ____________

Date: 24/07/2014

MAWA TRADITIONAL AUTHORITY
2014 -07- 28
T/L MOHALE MF

JUL-30-2014 09:27 From:0153072910 Page:1/1