# CONSUMPTION PATTERNS FOR SELECTED ROOTS AND TUBERS AMONG URBAN HOUSEHOLDS IN NAKURU COUNTY, KENYA

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# DECLARATION AND RECOMMENDATION

## Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

Signature…………………… Date 12/11/2022

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## Recommendation

This thesis has been submitted with our approval as University supervisors.

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# DEDICATION

I dedicate this thesis to my wife, Miriam Nuani, sons Kenneth Nuani and Marcus Nuani, parents Kenneth Nuani and Judith Nuani, and siblings Eveline, Caroline, Eric, Phoebe, and Beverly.

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## ABSTRACT

Population increase exerts pressure on existing resources, including food. As evidenced in West African Countries such as Nigeria, roots and tubers (R&Ts) are alternative meals to turn around healthy diets for enhanced food and nutrition security. Although R&Ts have been promoted in Kenya, their consumption among urban dwellers is still inadequate. To enhance their utilisation, this study sought to understand R&Ts consumption patterns among urban households of Nakuru Town East Sub-County. A multistage sampling technique selected 385 households, and data were collected using a pre-tested semi-structured questionnaire. Data were analysed using SPSS and STATA data analytical software. A multivariate Probit model was used to analyse the factors influencing consumer preferences for R&Ts. A negative binomial regression model was used to analyse the determinants of consumption frequency for R&Ts, while a linear approximate almost ideal demand system model was used to assess household demand analysis for selected R&Ts. Results revealed that Irish potatoes (*Solanum tuberosum* L.) had the highest preference level (70%), followed by sweet potatoes (*Ipomoea batatas* L. Lam.) at 61%. Arrowroot (*Maranta arundinacea* L.) had a preference of 42%. Cassava (*Manihot esculenta* Crantz) and yams (*Dioscorea alata* L.) were the least preferred at 22% each. The mean consumption frequency of R&Ts was seventeen times a month. The R&Ts exhibited negative own-price elasticities for both Marshallian and Hicksian demand analyses, thus conforming to utility theory. Cross-price elasticities had positive and negative signs signifying the presence of substitutes and complements, respectively, in R&Ts categories. The expenditure elasticities varied from positive to negative, implying the presence of normal to inferior goods respectively in R&Ts categories. Additionally, age, education, household size, the proportion of household size (≤18 years old and ≥ 19 years old), monthly income, household health, cultural orientation, market distance, farming, nutritional knowledge, market prices, production place, availability of R&Ts, size, quality, Covid-19 pandemic, taste, and preparation time significantly influenced consumption patterns for R&Ts. These results contribute to the existing literature on consumer studies. Moreover, the findings could assist in formulating strategies and policies that promote awareness (nutritional knowledge) for R&Ts, thereby increasing their consumption. For instance, R&Ts can be widely accepted through value-addition strategies, resulting in increased uptake. Additionally, introducing price control policies such as a price ceiling; and a price floor will help regulate retail prices for R&Ts, making them affordable to many households, thereby increasing their consumption.

## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AIDS** | Almost Ideal Demand System |
| **AERC** | Africa Economic Research Consortium |
| **CIP** | International Potato Centre |
| **FAO** | Food and Agricultural Organization |
| **FAOSTAT** | Food and Agricultural Organization Statistics of the United Nations |
| **HH** | Household |
| **IFPRI** | International Food Policy Research Institute |
| **IMRs** | Inverse Mills Ratios |
| **KES** | Kenyan Shilling. |
| **KNBS** | Kenya National Bureau of Statistics |
| **LA/AIDS** | Linearized Approximate Almost Ideal Demand System |
| **LES** | Linear Expenditure System |
| **M MT** | Million Metric-tones |
| **MoALFI** | Ministry of Agriculture, Livestock, fisheries, and Irrigation |
| **MVP** | Multivariate Probit |
| **NBR** | Negative Binomial Regression |
| **OLS** | Ordinary Least Square |
| **QUAIDS** | Quadratic Almost Ideal Demand System |
| **R&Ts** | Roots and Tubers |
| **SDGs** | Sustainable Development Goals |
| **SPSS** | Statistical Package for Social Scientists |
| **SSA** | Sub-Saharan Africa |
| **SURE** | Seemingly Unrelated Regression |
| **WHO** | World Health Organization |
| **ZINB** | Zero-Inflated Negative Binomial |
| **ZIP** | Zero-Inflated Poisson |

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background of the study

The world's population is steadily growing coupled with urbanisation, which, in turn, exerts pressure on existing resources and food (FAO *et al.*, 2020; Godfray & Garnett, 2014; Ogbonna *et al.*, 2017; Pieterse & Parnell, 2014; Satterthwaite *et al.*, 2010). A report on urbanisation by Ritchie and Roser (2018) indicates that half of the world's population resides in cities, and by 2050 two-thirds of the global population is expected to live in urban areas. This argument is further echoed by the United Nations (2019), which shows that the world population stood at 7.7 billion people in 2019 and is projected to increase to 8.5 billion and 10 billion people by 2030 and 2050, respectively. Additionally, the population in Sub-Saharan Africa (SSA) is projected to double by 99% by 2050, with most growth occurring in urban areas of less developed countries (United Nations, 2019).

Migration from rural to urban areas causes urbanisation, possibly leading to the emergence of slums, water and air pollution, waste disposal problems, and food shortages. Moreover, urbanisation has reduced the physical activities of many urban dwellers, in addition to unhealthy nutrition. In turn, it poses challenges to the food security system because the demand for food outpaces the supply (Githunguri & Njiru, 2021; Steensland & Zeigler, 2018). This situation likely result in food shortage, especially in the urban areas of developing countries where most residents are net food buyers who spend a significant part of their income on food items (Matuschke, 2009; Szabo, 2016). Moreover, many of these urban populations earn low income, implying low purchasing power (Ruel *et al.*, 2010); therefore, the most vulnerable consumers. The urban poor is part of the 820 million people facing hunger in Africa, parts of Asia, and Latin America (FAO, 2019). In addition, inadequate food caused by seasonal food shortages, insufficient energy intake resulting in hunger and malnutrition, and protein deficiency retards economic growth in many developing countries such as Kenya (FAO, 2004).

World Health Organization (2016) predicted a shift in urban consumption patterns by 2020 due to urbanisation. Further, 69% of all deaths would be due to non-communicable chronic diseases such as obesity, diabetes, cardiovascular diseases, cancer, dental diseases, and osteoporosis caused by a shift in consumption patterns, lifestyle changes, and poor nutrition (WHO, 2016). For instance, consumption of saturated fats and sugars, highly processed foods, and out-of-home meals pose health and nutritional risks such as obesity and diabetes (Keats & Wiggins, 2019; Magbalot-Fernandez & Umar, 2019).

To address the highlighted challenges, nutritionists advise consuming indigenous foodstuffs such as R&Ts, also called underutilised crops. Roots and tubers are ranked the second most frequently consumed crops after cereals in Kenya. These include Irish potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomoea batatas*), cassava (*Manihot esculentum*), arrowroots (*Maranta arundinacea*), yams (*Dioscorea alata*), cocoyams/taro (*Colocasia esculenta*), beets (*Beta vulgaris*), carrots (*Daucus carota*), and turnips (*Brassica rapa*). They are produced in more sustainable ways, are readily available, and provide high nutritional value Dotto *et al.* (2018); Dawson *et al.* (2009), implying high versatility in addressing food and nutrition security in Africa.

These crops have a wide variety of uses, such as the provision of food for households, feeds for animals, and raw materials for industries; as such, R&Ts have increased economic importance for producers and consumers (Alexandratos & Bruinsma, 2012; Muthoni & Nyamongo, 2010; Scott *et al.*, 2000; Wijesinha-Bettoni & Mouillé, 2019). For instance, yam is a significant food source for millions of people in the tropics and subtropical regions of the world. It contributes to income and food for more than 60 million people (Asiedu & Sartie, 2010). Roots and tubers meet local food preferences, provide alternative diet sources, have affordable prices, and supply high calories per plant (Scott *et al.*, 2000). In addition, they have nutritional, health, and medicinal benefits such as antiobesity, hypocholesterolemic, and immunomodulatory activities (Chandrasekara & Kumar, 2016; Saranraj *et al.*, 2019). Therefore helps to deal with these "lifestyle diseases"(McFadden & Lusk, 2016; Okrent & Alston, 2012).

Despite their aforementioned potential, the old R&Ts varieties face production challenges such as low-quality planting materials, an unconducive policy environment, low-yielding varieties, and susceptibility to pests and diseases (Sanginga & Mbabu, 2015). Fortunately, researchers have developed new high-yielding varieties resistant to pests and diseases with a shorter maturity period, contributing to food and nutritional security. The Kenyan government is coming together through relevant ministries and other development partners to boost the production and commercialisation of R&Ts (Almekinders *et al.*, 2019). Through these interventions, farmers are provided with high-quality planting materials to boost the production of R&Ts (Almekinders *et al.*, 2019; Kaguongo *et al.*, 2013; MoALFI, 2019). Because of these benefits, demand for R&Ts has increased across the world. However, the main challenges are lack of awareness and unconducive sectoral policies promoting marketing for R&Ts. In developing countries like Kenya, undersupply of R&Ts in the market is due to marketing constraints (MoALFI, 2019). Production of R&Ts in developing countries was projected to increase by 58 % between 2003 and 2020 (Scott *et al.,* 2000). For instance, the global yearly potato output is approximately 388M MT, with an average yield per hectare of 20,110.8 tons/ha (FAO *et al.,* 2020). In Africa, annual potato outputs were estimated at 25M MT with a production capacity of about 13,215.40 tons/ha. In Kenya alone, production of R&Ts increased from 2.4M MT in 2015 to 3.68M MT in 2018 (MoALFI, 2019).

Even though R&Ts have the potential to turn around healthy diets, especially among the urban populations in Kenya, their consumption is still low. For instance, their consumption per capita is still below the recommended levels (Mohamed *et al.,* 2021). The national per capita energy provision from R&Ts consumption per day is less than the recommended rate of 2,250 Kcal/day per individual, implying that the basic diet is inadequate in quality and diversity (MoALFI, 2019). There is a dearth of knowledge concerning R&Ts consumption patterns among urban households in Kenya. Without evidence of the determinants of R&Ts consumption trends (preference and expenditure), it will be hard to promote their incorporation among urban diets. Moreover, formulating food policies that tackle dietary problems requires in-depth knowledge of healthy and unhealthy food consumption drivers. This study seeks to address the aforementioned knowledge gap by assessing the determinants of consumer preference, frequency of consumption, and expenditure for R&Ts among Nakuru Town East Sub County urban households.

Nakuru Town East Sub County was chosen as a case study since it is an urban area with increased dietary-related diseases due to a shift in dietary patterns (NCIDP, 2018). This urban area has a total area of 230.9 square km, a population density of 840 persons per square km, and a population of 193,926 people (KNBS, 2019). The regions surrounding Nakuru Town East Sub-county are known for vast agricultural potential with numerous large and small farms majorly farming crops such as coffee, barley, wheat, beans, maize, tomatoes, leafy vegetables, potatoes, arrowroots, yams and cassava, introduced of late (MoALFI, 2019). Since agriculture is not the mainstay activity in the study area, the residents rely on food supplies from other regions (NCIDP, 2018). However, a few households residing in Nakuru Town East Sub County practice urban or rural farming. Like many other urban areas, Nakuru Town East Sub County is experiencing shifts in their consumption habits likely attributed to lifestyle changes among urban households in the study area. Many households focus on consuming highly processed and refined foods to the detriment of traditional diets, in this case, R&Ts (Korir *et al.,* 2020; NCIDP, 2018; Ngenoh, 2021). The low R&Ts utilisation of R&Ts among urban dwellers is constrained by factors such as; socio-cultural, economic, institutional and product-related factors. For instance, urban dwellers are socio-culturally diverse and more likely exposed to a wide variety of food items which affect R&Ts consumption as a staple food (Wanyama, 2019).

Convenience, texture, taste, colour, perceptions, habits, familiarity and beliefs were cited as contributing factors in defining R&Ts consumption patterns among urban households and therefore influencing their R&Ts choices. Even though some urban dwellers have started turning to underutilised R&Ts such as cassava and yams (Ngenoh, 2021), a section of consumers still regards them as poor man’s food and therefore prefer other alternative meals (Charles, 2022; Kenyon *et al.*, 2006; MoALFI, 2019; Oke *et al.*, 1990). The presence of toxic substance “cyanide” produced by cassava discourages some urban households from consuming the crops, which likely explains the low usage (Lambein & Diasolua, 2019). In addition, the urban working population lacks time to prepare R&Ts, hence opting for more convenient alternatives such as cereals and fast foods (Tan, 2015).

Kenya’s agricultural policy seeks to promote production and consumption of R&Ts due to their increased importance in food and nutrition security, ability to withstand drought and various uses in many agro-industries (MoALFI, 2019). To promote urban farming and consumption of these underutilised R&Ts, the County government of Nakuru formulated the Urban Food and Agriculture 2019 Bill, enhancing urban food security and agricultural activities as a source of income in the county. The bill came at a time when the county faced a rising population; hence, the need to formulate a food system to cater to this urban population's dietary needs. The bill promotes urban agriculture policies enhancing food such as R&Ts’ processing and distribution (NCIDP, 2018). At a local level, the R&Ts subsector in Nakuru Town East Sub-County contributes to food security and income generation directly through consumption and farming or trade of the crops; however, their contribution as a source of income is still inadequate (NCIDP, 2018).

## 1.2 Statement of the problem

Roots and tubers are the second most consumed crops after cereals in Kenya. The role they play in curbing food insecurity in SSA, Kenya included, cannot be underestimated. Even though R&Ts were previously integrated into household meals, their consumption among urban consumers remains low, and the reasons for their low utilisation are still unknown. A few studies in Kenya have been conducted on household consumption and purchasing patterns for R&Ts. However, factors influencing consumer preference for R&Ts, their consumption frequency, and household allocation of budgetary shares for the crops among urban dwellers remain unaccounted for. Therefore, this study intends to bridge the highlighted knowledge gap by analysing consumption patterns for selected R&Ts among urban households of Nakuru Town East Sub County.

## 1.3 Research objectives

### 1.3.1 General objective

To contribute to urban household food and nutrition security by analysing consumption patterns for selected root and tuber crops in Kenya.

### 1.3.2 Specific objectives

i. To assess the factors influencing consumer preference for selected roots and tubers among urban households in Nakuru Town East Sub-County.
ii. To determine the role of socio-economic and institutional variables and product attributes in influencing consumption frequency for selected root and tuber crops among urban households in Nakuru Town East Sub-County.
iii. To evaluate the effect of demographic variables, price, and expenditure elasticities on household demand for selected root and tuber crops among urban consumers in Nakuru Town East Sub-County.

## 1.4 Research questions

i. What factors influence consumer preferences for selected roots and tubers among urban households in Nakuru Town East Sub-County?
ii. What role do socio-economic and institutional variables and product attributes play in influencing consumption frequency for selected root and tuber crops among urban households in Nakuru Town East Sub-County?
iii. What is the effect of demographic variables, price, and expenditure elasticities on household demand for selected root and tuber crops among urban consumers in Nakuru Town East Sub-County?

## 1.5 Justification of the study

Despite policy focus on improving food security, Kenya is still classified as a food insecure nation. The national *per capita* energy provision per day is less than the recommended rate of 2,250 Kcal/day per individual, indicating that the basic diet is inadequate in quality and diversity (MoALFI, 2019). This study identified factors influencing household consumption of selected R&Ts, consumption frequency, and demand analysis for these crops to improve Kenyan urban consumers' health, food, and nutritional security. The knowledge gained could help increase consumption of R&Ts by providing a more comprehensive nutritional alternative for households to choose from, thereby improving dietary diversification. Vanlauwe *et al.* (2013) suggested that root and tuber crops play an important role in ensuring food security in Africa; therefore, there is a need to tap the opportunities provided by the crops. The disclosure come when the world faces climate change challenges that result in a shortfall in yield for cereals and other crops. Therefore, consumers have to be cushioned by providing them with an alternative meal source, including R&Ts, whose potential has not been fully exploited (Vanlauwe *et al.,* 2013). In addition, the study is in line with SDG2 (to ensure there is zero hunger in the country) and SDG12 (which ensures responsible consumption and production). The study also supports the measures taken by the government of Kenya as it tries to achieve food and nutritional security in the country (Godfray *et al.,* 2010; Zwaagstra *et al.,* 2010).

## 1.6 Scope and limitation of the study

The study targeted households consuming selected R&Ts crops in Nakuru Town East Sub-County. To ensure that only the households mentioned above were selected, respondents were interviewed immediately after buying their preferred R&Ts from selected market outlets. This study area was selected to represent consumption patterns in urban areas and their implications for urban food security. The R&Ts crops studied were; Irish potatoes, sweet potatoes, cassava, arrow roots, and yams because they are the main R&Ts produced and consumed in Kenya (MoALFI, 2019). The findings apply mainly to the study area; therefore, they do not reflect the position of all consumers in Kenya because factors affecting households' consumption patterns are heterogeneous across regions. Moreover, the inadequacy of proper records could affect the accuracy of the estimates, and therefore the study relied heavily on the household's ability to recall information.

## 1.7 Operational definition of terms

**Budgetary allocation:** The total amount of income allocated to each expenditure line in a household.

**Consumption pattern:** How different consumers spend their income across or within categories of products, such as food, clothing, and discretionary items.

**Consumer preference:** The subjective taste of individual consumers for different agricultural commodities.

**Consumption:** The use of goods and services by households.

**Demand:** The consumer's desire to buy agricultural commodities and willingness to pay the price for the commodity.

**Food security:** A state where all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

**Food system:** Diverse web of activities involving food items' movement from production to consumption.

**Household:** A social unit composed of people living together in the same dwelling.

**Root and tuber crops:** Starch-yielding plants mainly store their food in the roots, tubers, rhizomes, corms, and stems.

**Urbanisation:** Refers to the population shift from rural to urban areas, the decrease in the proportion of people living in rural areas, and how societies adapt to this change.

# CHAPTER TWO
# LITERATURE REVIEW

## 2.1 Introduction

In this chapter, literature of past studies and recent studies on R&Ts consumption trends, their impact on food and nutrition security, contribution to the welfare of producers and consumers were reviewed. The chapter starts by providing empirical literature on consumption preference for R&Ts, their frequency of consumption and demand analysis for the crops. Moreover, possible socio-cultural, economic and institutional factors were investigated to understand their influence on R&Ts consumption. The review assisted in identifying knowledge gaps in the existing literature which this study sought to address. Finally, the random utility maximisation theory was reviewed in the theoretical literature and a conceptual framework was presented to lay a foundation upon which this study was anchored.

## 2.2 The concept of food and nutrition security

Food security is a major topic of interest worldwide, and as such, many research and development organisations try to identify solutions to this problem. Good nutrition and a high-quality diet are associated with consuming various food items (Murage *et al.,* 2019). In addition, households accessing enough quantity and safe food all year round are economically viable and food secure. One way of leading a healthy lifestyle is by eating a well-balanced diet. Therefore, any condition in which food consumption fails to sustain a healthy and nutritious diet for an individual results in food insecurity (Barrett, 2010; FAO *et al.,* 2020; Haddad *et al.,* 2014).

## 2.3 The importance of production and consumption of roots and tubers.

In the global food system, especially in developing countries, R&Ts are ranked among the top 10 primary crops (Gweyi-Onyango *et al.,* 2020; Onodu *et al.,* 2020; Phillips *et al.,* 2004; Scott, 2000). Sanginga and Mbabu (2015) found that the aggregate value of cassava, sweet potato, potato, and yam exceeds all other African staples, including cereals. Roots and tubers grow in varying climatic and production systems, producing 240 million tons per year. Their production covers an estimated 23 million hectares of land, only for documented root and tuber crops, way above cereals, whose production stands at 169 million tons and covers 108 million ha per year (Sanginga & Mbabu, 2015).

Roots and tubers are produced using very low inputs and mostly serve as food for the poor due to their affordability. Moreover, they act as feed for animals, raw materials for industries, and contribute to food security. Yam, cassava, potato, and sweet potato are affordable sources of protein, vitamins A, B, and C, zinc, and iron for the dietary demand across many regions (Lebot, 2019; Okareh *et al.,* 2021). For this reason, R&Ts are embraced for sustainable food production in Africa. Potato and sweet potato have a short production duration of 3-4 months compared to grain crops. Therefore, it helps augment "hunger months," that is, several months before harvesting new crops. Even though yam and cassava take longer to mature, they are vital for the annual food supply cycle. The crops are primarily traded in developing countries and are less affected by large-scale market shocks and price fluctuations than other staples such as cereals.

Despite the important role played by R&Ts in Africa, African food policy has been inclined to support cereals such as wheat, rice, and maize at the expense of R&Ts (Scott, 2000). Moreover, the crops are neglected in production and trade to favour cereal crops and cash crops such as tea, coffee, cotton, cocoa, and cereals (Nweke, 2004). The aforementioned implies that participatory research for new crop varieties characterising some cash crops had bypassed root and tuber crops leading to the continued use of traditional varieties for production (Nweke, 2004; Phillips *et al.,* 2004). As a result, it led to the stigmatisation of R&Ts by many consumers who viewed them as inferior, low-quality poor man's food (Kenyon *et al.,* 2006; Oke *et al.,* 1990; Reincke *et al.,* 2018). Therefore, most households prefer cereals and other traditional cash crops to R&Ts.

Scott *et al.* (2000) revealed a significant increase in consumption and utilisation of root and tuber crops between the 1960s and 1970s. The aforementioned changes could be attributed to diversification in using R&Ts as alternative meals and specialisation in their production. For instance, between 1983 and 1996, consumption of R&Ts in developing countries had increased by 22%, that is, 45M MT- 253M MT, respectively. Cassava accounted for the largest share at 93M MT of R&Ts consumed for food, followed by sweet potato at 65M MT, and yam at 16M MT (Scott, 2000). In addition, in China and Latin America, the use of R&Ts as animal feeds increased rapidly by 50% between 1983 and 1996 to stand at 96M MT. The variation in consumption and utilisation of R&Ts is due to differences in population, economic growth, urbanisation, and cultural factors (Scott, 2000).

In SSA, population growth, low *per capita* income, and urbanisation have generated demand for R&Ts since they are viewed as cheap, starchy staples (Nanbol & Namo, 2019; Scott, 2000). In addition, Phillips *et al.* (2004) observed an increased demand for cassava in

Nigerian markets because of its enhanced use as processed food, with rural and urban consumption patterns being increasingly similar. Therefore, it shows how cassava is overcoming the initial stigmatisation as a less preferred food crop. A similar reversal in consumption trend is also witnessed with increased demand for sweet potato and its products in other parts of Africa (Mkamilo & Jeremiah, 2005).

## 2.4 The concept of consumer behaviour

Consumer behaviour involves the acquisition, and disposition of goods, services, time, and ideas by a consumer (Jacoby, 2003). Consumers' choices involve the internal cohesion of the decision process and action when planning, acquiring, using, and disposing of a good or service (Loudon & Della Bitta, 1984). More recent works are built on the definitions above (Hawkins & Mothersbaugh, 2010; Solomon, 2010). The gist of this definition emphasises the main phases of consumption: searching for information, making decisions, using a commodity, and its disposal (Kotler & Keller, 2011).

## 2.5 Empirical framework

### 2.5.1 Factors influencing consumers' preference and consumption frequency for roots and tubers.

Consumers vary in shopping for different food commodities, preparation methods, and consumption styles (substitutes or complements). Households consume those food items as complements, while others are used as substitutes for other meals. Moreover, the purchase decision driving the choice of food and quality perception varies from one consumer to the other (Ritson & Petrovici, 2001). The literature review shows foundation factors influencing consumer preference: cultural, social, personal, psychological, and commodity-related (Armstrong *et al.,* 2014; Barlagne *et al.,* 2017; Gc & Yeo, 2019; Gwladys *et al.,* 2020; Mmasa *et al.,* 2012; Teweldemedhin & Mulonda, 2016). Bhatta *et al.* (2009) studied determinants for preference and willingness to pay. His findings categorised these factors into two: product-related factors and consumer-related factors. Product-related factors influencing consumer preference were quality, price, type (perishable or non-perishable), the origin of production, information about the product, and its availability. Consumer-related factors include income, age, education, gender, occupation, and family size. Bhatta's findings resonate with Piyasiri and Ariyawardana (2002), who revealed that consumer awareness positively affects demand for organic food products.

Haghjou *et al.* (2013) indicated that peer influence, individual habits, and socio-cultural factors affect preference. In addition, consumer awareness of the nutritional benefits of consuming specific food items is another important factor determining consumption patterns. A study by Barlagne *et al*. (2017) on consumer preference for fresh yams using a focus group study in Guadeloupe found that consumers considered the price, origin, taste, texture, external damage, and size as important determinants for yam preference. Focus group discussions have been proposed for use since they are efficient ways of eliciting drivers of consumer choices (Van Kleef *et al.*, 2005). Besides, consumers sharing the same platform make much information available quickly (Boquin *et al.*, 2014; Cardinal *et al.*, 2003; Lee & Lee, 2007).

Food safety is another essential factor driving consumption choices for food commodities (Piyasiri & Ariyawardana, 2002); therefore, food items that are perceived to possess unhealthy elements tend to be avoided by consumers. Alternatively, food rich in nutritional and medicinal properties attracts more preference among households. For instance, the medicinal properties of root and tuber crops help tackle dietary-related diseases; therefore, their consumption is highly encouraged. Some health benefits are difficult to assess; therefore, 'estimating consumers' willingness to pay for safer food quality' is a simple method to determine food safety benefits (Goldberg & Roosen, 2005). Using a multiple regression model to examine social-economic factors affecting consumption of sweet potato products in Tanzania, Mmasa *et al.* (2012) found age, gender, household size, and income to have significant influence followed by price, quality, and availability.

For households to derive the nutritional benefits of different foods, they have to consume them more often. Moreover, the availability of other food items helps achieve dietary diversity among households, improving their diets. By examining factors affecting the frequency of purchase of sweet potatoes in Argentina, Lacaze *et al.* (2012) found that 50% of the respondents mentioned at least one nutrient that attracts them to consume the crops more frequently (Carbohydrates 83%, vitamins 24%, Potassium 16%, and Fibre 12%). This indicates that the characteristics of food items in terms of nutritional endowment are more likely to influence their frequency of consumption. Large households had a higher probability of consuming fresh sweet potatoes than smaller households. This could be attributed to the cost of food purchases; it is more expensive to feed households with many members than smaller households. Sweet potato retails at a fairly cheaper price than alternative food commodities such as grains, meat, and wheat products, therefore highly consumed in larger households. This explains the higher frequency of sweet potato consumption among larger households than in smaller ones (Lacaze *et al.*, 2012).

### 2.5.2 Determinants of household food consumption expenditure.

According to Korir *et al.* (2020), the household's size, income, and food commodity prices were the major determinants of food demand decisions. These observations are consistent with the finding of Iorlamen *et al.* (2014), who assessed expenditure on food among urban households in Benue State, Nigeria. The above-mentioned used multiple linear regression and logit regression to analyse data; and revealed that household size, income, and price of commodities influenced food demand in the study area, which agrees with the findings of Vigani *et al.* (2019) from Kenya. Moreover, household size and income of household heads were the main factors influencing food demand in the area ($F = 19.78$; $p \leq 0.05$). Therefore, for a unit increase in household size, there is an increase in household food demand expenditure by about N788.10. Similarly, for every increase in a household's head income, the expenditure on food items increased by 23 Kobo (100 kobo makes N1). Other variables studied include education, gender, and marital status, which showed a significant effect (Iorlamen *et al.*, 2014).

Using the QUAIDS model to analyse urban households' food expenditure in Kenya, Mohamed *et al.* (2021) found four significant themes influencing healthy eating: perceptions, policy, socioeconomic, and environmental factors. Ashagidigbi *et al.* (2012) used descriptive statistics and Quadratic Almost Ideal Demand System (QUAIDS) models to analyse determinants of household food demand in Nigeria. Using data on household socio-economic characteristics, prices, quantity purchased, and expenditure on different food groups, they found that Older respondents and higher-income households consume fewer fats in Nigeria (Ashagidigbi *et al.*, 2012). Moreover, expenditure elasticities of all R&Ts were positive and statistically significant at 1%, indicating that they could be considered normal to luxury goods, as expected a priori (Rono *et al.*, 2017). Income (expenditure elasticity) shows that staples, animal protein, and vegetables are normal goods, while fruits and fats are luxuries. This study's results concurred with previous ones (Akinleye & Rahji, 2006; Korir *et al.*, 2020; Okoruwa & Adebayo, 2006; Rozi *et al.*, 2021; Tsegai & Kormawa, 2009), the only difference being the area of study and method of analysis used.

While examining determinants of household food consumption expenditure in Gombe state in Nigeria, Bata *et al.* (2018) found a significant effect of marital status and household income on food consumption expenditure. Moreover, demographic characteristics and economic factors influenced household decisions to consume. Gabriel *et al.* (2017) revealed that income rather than price-oriented policies would be more significant in addressing food insecurity in Laikipia County, Kenya. While investigating household expenditure on food at home in Malaysia, Yeong-Sheng (2008) revealed that age of the household head had a significant effect on consumption expenditure. Household size also positively and significantly influenced food consumption expenditure, such that larger households spent more on food (Begum *et al.,* 2010; Sekhampu, 2012).

Education level positively and significantly affected food consumption expenditure (Bata *et al.,* 2018). Moreover, the respondent's location had a positive and significant effect on consumption expenditure, such that urban households spent more on food than their counterparts upcountry (Bata *et al.,* 2018; Bozoglu *et al.,* 2013). The area of residence of the consumer affects food diversity demand, possibly due to difficulty in accessing the foods (Huffman & Orazem, 2007; Ruel *et al.,* 2010; Tankari & Badiane, 2015). Additionally, the share amounts spent on food by developing countries are 60-80% compared to 10-20% in developed countries (FAO & IFAD, 2011; Rizov *et al.,* 2014). The income level explains the difference in food share allocation between the developing and developed regions. Most consumers in developing countries are net food buyers due to low-income levels; therefore, a bigger chunk of their income is directed to food expenditure. A contrary observation is made on households from developed countries.

Beyond the traditional factor "income" (Moon *et al.,* 2002; Stewart & Harris, 2005), household characteristics also influence food diversity demand (Tankari & Badiane, 2015). When estimated, socio-demographic characteristics of households, such as gender, have varying results. For instance, gender (female) can be negative Westenhoefer (2005); Zainal Badari *et al.* (2012), sometimes positive depending on the socio-cultural orientation of the households (Rashid *et al.,* 2011). Age seems influential in a non-linear fashion for food diversity demand (Moon *et al.,* 2002; Stewart & Harris, 2005). The level of education was positive on food demand, with the effect being higher on women than on men (Rashid *et al.,* 2011).

Household size was positive and significant (Moon *et al.,* 2002), just like the nature of employment (Stewart & Harris, 2005), race (Jekanowski & Binkley, 2000), and area of residence. For instance, households living in big cities have greater demand for food diversity (Thiele & Weiss, 2003). One crucial observation is that these studies are made on assumptions of homogeneity of household preferences; hence, the demand for food diversity is assumed to be homogenous. Therefore, the study is restrictive as it goes against the nature of diversity for demand unobserved in the survey data (Tonsor *et al.*, 2009). To overcome this weakness, Tankari and Badiane (2015) studied determinants of food diversity in Uganda. Their analysis did away with previous literature on homogeneity assumptions by incorporating unobserved heterogeneity.

Kostakis (2014) surveyed determinants of household food consumption in Greece, where cross-sectional data set from Athens and Crete was collected and analysed. The results revealed that demographic and socioeconomics variables such as income, gender, age, marital status, residence, and employment status significantly influenced household food expenditure. The food expenditure study found a strong association between demographic, socio-economic parameters, and consumer attitude (Kostakis, 2014). This study concurs with several others conducted on socio-economic and demographic factors (Gabriel *et al.,* 2017; Jae *et al.,* 2000; Musyoka *et al.,* 2010, 2014; Raper *et al.,* 2002). There is a positive relationship between income and expenditure on food (Abdel-Ghany *et al.,* 2002; Gould, 2002; Ricciuto *et al.*, 2006), although this relationship is non-linear on household expenditure for food concerning Engel's law of income (Vitaliano, 2010). In demand analysis, the absence of income data can be substituted with expenditure data when calculating income elasticities since one is a possible proxy measure of the other. In addition, highly educated consumers have a different attitude toward diet styles. They choose several food items with a more balanced dietary model. Therefore there are discrepancies in household food expenditure (García & Grande, 2010).

On consumer age, different studies found varying preferences between young and old consumers; and this has led to differences in type, quantity, and quality of food consumed among households of different age categories (Jacobson *et al.,* 2010; Liu *et al.,* 2013; Ricciuto *et al.,* 2006). Employment status, gender, marital status, and religion affect food expenditure across all consumer groups. Consumers living in urban areas have more food consumption options. Therefore expenditure on food is higher in urban than in rural areas because the latter produce most of their foodstuffs (García & Grande, 2010; Liu *et al.*, 2013; Tekgüç, 2012). Moreover, household food expenditure directly correlates with the size of the food commodity (García & Grande, 2010; Jacobson *et al.,* 2010; Sabates *et al.,* 2001; Thiele & Weiss, 2003).

## 2.6 Theoretical Framework

Consumer choice theory shows that consumers want to maximise utility subject to budget constraints and the market price of the preferred goods (Hill & Schiller, 2015).

Therefore, the economic explanation for consumer choice has the foundation of marginal utility and the law of demand.

### 2.6.1 The theory of consumer behaviour

Consumer behaviour theories are concerned with how consumers allocate income over different commodities to maximise utility (Hill & Schiller, 2015). It is worth noting that consumers are rational; therefore, it is possible to express the probability of utility gained from consuming available alternatives (Cascetta, 2009). Moreover, they always compare utility anticipated from consumption of various commodities before purchase, subject to the commodity's price and income level. In addition, the consumer faces several alternatives that shape his decision from a set of choices (Ben-Akiva & Lerman, 2018).

The importance of any alternative among the available choices depends on commodity taste, prices, income level, availability, and the role the food commodity plays to an individual regarding nutritional and medicinal benefits. Therefore, a random utility theory (RUT) was used to understand this concept because it explains and quantifies consumers' preferences based on a finite set of alternatives. RUT operates on the assumption that the type of food the consumer chooses provides the highest utility among all alternative food types in a set of choices. Random utility theory models an individual's preference for alternatives using a real-valued score for each alternative independently and then ranking the alternatives according to the score. These scores represent the level of utility realised by consumers. According to this theory, the choice of a given root and tuber is governed by random factors (McFadden, 1973). The utility choice model is divided into deterministic (observable) components and an error (random) component, which are independent.

The utility $U$ that household $i$ gains from consuming good $n$ is made of observable/deterministic component $V$ (the utility function) and random component $\mathcal{E}$ defined by Cascetta (2009) as shown in equation (2.1);

$$U_{in} = V_{in} + \mathcal{E}_{in} \tag{2.1}$$

where $U_{in}$ is Utility, $V_{in}$ is deterministic component and $\mathcal{E}_{in}$ the error term. The assumption made is, $U_{in}$ utility depends on consumer choices of type of foodstuff selected from $n$ set of root and tuber crops. The consumer is assumed to have a utility function of the form shown in equation (2.2);

$$U_{in} = V(X_n, Z_i) \tag{2.2}$$

where; $X_n$ are R&Ts attributes while $Z_i$ is consumer attributes. A rational consumer aiming to maximise utility and achieve food security over a period must select among a set of *n* R&Ts categories. The consumer chooses *n* root and tuber crop if the perceived utility from the foodstuff is greater than utility from foodstuff $q$. That is, $U_n > U_q$. The utility of consuming any root and tuber crop is assumed to depend on the attributes of the selected foodstuff and the socio-economic characteristics of consumers (Cascetta, 2009). Due to various factors, the utility derived by consumers from alternative food selections may not be known with certainty by the researcher when modelling the utility function. Therefore an error term/random element $\mathcal{E}$ is introduced in the model to capture uncertainties or unobserved variables affecting an individual's utility, as shown in equation (2.3).

$$U_{in} = V(X_n, Z_i) + \mathcal{E}(X_n, Z_i) \tag{2.3}$$

The probability that consumer *i* will choose any root and tuber crop from the set of R&Ts category is shown in equation (2.4);

$$P[i(R\&Ts)] = P[U_n > U_q] \ , \qquad n \in \text{R\&Ts} \tag{2.4}$$

$$= P[(V_n + \mathcal{E}_n) > (V_q + \mathcal{E}_q)]$$

$$P[(V_n - V_q) > \mu]$$

where R&Ts is a complete set of choices for the crops. For equation (2.4) to be estimated, error terms were assumed to have Gumbel distribution with independence and identical distribution (IID) characteristics (McFadden, 1973).

The RUT is mainly preferred compared to the consumer demand theory (Marshallian consumer behaviour theory). This is attributed to its ability to encompass other factors affecting consumer behaviour, from demographic, economic, institutional, and product-related factors. The RUT applies a holistic approach when explaining variations in consumer behaviour. In contrast, the Marshallian theory of consumer behaviour (Colander, 2008) looks at the narrow scope of consumer demand at the point of purchase. The Marshallian theory concentrates on the quantity demanded of a commodity against its own price, cross-price and income level. Consumers, especially urban dwellers, are multicultural and likely to adopt different consumption habits. This results to shifting in their lifestyle, consumption trends, and reduced physical activities. Therefore, the RUT was adopted because it is superior to the Marshallian theory and can capture the dynamic socio-cultural, economic and institutional factors affecting R&Ts consumption patterns among urban dwellers.

## 2.7 Conceptual framework

The study is conceptualised as presented in Figure 2.1. The framework links the factors affecting consumer preference for R&Ts, frequency of consumption for R&Ts, and how these interrelationships further affect the budgetary allocation for these crops. Demographic, institutional and economic factors, as well as product characteristics, are explanatory variables with a direct effect on three dependent variables; “Consumer preference,” “frequency of consumption,” and “household food demand budgetary allocation” for R&Ts. The price relationship between R&Ts predicts whether the selected crops are consumed as substitutes or complements for each other. Moreover, R&Ts characteristics such as quality, size, taste, and availability also affect consumer preference.

There is a positive relationship between dependent variables, consumer preference and frequency of consumption. The highlighted relationship could be explained by intervening variables “consumer knowledge/awareness”. Consumers with enhanced nutritional knowledge concerning R&Ts are more likely to prefer them; therefore, they consume them more frequently. Regarding the frequency of consumption, dependent variables predict how often households consume R&Ts to achieve nutritional goals. Factors such as Covid-19 pandemic is more likely to attract frequent consumption of R&Ts due to their medicinal properties in fighting against the disease. Moreover, the frequency of R&Ts consumption influences how households allocate budgetary shares for selected crops hence helping to achieve food and nutrition security in the long run.

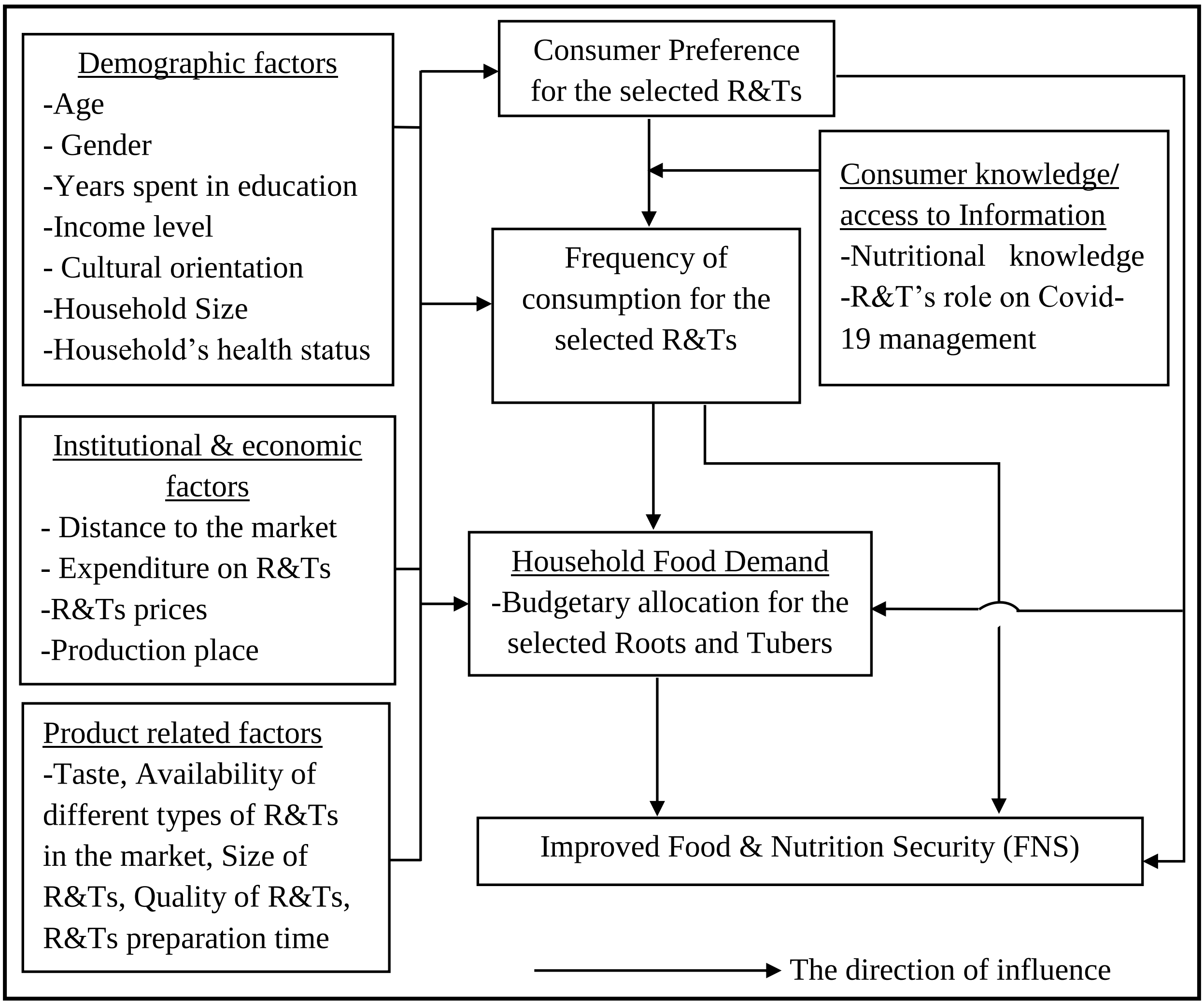


**Figure 2.1:** Conceptual framework

# CHAPTER THREE
# CONSUMER PREFERENCE FOR SELECTED ROOTS AND TUBERS AMONG URBAN HOUSEHOLDS

**Abstract**

Consumption of roots and tubers (R&Ts) among urban households can be low. Understanding factors influencing consumption decisions for R&Ts is important in enhancing their utilisation. This study assessed determinants of consumer preference for selected R&Ts using a multivariate Probit model. A stratified multistage sampling technique was adopted to select 385 respondents, and data collected using a pre-tested semi-structured questionnaire. Irish potatoes (*Solanum tuberosum* L.) had the highest preference level (70%), followed by sweet potatoes (*Ipomoea batatas* L. Lam.) at 61%. Arrowroot (*Maranta arundinacea* L.) had a preference of 42%. Cassava (*Manihot esculenta* Crantz) and yams (*Dioscorea alata* L.) were the least preferred at 22% each. Education, monthly income, cultural orientation, nutritional knowledge, Covid-19 pandemic, market distance, farming of R&Ts, retail prices, production location, availability of R&Ts, size, quality, taste, and preparation time influenced preferences for R&Ts by urban households. The results identify factors affecting consumer preference for R&Ts, reveal the causes of their low consumption among urban dwellers, and explain their actual contribution to nutrition among households. Inadequate time to prepare R&T meals at home and availability of conveniently prepared alternatives likely explains their low preference by urban residents. R&Ts provide significant amounts of essential macro and micronutrients that improve nutrition and help fight against various diseases due to their medicinal properties to support their increased household consumption.

**Keywords**: dietary diversity, essential elements, household consumption, multivariate Probit model, Sub-Saharan Africa

## 3.1 Introduction

Due to their potential in adapting to different climatic conditions, roots and tubers (R&Ts) are a reliable source of food, found throughout Sub-Saharan Africa (SSA) and include cassava (*Manihot esculenta* Crantz), Irish potatoes (*Solanum tuberosum* L.), sweet potatoes (*Ipomoea batatas* L. Lam.), yams (*Dioscorea alata* L.), arrowroots (*Maranta arundinacea* L.), and ginger (*Zingiber officinale* Rosc.) (Ferraro *et al.*, 2016; MoALFI, 2019). The introduction of new varieties for R&Ts increased yields but their consumption is below their potential (Scott *et al.,* 2000). The negative perception as a poor man's food Reincke *et al.* (2018), presence of toxic antinutrients produced by cassava Lambein and Diasolua (2019), and lack of nutritional knowledge regarding R&Ts likely explain the low usage (Ayanwale *et al.,* 2016; Tefft & Jonasova, 2020).

Rising consumer preference for exotic foods and convenient alternatives such as fast foods and other highly processed foods has increased dietary-related non-communicable diseases such as obesity, diabetes, cardiovascular diseases, cancer, dental diseases, and osteoporosis (Wiggins & Keats, 2014). Health-conscious consumers prefer moderate consumption of R&Ts. They form part of a diet that reduces chronic diseases (Chandrasekara & Kumar, 2016) by acting as functional foods (Saranraj *et al.,* 2019). The R&Ts provide cheap sources of carbohydrates and calories for many households in the SSA (Nanbol & Namo, 2019). They also supply iron, zinc, calcium, and vitamins A, B, and C (Okareh *et al.,* 2021). It is not clear why some have been abandoned and classified as orphan crops. Consumption of R&Ts among urban households is low and their actual contribution to nutrition by urban dwellers is unknown. Studies (Ayanwale *et al.*, 2016; Barlagne *et al.,* 2017) on food consumption patterns have not assessed preference patterns for R&TS among urban dwellers.

This study examined factors influencing consumer preference for selected R&Ts among urban households. Previous work reported socio-cultural, economic and institutional factors as key elements shaping dietary choices and preferences among households (Barlagne *et al.*, 2017; Gc & Yeo, 2019; Teweldemedhin & Mulonda, 2016). Indigenous food systems and preferences are likely to reduce consumption of nutritious food commodities when these foods are not traditionally known or culturally accepted (Gwladys *et al.,* 2020). However, urban dwellers are diverse in their socio-cultural composition and more likely exposed to a wide variety of food items. Additionally, convenience, texture, taste, colour, perceptions, habits, familiarity and beliefs were cited as contributing factors in urban households' R&Ts choices (Bhatta *et al.,* 2009; Gitonga, 2013; Kassie *et al.*, 2013; Mmasa *et al.*, 2012; Piyasiri & Ariyawardana, 2002; Teklewold *et al.,* 2013). Findings from this study are likely to inform the formulation of relevant policies that enhance consumer awareness of the nutritional benefits of R&Ts, and the long-term health consequences, therefore increasing consumption and promoting the growth of R&Ts subsector.

## 3.2 Materials and Methods

The study was conducted in Nakuru Town East Sub County in Nakuru County, Kenya. It has a total area of 230.9 square km, a population density of 840 persons per square km, and a population of 193,926 people (KNBS, 2019). The sub-county is subdivided into five wards: Biashara, Flamingo, Kivumbini, Menengai, and Nakuru East. The sub-county is located between longitude 36º 3′6″ East and 36º 9′45 ″ East and Latitude 0° 15′ 36″ South and 0° 30′ 0″ South, at 1,850 m above sea level. Since agriculture is not the mainstay activity in the area, the residents rely on food supplies from other regions (NCIDP, 2018). The map of the study area is shown in Figure 3.1.

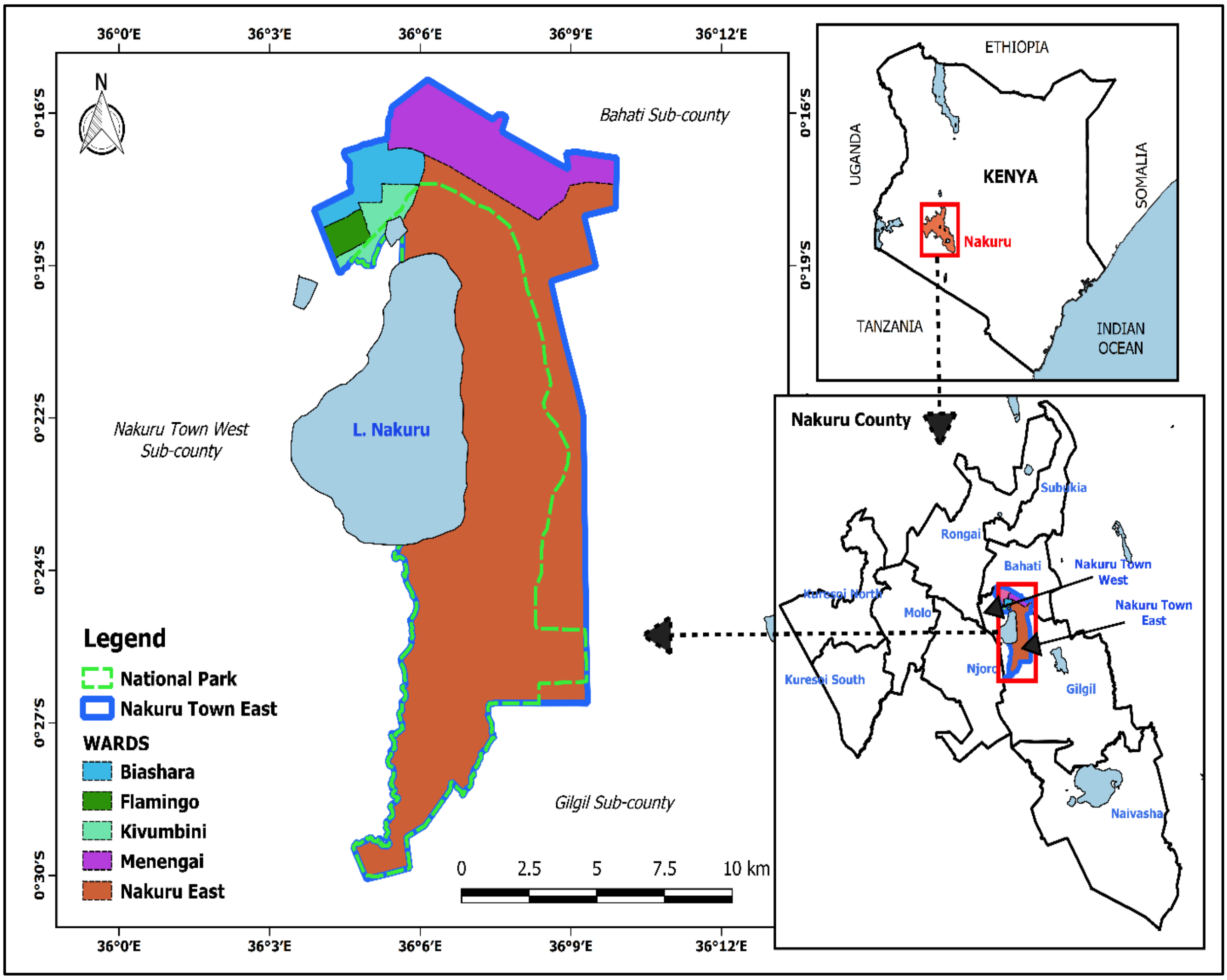


**Figure 3.1:** Map of the study area

**Source:** Independent Electoral and Boundaries Commission (2017)

The study was anchored on a cross-sectional research design where data for various variables were collected simultaneously. A cross-sectional design was adopted for this study since it saves time, is cost-effective, and has a lot of information collected in a short time.

Moreover, the design allows data to be collected from different respondents at a given time (Kothari, 2004; Peter, 2015). This design also enables collection of data that measures the prevalence of all factors under study. A stratified multistage sampling technique was used to select R&Ts consumers as the targeted respondents. In the first stage Nakuru County was purposively selected because of the heterogeneous nature of its consumers. In the second stage, Nakuru Town East Sub-County was purposively selected because it hosts the highest number of market outlets for R&Ts. The third stage involved stratification of R&Ts markets into supermarkets, organised open-air markets, and roadside stalls for all wards of Nakuru Town East Sub-County. In the fourth stage, a mixed sampling technique was adopted and split into 2 levels. The first level used non-probability/judgmental sampling because the population of R&Ts consumers in the study area is infinite, and its distribution per ward is unknown (Kothari, 2004). In the second level, random sampling was used to select an equal number of respondents from each of the selected market outlets and in all wards.

Eliminating sample selection bias and ensuring randomness was achieved through a lottery to generate a random number nth in this case, number two was selected. Therefore, every second customer who visited the R&Ts retail outlet and made a purchase was interviewed. To ensure the obtained data was as representative as possible, immediately after the interview, respondents were asked to inform their household members not to participate in the same interview if they were to encounter any of our enumerators in the field. Moreover, before the interview, we asked the respondent if he or any of their household members had been interviewed about R&Ts during the study duration. This prevented interviewing the same household more than once hence enhancing data reliability.

The sample size was determined based on Kothari (2004), where a total of 385 respondents were selected and distributed evenly across wards and in their respective market outlets as shown in equation (3.1).

$$n=\frac{z^2 . p . q}{e^2} \tag{3.1}$$

where; $n$ = size of the sample; Z = confidence level (α=0.05), which gives 1.96; $p$ = population proportion of interest (R&Ts consumers) set at 0.5, since statistically, a proportion of 0.5 results to sufficient and reliable sample size when dealing with the infinite population; $q$ = weighting variable computed as 1-$p$; and $e$ = precision rate set at 5% or 0.05 (acceptable error). This formula resulted in 385 respondents computed as shown in equation (3.2);

$$n = \frac{1.96^2 . 0.5 . 0.5}{0.05^2} = 384.16 \cong 385 \tag{3.2}$$

The 385 respondents were selected and distributed evenly across wards and in their respective market outlets. For research clearance in Kenya, the National Commission for Science, Technology and Innovation and Ethics research permits attached in Appendix K**: Research Permit** were acquired from relevant authorities. Primary data were collected using semi-structured questionnaires attached in Appendix L**: Household Questionnaire**. To assess the suitability and viability of the data, pre-testing questionnaires were done and corrected for data quality before actual data collection. Respondents were interviewed at market outlets immediately after purchasing R&Ts, where they provided information on socio-demographic, institutional, economic, and product characteristics influencing preference for R&Ts. The collected data were coded, entered, and data entry errors removed using IBM SPSS Statistics 20 (IBMCorp, 2011) data analysis program. The data were transferred to Stata 12 (StataCorp, 2014) computer program, where econometric analysis was performed.

The dependent variable, "consumer preference", for each R&Ts, was binary in choice. One indicated that a given R&T crop was chosen for consumption, while zero otherwise. Due to the dichotomous property of the dependent variable, a binary selection model would fit the analysis of the data set (Greene, 2002). The R&T crops identified were Irish potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* L. Lam.), cassava (*Manihot esculenta* Crantz), arrowroot (*Maranta arundinacea* L.), and yam (*Dioscorea alata* L.) (MoALFI, 2019). Since the estimation involved several R&Ts, selection of one or more of these was likely to occur due to variation in consumer taste and preferences. Selection of a single R&T crop may affect the likelihood of selecting the remaining ones due to the potential relationships existing between R&Ts. This relationship, otherwise called the correlation of R&T crops, maybe due to complementarity (positive correlation) or substitutability (negative correlation) between R&Ts (Belderbos *et al.*, 2004).

Estimating a binary equation for each R&Ts independently would lead to potential bias because the analysis does not capture the error terms' correlation, which results in inefficient estimates (Greene, 2008). Therefore, a multivariate probit (MVP) model was used because the consumption preference decision is inherently multivariant. The MVP model simultaneously regresses the influence of a set of explanatory variables on each R&T combined while allowing for correlation of error terms for binary equations (Kassie *et al.*, 2013; Teklewold *et al.*, 2013). The MVP model represented a system of 5 binary equations that were jointly estimated using a maximum likelihood method to determine consumer preferences for each R&T. The MVP model was derived by Kassie *et al.* (2013) as shown in equation (3.3);

$$Y_{hj}^{*} = X_{hj}^{'}\beta_{j} + \mu_{hj},\ j = 1, ...,\qquad (3.3)$$

and

$$Y_{hj} = \begin{cases} 1 \text{ if } Y_{hj}^{*} > 0 \\ 0 \text{ otherwise} \end{cases},\qquad (3.4)$$

where $j = 1...m$ denotes the R&Ts choices available. In equation (3.3), the assumption is that a rational $h^{th}$ consumer has a latent variable $Y_{hj}^{*}$ that captures the unobserved preferences of demand associated with the $j^{th}$ choice of R&Ts. The latent variable is assumed to be a linear combination of observed characteristics $(X_{hj})$ that affect consumer preference for $j^{th}$ R&T and unobserved characteristics captured by the stochastic error term $\mu_{hj}$. The vector of parameters to be estimated is represented as $\beta_{j}$. With the latent nature of $Y_{hj}^{*}$, the estimations are centred on observable binary discrete variables $Y_{hj}$, which indicate whether a household consumes a particular R&T.

If the preference for a particular R&T is independent of whether or not a consumer chooses another R&T, that is, the error terms $\mu_{hj}$ are Independent and Identically Distributed (IID) with a standard normal distribution, then equations (3.3) and (3.4) specify univariate Probit models. This model indicates that the information on the household’s preference for one R&T crop does not alter the preference probability of another R&T crop. However, if consumer preference for several R&Ts is possible, a more realistic specification is to assume that the error terms in equation (3.3) jointly follow a multivariate normal (MVN) distribution, with zero conditional mean and variance normalised to unity such that $\mu_{hj} \sim MVN(0, \Omega)$ and the symmetric covariance matrix is given by equation (3.5);

$$\Omega = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \cdots & \rho_{1m} \\ \rho_{21} & 1 & \rho_{23} & \cdots & \rho_{2m} \\ \rho_{31} & \rho_{32} & 1 & \cdots & \rho_{3m} \\ \vdots & \vdots & \vdots & 1 & \vdots \\ \rho_{m1} & \rho_{m2} & \rho_{m3} & \cdots & 1 \end{bmatrix} \quad (3.5)$$

Of particular interest are the off-diagonal elements in the covariance matrix, $\rho_{jm}$ representing the unobserved correlation between the stochastic part of the $j^{th}$ and $m^{th}$ type of R&Ts. This assumption reveals that equation (3.3) gives an MVP model that jointly represents decisions to consume a particular R&T. This specification having non-zero off-diagonal elements allows for correlation across the error terms for several latent equations, representing the unobserved characteristics that affect the choice of alternative R&Ts.

Socio-economic, institutional, and product-related characteristics used as independent variables to analyse factors influencing consumer preference for R&Ts were derived from previous studies (Barlagne *et al.*, 2017; Bhatta *et al.*, 2009; Gc & Yeo, 2019; Gitonga, 2013; Kassie *et al.*, 2013; Mmasa *et al.*, 2012; Piyasiri & Ariyawardana, 2002; Teklewold *et al.*, 2013; Teweldemedhin & Mulonda, 2016). A decision-maker is a household member responsible for making critical decisions on food consumption in the house. The choice of dependent and independent variables is shown in

Table **3.1**

**Table 3.1:** Description of variables used in multivariate probit model

| **Variables** | **Description and measurement** | **sign** |
|---|---|---|
| | **Dependent variables** | |
| Irish potatoes | If the household consumed Irish potatoes (1=Yes; 0=No) | |
| Sweet potatoes | If the household consumed sweet potatoes (1=Yes; 0=No) | |
| Cassava | If the household consumed cassava (1=Yes; 0=No) | |
| Arrowroots | If the household consumed arrowroots (1=Yes; 0=No) | |
| Yams | If the household consumed yams (1=Yes; 0=No) | |
| | **Independent Variables** | |
| Age | Age of the decision-maker in years (continuous) | ± |
| Gender | Gender of the decision-maker[1] (1=Male; 0=Female) | ± |
| Education | Years of education of the decision-maker(continuous) | ± |
| Household size | Number of household members (continuous) | ± |

| | | |
|---|---|---|
| Household Income | Monthly income of the decision-maker in KES[2] (continuous) | ± |
| Culture | If cultural orientation influences preference for R&Ts (1=Yes, 0=No) | ± |
| Household health | If the health condition of the household members influences preference for R&Ts (1=Yes, 0=No) | ± |
| Covid-19 | If the Covid-19 pandemic influence preference for R&Ts (1=Yes, 0=No) | ± |
| Market distance | Distance from home to the market outlet for R&Ts[3] (in km[4]) | - |
| Farming R&Ts | Whether the household farms on R&Ts (1=Yes, 0=No) | ± |
| Nutrition knowledge | If nutritional knowledge influences preference for R&Ts (1=Yes, 0=No) | ± |
| Prices for R&Ts | If price variation influence preference for R&Ts (1=Yes, 0=No) | ± |
| Production place | If the place of production for R&Ts influences preference (1=Yes, 0=No) | ± |
| Availability R&Ts | If the availability of different types of R&Ts in the market influence preference for the crops (1=Yes, 0=No) | ± |
| Size of R&Ts | If the size of R&Ts influences preference for the crops (1=Yes, 0=No) | ± |
| Quality of R&Ts | If the quality of R&Ts influences preference (1=Yes, 0=No) | - |

**Table 3.1:** Description of variables used in multivariate probit model (Continued)

| | | |
|---|---|---|
| Taste for R&Ts | If taste perception for R&Ts influences preference (1=Yes, 0=No) | + |
| Preparation time | If preparation time for R&Ts influences preference (1=Yes, 0=No) | ± |

[1] Decision-maker is the household member responsible for making food consumption decisions

[2] KES refers to the Kenyan shilling (official Kenyan currency); exchange rate is 1 $US = KES. 113.05

[3] R&Ts = Roots and Tubers

[4] km = distance in kilometres

### 3.3 Results and discussion

The majority (52%) of decision-makers were females (Table 3.2), implying that household food consumption decisions are made majorly by women, which agrees with Wahyudi *et al.* (2019). Many decision-makers were approaching middle age (approximately 40 years old) and literate having attained at least secondary school education (with about 13 years of education). A moderate minority (2.34%) of households received a monthly income of over KES. 100,000 implying that a vast majority (97.66%) are low-income earners (Table 3.2). The respondents had an average of 4 household members and the distance from home to market for R&Ts was long (approximately 7 km), agreeing with Gido *et al.* (2017). The respondents agreed that distant markets are within their working environs, therefore convenient for buying R&Ts when going home after work.

**Table 3.2:** Description of variables and descriptive statistics

| Variable | | Mean |
|---|---|---|
| Continuous variables | Variable description and their measurements | |
| Age | Age of the decision-maker in years | 39.85 |
| Education | Years of education of the decision-maker | 12.61 |
| Household income | Monthly income of the decision-maker in KES | 31,822.73 |
| Household size | Number of household members | 4.31 |
| Market distance | Distance from home to the market outlet for R&Ts (in km) | 6.58 |
| Categorical variables | | Percent |

**Table 3.2:** Description of variables and descriptive statistics (Continued)

| | | |
|---|---|---|
| Gender | % of male decision-makers | 47.79 |
| Nutrition knowledge | % of respondents whose nutritional knowledge influences preference for R&Ts | 86.49 |
| Prices for R&Ts | % of respondents who perceive prices of R&Ts are affordable | 90.13 |
| Farming R&Ts | % of respondents with their own farm production of R&Ts | 25.71 |
| Culture | % of respondents whose culture influence preference for R&Ts | 79.22 |
| Household health | % of respondents who prefer R&Ts for health reasons | 25.71 |
| Covid19 | % of respondents who consume R&Ts due to the Covid- | 74.29 |

| | | |
|---|---|---|
| | 19 pandemic | |
| Preparation time | % of respondents who perceive R&Ts take a shorter time to prepare | 69.61 |
| Production location | % of respondents who were concerned about production location for R&Ts | 63.90 |
| Availability R&Ts | % of respondents who perceive the availability of R&Ts influences preference for the crops | 67.01 |
| Size of R&Ts | % of respondents concerned about R&Ts size | 96.10 |
| Quality of R&Ts | % of respondents who were concerned about R&Ts quality | 97.14 |
| Taste for R&Ts | % of respondents who perceive R&Ts taste for R&Ts influence preference | 92.47 |

Generally, the preference levels for R&Ts were relatively high (Figure 3.2), indicating importance among urban dwellers and agree with Wiebe *et al.* (2021). The high preference for R&Ts could be attributed to affordability, making them favoured meals for the urban poor, whose larger proportion of income goes to food (Onodu *et al.*, 2020). Irish potato and sweet potato had the highest preference levels, while arrowroot, cassava, and yam were least preferred (Figure 3.2).

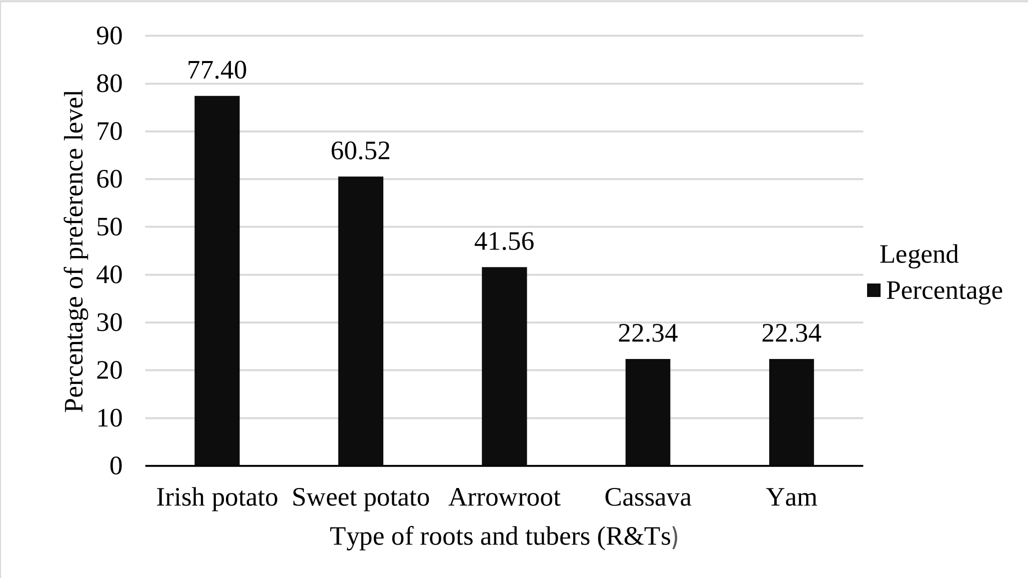


**Figure 3.2:** Descriptive statistics on preference level of R&Ts (in percentages)

To determine the feasibility of the MVP model in analysing the relationship between selected R&Ts in consumption, error terms between the binary choice equations for the R&Ts were estimated (Table 3.3). Results indicated that 8 pairs were negative, and significant out of 10 pair cases; the remaining 2 were positive and insignificant.

**Table 3.3:** Binary correlation coefficients for multivariate Probit regression equations

| | Irish potato | Sweet potato | Cassava | Arrowroot |
|---|---|---|---|---|
| Sweet potato | -0.336*** | | | |
| Cassava | -0.284** | 0.055 | | |
| Arrowroot | -0.399*** | -0.271*** | -0.218** | |
| Yam | 0.076 | -0.387*** | -0.254** | -0.244** |

***, ** = Significant at 1% and 5%, respectively

Estimated correlation coefficients between pairs of R&Ts were different from zero, indicating some degree of relationship among the R&Ts under study. The significant negative coefficients implied that the R&Ts are substitutes in the household food plate. The findings support using an MVP model in the study. The correlation between arrowroot and Irish potato was highest, with the least for arrowroot and cassava.

The MVP model analysis on consumer preference for R&Ts was estimated using the maximum likelihood method (Table 3.4). The Wald test of the hypothesis that the regression coefficients in all equations are jointly equal to zero was rejected implying the data fit analysis by the MVP model. Additionally, the likelihood ratio test of the null hypothesis for the covariance matrix of the error terms across the 5 equations not being correlated was rejected, supporting the correlation between the error terms of the R&Ts equations (Table 3.3), implying that preference for different R&Ts was mutually dependent.

Of 18 independent variables, 14 had positive or negative significant influences on R&Ts preference (Table 3.4). These variables are education, monthly income, distance to the market, nutritional knowledge, R&Ts retail prices, own farm production of R&Ts, cultural orientation, the prevalence of Covid-19 pandemic, preparation time for R&Ts, production location, availability of R&Ts, size, quality, and taste. The remaining 4 independent variables, age, gender, household size, and household health, did not influence consumer preference for R&Ts.

Higher levels of education negatively influenced preference for Irish potato by decision-makers. Studies on food consumption patterns indicate that convenience and health awareness are the main determinants of food preference among educated households. Educated households are likely to have formal employment, leaving them with inadequate time to prepare meals at home. Such households would probably select food items that take a shorter time to prepare, thereby reducing their preference for Irish potatoes which agrees with Thorne *et al.* (2017).

Increased monthly income negatively influenced preference for Irish potato, and positively influenced preference for arrowroot. Irish potato is a staple food in Nakuru county where its production and consumption is high. This makes it more affordable especially among low-income earners. However, households with larger monthly incomes have high purchasing power; their preference for alternative foods is likely high at the expense of Irish potatoes. These results agree with Salmensuu (2021) confirming that household income is a major determinant of dietary preferences across regions. High-income earners concerned with the safety of their diets are likely to prefer consuming arrowroot due to health and nutritional benefits. Arrowroot contains high energy, vitamins A, B, and C, and essential elements (Saranraj *et al.*, 2019). Its retail price is higher than that of Irish potatoes, therefore affordable for households with higher incomes.

**Table 3.4:** Multivariate Probit results on factors influencing consumer preference for roots and tubers among urban households

| | Irish potato | | Sweet potato | | Cassava | | Arrowroot | | Yam | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Coef. | Robust Std. err. | Coef. | Robust Std. err. | Coef. | Robust Std. err. | Coef. | Std. err. | Coef. | Robust Std. err. |
| Age | -0.01 | 0.01 | -0.00 | 0.01 | 0.01 | 0.01 | -0.00 | 0.01 | -0.00 | 0.01 |
| Gender | -0.15 | 0.16 | 0.02 | 0.15 | 0.06 | 0.16 | -0.02 | 0.14 | -0.02 | 0.16 |
| Education | -0.07** | 0.03 | -0.00 | 0.03 | 0.03 | 0.03 | -0.02 | 0.03 | 0.02 | 0.03 |
| H_hold size | 0.01 | 0.05 | 0.02 | 0.05 | 0.06 | 0.05 | 0.00 | 0.04 | 0.04 | 0.05 |
| Hous_income | -0.41*** | 0.15 | 0.03 | 0.14 | -0.01 | 0.17 | 0.35** | 0.15 | 0.01 | 0.18 |
| Culture | 0.67*** | 0.09 | -0.42*** | 0.09 | 0.02 | 0.08 | -0.03 | 0.08 | 0.16* | 0.08 |
| H_health | 0.22 | 0.14 | 0.03 | 0.13 | 0.10 | 0.10 | -0.01 | 0.10 | -0.08 | 0.12 |
| Covid-19 | -0.09 | 0.10 | 0.02 | 0.09 | 0.30*** | 0.09 | -0.04 | 0.08 | 0.08 | 0.09 |
| Mrkt_dist | 0.00 | 0.01 | 0.04*** | 0.01 | 0.02 | 0.01 | -0.01 | 0.01 | 0.01 | 0.01 |
| Farm_R&Ts | 0.18 | 0.13 | -0.22* | 0.11 | 0.19 | 0.12 | 0.20* | 0.12 | -0.24** | 0.12 |
| Nutri_know | 0.01 | 0.11 | 0.06 | 0.11 | -0.01 | 0.10 | 0.21** | 0.10 | 0.05 | 0.10 |
| Prices_R&Ts | 0.02 | 0.09 | 0.22** | 0.10 | -0.01 | 0.10 | -0.02 | 0.09 | 0.40*** | 0.14 |
| Prdn_place | -0.29*** | 0.09 | 0.18** | 0.08 | 0.17** | 0.08 | 0.16** | 0.07 | 0.20** | 0.08 |
| Availability | -0.02 | 0.18 | 0.37** | 0.17 | -0.45** | 0.20 | -0.12 | 0.17 | 0.07 | 0.19 |
| Size_ R&Ts | 0.06 | 0.13 | 0.27** | 0.13 | 0.01 | 0.15 | 0.18 | 0.12 | -0.08 | 0.15 |
| Qlty_R&Ts | 0.13 | 0.12 | 0.49*** | 0.14 | 0.25 | 0.16 | 0.35*** | 0.13 | 0.00 | 0.15 |
| Taste_ R&Ts | 0.24* | 0.12 | 0.19 | 0.12 | -0.01 | 0.14 | -0.09 | 0.12 | -0.04 | 0.12 |
| Prep_time | 0.02 | 0.10 | 0.04 | 0.09 | 0.16* | 0.08 | 0.10 | 0.08 | 0.03 | 0.08 |

**Table 3.4:** Multivariate Probit results on factors influencing consumer preference for roots and tubers among urban households (Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Constant | 4.83 | 1.36 | -2.32 | 1.23 | -3.21 | 1.45 | -4.69 | 1.25 | -2.40 | 1.49 |

Number of obs = 385

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: $chi^2(10)$ = 154.051

Wald $chi^2(90)$ = 918.39

Prob > $chi^2$ = 0.0000

***, **, * Significant at 1%, 5% and 10%, respectively

Distance to market positively influenced preference for sweet potato. This variable affects consumers' flexibility in accessing food. Some respondents revealed that far distant markets are located within their workplaces and convenient for buying sweet potatoes when returning home from work. Findings on sweet potato conforms to the economic theory, which postulates the utility obtained from sweet potato consumption to be higher than its searching cost (Mukras *et al.,* 2013).This implies that households are more concerned with getting their preferred foods than the market distance. However, far market distance constrains access to essential foods due to cost and time required for traveling to retail outlets (van Rensburg Willem *et al.,* 2007). This finding needs further study.

Nutritional knowledge among decision-makers positively influenced arrowroot preference. Nutritional knowledge provides information concerning diet and health, diet and diseases, and the nutritional content of different foods. In this regard, households with nutritional knowledge are less likely to prefer foods that are not safe and less nutritious in favour of arrowroot which is healthier, secure, and more nutritious. Arrowroot provides nutritional and functional benefits to people with celiac disease, encouraging its consumption (Amante *et al.,* 2021). Nutritional knowledge enhances utilization of arrowroot due to its diverse uses (Francis & Jayalakshmi, 2021).

Decision-makers who perceived retail prices offered on sweet potato and yam were affordable were more likely to prefer them for consumption. Like many other agricultural commodities, retail prices for R&Ts fluctuate seasonally, such that during low supply occasioned by dry periods, prices go up, making them less affordable among poor households (Amaza, 2009). However, the increment in prices for R&Ts is lower than grains and cereals. Households would less prefer other foods in favour of sweet potato and yam. There was an increased preference for sweet potato and yam as prices of imported carbohydrates such as rice and wheat rise (Kathiravan & Churaman, 2021). This was attributed to sweet potato and yam acting as substitutes with the increase in prices of competing commodities.

Own farm production of R&Ts negatively influenced preference for sweet potato and yam and positively influenced preference for arrowroot. Households with their own farm production of sweet potato and yam are likely to get bored from their frequent consumption over time; hence, they would prefer other food items. This could probably be explained by the Marshallian law of diminishing marginal utility, where higher consumption levels for sweet potato and yam result in utility saturation (Ormazabal, 1995). At the utility saturation point, households no longer crave sweet potato and yam and revert to selling excess R&Ts to meet their expenditures and purchase alternative food commodities not produced on the farm. However, increased arrowroot preference by households who farmed it was probably due to reduced expenditure on food purchases.

Cultural orientation dictates consumer choices and perceptions towards the type of food to consume. Households culture is based on ethnicity, region of origin, and social upbringing (Alonso *et al.,* 2018). This variable positively influenced preference for Irish potato and yam and negatively influenced preference for sweet potato among households. Most households of Nakuru county originate from Irish potato and yam-producing areas and likely consume them as staple foods. This is probably because people align their food cultures based on region of origin and adoption of diets from other regions (Forsythe *et al.,* 2017). These results agree with Gwladys *et al.* (2020) confirming that culture influences food choices. Low consumer preference for sweet potato was probably because most urban households adopt different food cultures and go for more convenient meals (Gething *et al.,* 2012).

Prevalence of Covid-19 pandemic positively influenced preference for cassava among households. Due to the fear of this global pandemic, many households incorporate diverse meals, including cassava, in their diets to boost body immunity in the fight against the disease. Cassava contains vitamins A, B, and C, minerals, essential elements, and micronutrients which act as immune boosters (Okareh *et al.*, 2021), especially for populations with underlying health risks. This is supported by recent studies that show cassava consumption helps in the fight against various diseases (Afolami *et al.,* 2021), including Covid-19 (Aman & Masood, 2020).

Households who perceive that cassava takes a shorter time to prepare are more likely to prefer it. However, the time factor that influences cassava preference is probably based on cassava variety and the end product by the consumers (Tran *et al.,* 2021). Cassava can still be hard even after being cooked for a longer time (Bechoff *et al.,* 2018).

Decision-makers with concerns for production location of R&Ts were less likely to prefer Irish potato but more likely to prefer sweet potato, cassava, arrowroot, and yam. Environmental pollution of places where food is farmed raises safety concerns among health-conscious consumers. Moreover, different regions vary in climatic and soil fertility levels that determine the quality of food produced. In this regard, Irish potato produced from industrialized regions is likely to harbour toxic and carcinogenic metallic trace elements and are less preferred for consumption by households (Ćwieląg-Drabek *et al.,* 2020). Sweet potato, cassava, arrowroot, and yam produced from fertile regions are likely rich in nutrients attracting high consumer preference. Households from R&Ts producing areas can identify better varieties using product attributes, colour and flesh texture and are more likely to prefer them (Barlagne *et al.,* 2017; Forsythe *et al.,* 2017; Villano *et al.,* 2016).

Availability of R&Ts is more likely to influence preference for sweet potato and less likely to influence preference for cassava. Perhaps the different R&Ts give households a broader choice of alternatives. Presence of sweet potatoes in the market is more likely to attract households who use them to complement other meals (Laurie *et al.,* 2018). Low cassava preference is probably due to the negative perception that it is a "poor man's food" (Reincke *et al.,* 2018). Cassava is characterized by toxic hydrocyanic acid, discouraging its preference (Mombo *et al.,* 2017). Households opt for safer alternatives like sweet potatoes.

The R&Ts size positively influenced preference for sweet potato among households. Consumers apparently use size to measure maturity and nutritional content of agricultural commodities. Households prefer large-sized sweet potatoes probably because of their high dry matter content. Smaller-sized sweet potatoes were watery and fibrous (stringy) and not enough for one serving (Baker, 1947; Naico, 2009).

Quality of R&Ts positively influenced preference for sweet potato and arrowroot. Normally, quality perception of agricultural products is revealed in terms of visual appearance (level of skin damage and flesh colour). Sweet potato with smooth undented skin represents high quality (Villano *et al.,* 2016). Flesh colour for arrowroot influenced its preference such that its pure white or pink colour depending on the variety imply freshness and perceived to be of high quality (Simi *et al.,* 2016). However, arrowroot preference based on colour varies across consumers because of visual perception (aesthetics) differences.

The taste perception for R&Ts positively influenced preference for Irish potato by households. The unique taste of Irish potato allows households to prepare it in different forms of preference (baking, roasting, boiling, steaming, frying, and microwaving). Irish potatoes which contain large proportions of salt and sugar are highly preferred (Kourouniotis *et al.,* 2016). The finding conforms with that of Gwladys *et al.* (2020), who found a positive association between potato taste and its preference, especially by urban consumers.

## 3.4 Conclusion and Recommendations

This study used an MVP model to assess factors influencing consumer preference for selected roots and tubers among urban households in Nakuru County. Based on the survey data collected from all five wards of Nakuru Town East Sub-county, the results show that Irish potato, sweet potato, and arrowroot are generally more preferred compared to cassava and yam. The low preference for cassava and yam could be attributed to the fear of consuming cassava due to cyanide poisoning and lack of knowledge on preparing yam. Households with underlying health conditions seem to create a market opportunity that is adequately informed about the medicinal benefits of R&Ts. The findings from this study reveal increased R&Ts preference among urban dwellers attributed to enhanced awareness of their health benefits. The urban poor prefer R&Ts because they are affordable and cheap sources of starch, carbohydrates, calories, and essential elements. R&Ts are sources of income among urban households who produce and sell them from their own farms (see Appendix I**: Publication abstract**).

Higher-income households likely have higher purchasing power to incorporate R&Ts in their diet. Decision-makers with high monthly incomes are more likely to prefer arrowroot, which retails at a higher price than other R&Ts, probably because they can afford it. Moreover, due to the consumption of highly processed foods, high-income earners are probably prone to dietary-related diseases such as diabetes and cancer; hence opt to consume safer foods (in this case, arrowroot). The cultural orientation of the households influenced preference for R&Ts. Therefore, it highlights the importance of developing R&Ts promotion strategies that align with the respondents' cultural values.

More awareness campaigns should be done to sensitise households to embrace other R&Ts diets outside their cultural bound. The sensitisation could be based on the nutritional benefits of R&Ts and different methods of preparation by households. The sensitisation should involve consumer and producer organisations and the government through relevant ministries by ensuring the availability of improved R&Ts varieties that captures the heterogeneous needs of consumers. Moreover, value-addition strategies for R&Ts will ensure their prolonged shelf life, facilitating a continuous supply of high-quality R&Ts in the market throughout the year. The continuous supply of crops alongside the introduction of price control policies by the government, such as; a price ceiling (the maximum chargeable price); and a price floor (the minimum chargeable price), could help stabilise food prices in the market therefore, improving human diet and food security in the long run. Incorporating R&Ts in the households' diets is in line with the government's commitment to achieving food and nutrition security, which is one of the pillars of the big four policy agenda of the government of Kenya.

This study is based on cross-sectional data, but consumer preferences are dynamic, as shown in the literature. From a future survey perspective, it is vital to collect data over time to understand consumer behaviour and capture the dynamics of some of the independent variables that influence preference for R&Ts.

# CHAPTER FOUR
# CONSUMPTION FREQUENCY FOR SELECTED ROOTS AND TUBERS AMONG URBAN HOUSEHOLDS

**Abstract**

With the ever-increasing population suffering from hunger and malnutrition, frequent consumption of roots and tubers (R&Ts) is likely to improve household health and nutritional status. Roots and tubers contribute to improved nutrition, provide medicinal benefits and are a cheaper source of carbohydrates, vitamins, and minerals hence much affordable for urban poor households. Despite their highlighted benefits, R&Ts consumption levels among urban consumers have reduced significantly and the reasons for the decline remain unknown. Assessing households' consumption frequency for R&Ts is essential in enhancing their utilisation. This study evaluated factors influencing consumption frequency for selected R&Ts among urban households of Nakuru county, Kenya using a negative binomial regression (NBR) model. A stratified multistage sampling technique was employed to select a random sample of 385 urban respondents, and data were collected using a pretested semi-structured questionnaire. The mean consumption frequency for R&Ts was seventeen times a month. Household size, monthly income, household health, farming of R&Ts, nutritional knowledge, and availability of different types of R&Ts influenced their consumption frequency among urban households. In this regard, R&Ts value addition strategies such as peeling, washing, drying, packaging and labelling could increase their acceptance as convenient foods among urban dwellers. Food policies such as promoting access to healthy foods that improve R&Ts supply chain efficiency could increase production and consumption, consequently broadening the food base at household and national levels.

**Keywords**: Consumption frequency, household consumption, malnutrition, negative binomial regression, nutrition security, root and tuber crops, urban households.

## 4.1 Introduction

As the human population increases, pressure mounts on the global food system resulting in hunger and malnutrition thereby affecting millions of people, especially in the developing world. Hunger and malnutrition indicate inadequate consumption of fruits and vegetables, roots and tubers included (FAO *et al.*, 2020; Ogbonna *et al.*, 2017). For instance, the recommended World Health Organization's (WHO) minimum consumption of fruits and vegetables is 400g per person per day (Mason-D'Croz *et al.,* 2019). However, Sub-Saharan Africa (SSA) is a specific area of concern, with projections suggesting that by 2050 around 1.9 billion people could be consuming low than the recommended levels of R&Ts per person per day (Mason-D'Croz *et al.,* 2019). In Kenya, approximately 48 per cent of the urban households consume insufficient amounts of R&Ts (Mohamed *et al.,* 2021; Wanyama, 2019), likely resulting in micronutrient deficiencies, stunted growth, impaired cognitive development, and susceptibility to diseases.

Roots and tubers found in SSA, Asia, and the Americas include Irish potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* L. Lam.), cassava (*Manihot esculenta* Crantz), arrowroots (*Maranta arundinacea* L.), and yam (*Dioscorea alata* L.) (MoALFI, 2019). They are the second most highly regarded food after cereals and play a significant role in sustainable production and consumption contributing to food and nutrition security at the household and national level (Gweyi-Onyango *et al.,* 2020; Onodu *et al.,* 2020). Moreover, an estimated 300 million poor people in developing countries rely on R&Ts for consumption and income generation (Thiele *et al.,* 2017).

Roots and tubers global production is projected to reach 1400 million tons by 2050, with SSA accounting for the largest proportion (Petsakos *et al.,* 2019; Thiele & Friedmann, 2020). In Kenya, their production was estimated at 3,684,000 metric tonnes (MT) in 2018 compared to 2,419,000 MT in 2015. Unlike production, there is insufficient current aggregate R&Ts consumption data. However, using Irish potato consumption data as a proxy or representative measure, it is evident that their consumption in the country has declined. For instance, Irish potato consumption reduced from 2,507,000 MT in 2012 to 1,714,000 MT in 2019 (Helgi Analytics, 2022; MoALFI, 2019). This drop in R&Ts consumption is an indication that their consumption frequency has also reduced and could be attributed to a shift in consumption patterns favouring low-cost imports, exotic foods, and conveniently prepared alternatives. Moreover, their high perishability and lack of efficient value-addition strategies to prolong their shelf life further discourage consumption since consumers cannot purchase them in bulk, like grains and cereals. Therefore, R&Ts remain some of the most underutilised foods among many urban dwellers (Dawson *et al.,* 2009).

However, due to their unique characteristics such as; diverse maturity cycles, broader agroecological adaptation, and underground storage ability that allow for flexible harvesting duration, R&Ts have the potential of addressing hunger and essential element deficiency (malnutrition), especially in the developing world. As the primary source of cheap carbohydrates, they provide high energy and nutritional value per unit, contribute phenolic compounds, minerals (potassium, magnesium, calcium, and sodium), trace elements (iron, manganese, and zinc), and vitamins A, B, and C (Dawson *et al.,* 2009; MoALFI, 2019; Suárez *et al.,* 2016). In addition, when frequently consumed at moderate intervals, they provide medicinal benefits that curb dietary-related diseases such as obesity and diabetes (Chandrasekara & Kumar, 2016; Gayao *et al.,* 2018; Niehof *et al.,* 2018; Saranraj *et al.,* 2019).

Roots and tubers are consumed as staple foods during breakfast, lunch and dinner (de Sousa *et al.,* 2019), therefore forming the majority of delicacies by households across the world's tropical regions. More often, R&Ts serve as complements, substitutes, seasonal vegetables during famine, and meals for special occasions. For instance, cassava, sweet potato, and arrowroot substitute or complement cereals and wheat products (Chandrasekara & Kumar, 2016). The majority of R&Ts are consumed fresh or boiled, steamed, fried, roasted and mashed to form puree and often eaten with rice, leafy vegetables, and stew. Moreover, starch from R&Ts such as Irish potato and arrowroot are readily digestible, therefore, used to prepare food for infants (Dereje *et al.*, 2020; MoALFI, 2019). Thus, the regular inclusion of different R&Ts recipes in household diets could significantly explain their consumption frequency. Menza *et al*. (2014) revealed that R&Ts consumption ranges from daily to several times a week, with an average of about one kg of the crops being consumed per person per day. Similarly, Low *et al.* (2009) intimated an average R&Ts consumption frequency of two to four times a week.

Despite this, R&Ts consumption is constrained by socio-demographics, institutional, economic, cultural, and food characteristics (Baek & Chitekwe, 2019; Mbwana *et al.,* 2016). For instance, an increase in income allocated to R&Ts expenditures increases the likelihood of their consumption frequency (Adeosun *et al.,* 2017). Furthermore, preparation skills and nutritional knowledge significantly influenced the diverse consumption counts of R&Ts (Ochieng *et al.,* 2017). Teweldemedhin and Mulonda (2016) revealed that family size positively influenced consumption frequency for R&Ts. Older respondents consumed R&Ts more frequently than younger ones (Lacaze *et al.*, 2012). Taste perception has a significant influence on R&Ts consumption; that is, the tastier the vegetable, the more it was consumed (Gwladys *et al.,* 2020). Moreover, perceived nutritional value plays a significant role in how often R&Ts are consumed (Bechoff *et al.*, 2018).

Strategies for enhancing nutrition security have emphasised the inclusion of R&Ts in the household dietary diversity to reduce overreliance on cereal-based foods facing supply disruptions during the Covid-19 pandemic and climate change (Muthamilarasan & Prasad, 2021). Increasing R&Ts consumption frequency is a strategic way of addressing micronutrient deficiency and dietary-related diseases since they contain adequate essential elements, vitamins and minerals that are inadequate in grains and cereals (Birol *et al.*, 2015). However, the low R&Ts consumption levels and frequency do not guarantee the highlighted benefits (Mohamed *et al.*, 2021; Wanyama, 2019).

From the preceding, the study evaluates the role of socio-economic, institutional, and product attributes in influencing consumption frequency for selected R&Ts crops among urban households. This paper contributes to the limited literature on applying count model analysis in R&Ts consumption. To our knowledge, this is the first study to use the NBR model in analysing consumption counts for R&Ts among urban residents. Another unique aspect is the application of a one-month exposure period leading to non-zero R&Ts consumption, implying that the respondents' time frame (exposure period) affects the final estimates and determines the type of count model to use. Findings from the study identify new evidence of the policy-relevant variables influencing R&Ts consumption which could inform food policy formulation through relevant authorities as they seek to increase R&Ts consumption frequency to enhance food and nutrition security and curb other dietary-related diseases, especially among urban households.

## 4.2 Materials and Methods

### 4.2.1 Study area and sampling design

The study was undertaken in Nakuru Town East Sub County in Nakuru county, Kenya. The sub-county covers an area of 230.9 square km and is inhabited by 193,926 people, distributed within a population density of 840 persons per square km (KNBS, 2019). This sub-county has five wards; Biashara, Kivumbini, Menengai, and Nakuru East and enjoys a temperate climate all year round. It lies between longitude 36º 3′6″ East and 36º 9′45 ″ East and Latitude 0° 15′ 36″ South and 0° 30′ 0″ South, at 1,850 m above sea level. The sub-county hosts major agricultural retail and wholesale markets and serves consumers from within and outside the county (NCIDP, 2018). Moreover, it hosts Kenya's largest retail and wholesale chains of supermarkets: Quick Mart, Naivas, and Gilani's supermarkets, convenient markets for R&Ts. Since agriculture is not the main socio-economic activity of this sub-county, the residents rely on food supplies from other regions. Therefore, the area is strategically located for conducting the study.

Respondents were selected using a stratified multistage sampling technique. The first stage used a purposive selection of Nakuru County due to the heterogeneous nature of consumers. The second stage purposively selected Nakuru Town East Sub-County because it hosts the largest number of R&Ts markets. In the third stage, R&Ts markets were stratified into supermarkets, organised open-air markets, and roadside stalls across all Nakuru Town East Sub County wards. The fourth stage employed a mixed sampling technique divided into two categories. The first category applied judgmental sampling because the population of R&Ts consumers in the study area was infinite with unknown ward distribution (Kothari, 2004). Respondents were distributed evenly across the selected markets and in all wards. The second category used random sampling to select an equal number of respondents from each market outlet across the wards (Kothari, 2004).

The sample size was obtained using Kothari (2004) approach, and data were collected from mid-April to the end-April 2021, where 385 respondents were selected and spread equally across all the R&Ts markets in all wards. For research clearance in Kenya, the National Commission for Science, Technology, and Innovation and Ethics research permits attached in Appendix K**: Research Permit** were sourced from responsible authorities. Pretesting the questionnaires was done to assess the suitability and feasibility of the data. After correcting anomalies in the data tool, well-trained enumerators used the semi-structured questionnaires attached in Appendix L**: Household Questionnaire** to collect primary data. Respondents were interviewed immediately after buying R&Ts at the market outlets.

The information collected from the respondents includes decision-makers' gender, age, years of schooling, household size, income level, distance to the market, frequency of R&Ts consumption (recall of one month), availability of R&Ts, respondents' perceptions regarding R&Ts retail prices, and R&Ts characteristics. According to MoALFI (2019), the main roots and tubers identified as commonly produced and consumed in Kenya include Irish potatoes (*Solanum tuberosum* L.), sweet potatoes (*Ipomoea batatas* L. Lam.), cassava (*Manihot esculenta* Crantz), arrowroots (*Maranta arundinacea* L.), and yams (*Dioscorea alata* L.). Therefore, information on all 5 R&Ts was collected. Respondents' quality perception and nutritional knowledge of R&Ts were assessed using the questions ''Does the quality of R&Ts influence their consumption frequency?'' and "Does nutritional knowledge influence R&Ts consumption frequency?". The responses were categorised as "Yes = 1" and

“NO = 0”. Further questions then accompanied this on the positive response (Yes), where respondents selected essential nutrients found in various R&Ts. The collected data were then entered, coded, and data entry errors removed, followed by diagnostic and econometric analysis of the model using Stata 12 (StataCorp, 2014) computer program.

### 4.2.2 Econometric modelling of factors influencing consumption frequency of R&Ts

Consumption frequency in this study was measured as the number of times a household consumed R&Ts in the past one month regardless of the type of R&T crop because of variations in consumer taste and preferences. Nutritional benefits obtained from the consumption of R&Ts can be achieved by maintaining regular consumption intervals. This is important, especially in developing countries suffering from hunger and malnutrition. The duration of 1 month was presumed adequate for analysing consumption frequency for R&Ts because many household budgets their consumption expenditure monthly. The estimated results could be helpful in policy formulation for enhancing R&Ts consumption. Therefore, count data models were preferred in this study to evaluate consumption frequency for R&Ts (Gujarati & Porter, 2004). The survey analysed all the four-count models to identify the one that best fits the study.

The standard Poisson regression model was the first to be analysed (Gujarati & Porter, 2004). However, the model suffered from an over-dispersion problem where its conditional mean was lower than its variance function, violating its basic assumption. The test for over-dispersion was conducted using Deviance and Pearson goodness of fit tests, as explained in the results and discussion section. The limitation was addressed using the advanced negative binomial regression (NBR) model (Greene, 2002). The NBR model ran and passed all the goodness of fit tests such as; the lower Akaike information criterion (AIC) and Bayesian information criterion (BIC), implying the NBR was more appropriate than the standard Poisson. Higher models were analysed to ascertain the validity and feasibility of the NBR. The third model was the zero-inflated Poisson (ZIP) model. Unfortunately, it suffered from an over-dispersion problem of the data set as revealed by Deviance and Pearson goodness of fit tests, where the observed response variance was greater than the conditional mean (Gurmu & Trivedi, 1996; Mullahy, 1986). The fourth to be analysed was the zero-inflated negative binomial (ZINB) model (Minami *et al.*, 2007). However, the model failed because the data lacked zero consumption counts for R&Ts for the one-month exposure time. Moreover, the goodness of fit tests (AIC and BIC estimates) had higher values than the previous models.

Comparing the AIC and BIC values for all four models suggested using the NBR model, which passed all the necessary goodness of fit tests and had lower AIC and BIC values. Therefore, the NBR was used and is shown in equation (4.1);

$$q(y_i|\mu_i,\theta)=\frac{\Gamma(\theta+y_i)}{\Gamma(\theta)\Gamma(y_i+1)}\left(\frac{\theta}{\theta+\mu_i}\right)^{\theta}\left(\frac{\mu_i}{\theta+\mu_i}\right)^{y_i} \text{ for } y_i=0,1,2,3,... \quad (4.1)$$

where $q(y_i|\mu_i,\theta)$ is the probability function on non-negative integers, $y_i$ is the consumption outcome for household $i$, $\mu_i$ is the mean incidence rate $y$ per unit of exposure. Exposure may be space, time, distance, volume, area, or population size. $\theta$ is the precision or size parameter $\Gamma(.)$ is a gamma distribution function. $\mu_i$ are log-likelihood functions represented by $\ln\mu_i=B_i^{'}\beta$, such that, $B_i$ is the row vector of covariates and $\beta$ is the parameter estimate.

**Table 4.1:** Description of variables for the Negative Binomial regression model

| Variables | Description and measurement | sign |
|---|---|---|
| | **Dependent variable** | |
| Cons_frequency | Number of times a household consumed R&Ts in a month | |
| | **Independent Variables** | |
| Age | Age of the decision-maker in years (continuous) | ± |
| Gender | Gender of the decision-maker (1=Male; 0=Female) | ± |
| Education | Years of education of the decision-maker(continuous) | ± |
| Household size | Number of household members (continuous) | ± |
| Household Income | Monthly income of the decision-maker in KES (continuous) | ± |
| Culture | If cultural orientation influence consumption frequency for R&Ts (1=Yes, 0=No) | ± |
| Household health | If the health condition of the household members influences consumption frequency for R&Ts (1=Yes, 0=No) | ± |
| Covid-19 | If the Covid-19 pandemic influences consumption frequency for R&Ts (1=Yes, 0=No) | ± |
| Market distance | Distance from home to the market outlet for R&Ts (in Kilometres) | - |
| Farming R&Ts | Whether the household farms on R&Ts (1=Yes, 0=No) | ± |

**Table 4.2:** Description of variables for the Negative Binomial regression model (Continued)

| | | |
|---|---|---|
| Nutrition knowledge | If nutritional knowledge influences consumption frequency for R&Ts (1=Yes, 0=No) | ± |
| Prices for R&Ts | If price variation influences consumption frequency for R&Ts (1=Yes, 0=No) | ± |
| Production place | If the place of production for R&Ts influences consumption frequency (1=Yes, 0=No) | ± |
| Availability R&Ts | If the availability of different types of R&Ts in the market influence consumption frequency for the crops (1=Yes, 0=No) | ± |
| Size of R&Ts | If the size of R&Ts influences consumption frequency for the crops (1=Yes, 0=No) | ± |
| Quality of R&Ts | If the quality of R&Ts influences consumption frequency (1=Yes, 0=No) | - |
| Taste for R&Ts | If taste perception for R&Ts influences consumption frequency (1=Yes, 0=No) | + |
| Preparation time | If preparation time for R&Ts influences consumption frequency (1=Yes, 0=No) | ± |

The socio-economic, institutional, and product-related characteristics used as covariates in analysing factors influencing consumption frequency for selected roots and tubers among urban households of Nakuru County were derived from previous studies (Fang *et al.,* 2019; Gido *et al.,* 2015, 2017; Gitonga, 2013; Kimambo *et al.,* 2018; Lacaze *et al.,* 2012; Minami *et al.,* 2007; Saghaian & Mohammadi, 2018; Teklewold *et al.,* 2013; Wahyudi *et al.,* 2019). The choice of dependent and independent variables is shown in Table 4.1.

## 4.3 Results and discussion

### 4.3.1 Descriptive results

Descriptive and summary statistics (indicate that majority of the respondents were of middle age and literate, having attained secondary school level. Many of the decision-makers were females, probably because food consumption decisions are made mainly by women which agrees with Wahyudi *et al.* (2019).

**Table 4.3:** Description of variables and descriptive statistics

| Variable | Description of variables and their measurements | Mean |
|---|---|---|
| Continuous variables | | |
| Age | Age of the decision-maker in years | 39.85 |
| Education | Years of education of the decision-maker | 12.61 |
| Household Income | Monthly income of the decision-maker in KES | 31,822.73 |
| Household size | Number of household members | 4.31 |
| Market distance | Distance from home to the market outlet for R&Ts (in km) | 6.58 |
| Categorical variables | | Percentage |
| Gender | % of male decision-makers | 47.79 |
| Nutrition knowledge | % of respondents whose nutritional knowledge influences the frequency of consumption for R&Ts | 86.49 |
| Prices for R&Ts | % of respondents who perceive prices of R&Ts are affordable | 90.13 |
| Farming R&Ts | % of respondents with their own farm production of R&Ts | 25.71 |
| Culture | % of respondents whose culture influence preference for R&Ts | 79.22 |
| Household health | % of respondents who prefer R&Ts for health reasons | 25.71 |
| Covid-19 | % of respondents who consume R&Ts due to the Covid-19 pandemic | 74.29 |
| Preparation time | % of respondents who perceive R&Ts take a shorter time to prepare | 69.61 |
| Production place | % of respondents who were concerned about the production place for R&Ts | 63.90 |
| Availability R&Ts | % of respondents who perceive the availability of different types of R&Ts influence consumption of the crops | 67.01 |

| | | |
|---|---|---|
| Size of R&Ts | % of respondents concerned about the size of R&Ts | 96.10 |
| Quality of R&Ts | % of respondents concerned about the quality of R&Ts | 97.14 |
| Taste for R&Ts | % of respondents who perceive taste for R&Ts influence frequency of consumption | 92.47 |

A majority of the decision-makers earned low incomes and had fewer household members. Distance from the residence to the R&Ts market was reasonably long (approximately 7km). However, the respondents argued that these distant markets were convenient for accessing diverse and high-quality R&Ts, which agrees with Gido *et al.* (2017). Households' culture and an outbreak of the Covid-19 pandemic influenced frequent consumption of R&Ts probably due to their medicinal benefits (CIP, 2020).

The average consumption frequency of R&Ts among urban households was seventeen times a month (Table 4.4). The monthly maximum R&Ts consumption count was 85 because; Consumption frequency was a summation of R&Ts meal counts for each of the selected five crops. The study focussed on the number of R&Ts meals consumed in a month rather than the number of days. Finally, some households reported having consumed up to four R&Ts meals in a day; Therefore, likely to result in higher monthly counts. This could be attributed to varying dietary habits among households (Ferraro *et al.,* 2016). For instance, households recording higher consumption frequency for R&Ts utilised them as a substitute for wheat products during breakfast and food for infants throughout the day. Roots and tubers complemented other meals during lunch and supper, acting as staple food among households. On the lower counts, no zero consumption level was revealed during the survey implying that all households consumed R&Ts at least once per month.

**Table 4.4:** Monthly consumption frequency of R&Ts meals among households

| Variable Statistics | Obs. | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Cons_frequency | 385 | 17.22 | 11.12 | 1 | 85 |

### 4.3.2 Determinants of consumption frequency for R&Ts

Four count models were estimated consecutively to identify the model that best fits the data in explaining consumption frequency for R&Ts. The standard Poisson model was estimated first (Table 6.1). To determine its appropriateness, a test for goodness of fit was done (Table **6.2**B) and a test for over dispersion (Table **6.3**C). For comparison, NBR model was estimated (Table 4.5). Its results revealed an over dispersion problem because the likelihood ratio test was significant, as shown by alpha greater than zero, implying NBR was more appropriate than the standard Poisson model. Estimation of AIC and BIC was done to ascertain the goodness of fit for the NBR model (Table 6.4). Lower values of either AIC or BIC indicate a better fit. The lower AIC and BIC values for NBR suggested that it was preferred to the standard Poisson model.

The third level estimated the ZIP model (Table 6.5). ZIP model results did not display the *z*-test for Vuong because the model crushed; therefore, the appropriateness of the model over the Poisson could not be ascertained. The model returned the message "Cons_frequency never equal to zero; use Poisson instead," implying that it was not a significant improvement over the standard Poisson model. The possible reasons for the ZIP model crushing were the lack of zero consumption counts and the over-dispersed data that the ZIP model could not handle. Additionally, estimating the fit statistics for AIC and BIC indicated that the ZIP model was not preferred over NBR (Table 6.7). Finally, the ZINB model was estimated (Table 6.8), where the model fit was tested and compared to the NBR. The zip option tests for an alpha of zero had a significant likelihood ratio test, implying that the ZINB was more appropriate than the ZIP model. The *z*-test for Vuong was insignificant, indicating that the ZINB was not a significant improvement over the NBR model. A further comparison of model fit for all the four regression models (Table 6.10) indicated that the NBR model was more suitable for this study; therefore, it was adopted. The NBR results are shown in Table 4.5. Several variables significantly influenced the consumption frequency of R&Ts among urban households.

Household size significantly and positively influenced consumption count for R&Ts by decision-makers. Larger households require high quantities of food resulting in increased expenditure on meals. Roots and tubers are generally more affordable than other food items, therefore more likely to be frequently consumed in large households. Similarly, Zani *et al.* (2019) found that households with many members were more likely to increase the consumption of starchy staples (cassava in this case) than smaller households. This was attributed to less cost incurred in purchasing enough cassava for a larger family. Contrary, Villano *et al.* (2016) found a negative association between household size and consumption of sweet potatoes because they retailed at higher prices, therefore expensive to feed large families.

Increased monthly income significantly and positively influenced consumption frequency for R&Ts among households. High-income earners have higher purchasing power and are more likely to incorporate R&Ts in their dietary diversity and quality (Mmasa *et al.*, 2012). The results agree with Sanusi and Babatunde (2017) confirming a positive relationship between household income and consumption of sweet potatoes possibly for the same highlighted reason. Moreover, Zani *et al.* (2019) found household income to positively influence cassava consumption because it is a staple food, attracting more spending. However, according to Engel's Law, the increase in food spending is at a lower proportion than an increase in income (Mansfield, 1982). Higher levels of income enable incorporation of R&Ts into households' dietary systems improving their nutritional quality.

**Table 4.5:** NBR model results on factors influencing consumption frequency for R&Ts

| Factor categories | Variables for Cons_frequency | Coef. | Std.Err. |
|---|---|---|---|
| Socio-economic factors | Age | -0.003 | 0.003 |
| | Gender | -0.057 | 0.052 |
| | Education | -0.007 | 0.009 |
| | Household size | 0.047*** | 0.015 |
| | Household income | 0.140*** | 0.053 |
| | Culture | -0.002 | 0.028 |
| | Household health | 0.069* | 0.037 |
| | Covid-19 | 0.012 | 0.029 |
| Institutional factors | Market distance | -0.003 | 0.004 |
| | Farming R&Ts | 0.139*** | 0.040 |
| | Nutrition knowledge | 0.095*** | 0.036 |
| | Prices for R&Ts | 0.006 | 0.035 |
| | Production place | -0.023 | 0.026 |
| | Availability R&Ts | -0.124** | 0.063 |
| Product related factors | Size of R&Ts | 0.054 | 0.047 |
| | Quality of R&Ts | 0.039 | 0.045 |
| | Taste for R&Ts | 0.060 | 0.040 |
| | Preparation time | 0.009 | 0.028 |
| | Constant | 0.951** | 0.461 |
| | /lnalpha | -1.713 | 0.095 |
| | Alpha | 0.180 | 0.017 |
| LR test of alpha=0: *chi*bar$^2$(01) = 692.240 | | Prob >= *chi*bar$^2$ = 0.000*** | |
| LR test for the model *chi*$^2$(18) = 150.750 | | Prob > *chi*$^2$ = 0.000*** | |
| Akaike crit. (AIC) = 2680.703 | | Bayesian crit. (BIC) = 2759.768 | |

Households' health status significantly and positively influenced the frequency of R&Ts consumption. Households with pre-existence health conditions are cautious of their diets (de Ridder *et al.,* 2017); Therefore, they are more likely to consume R&Ts known to boost body immunity in the fight against various diseases. Discussions with the respondents revealed that the medicinal benefits of R&Ts increased their frequency of consumption among households. For instance, sweet potato consumption has been promoted due to its distinct nutritional and health properties (Gething *et al.,* 2012). Wallace *et al.* (2020) found similar results where sweet potato and white potato were more accepted for consumption among households suffering from dietary-related diseases (diabetes, obesity, and cancer) because of their medicinal properties.

Own farm production of R&Ts by households was more likely to influence consumption count for the crops at a 1% significant level. Farming of R&Ts by urban dwellers is a survival tactic, especially by the poor, who are net food buyers and suffer when prices of food items go up. Through this strategy, urban households producing R&Ts from their own farms; either urban farming or rural farming, are likely to increase the consumption frequency of the crops compared to those who buy them in the market due to reduced food expenditure. Moreover, the excess R&Ts can be sold to generate household income and purchase alternative food items not produced on the farm, therefore improving their dietary system (Petsakos *et al.*, 2019; Tasciotti & Wagner, 2015), contributing to household's food and nutrition security (Cohen & Garrett, 2010).

Nutritional knowledge among decision-makers significantly and positively influenced consumption frequency for R&Ts a 1% significant level. Nutritional knowledge provides dietary information that enables households to diversify their consumption plans by making food choices that improve metabolism and life quality (Olatona *et al.,* 2019). Through enhanced nutritional knowledge, decision-makers know the recommended daily consumption of different food items enabling them to consume a balanced diet by incorporating R&Ts in meals. Moreover, nutritional knowledge assists households in selecting R&Ts with high nutritive value and developing different recipes which are acceptable to all the family members. This finding corroborates with that of Villano *et al.* (2016), who found a positive association between nutritional knowledge and consumption of sweet potato, attributed to its role in curbing malnutrition.

The availability of different types of R&Ts is less likely to influence their consumption frequency. Perhaps because of exposure to a wide variety of foods many urban households have shifted their consumption trends from traditional diets (R&Ts in this case) in favour of other food items that are more convenient to prepare (Cockx *et al.*, 2019). Consequently, as time goes by, households are less aware of selecting the best quality R&Ts and how to prepare them for meals. As to health impact, R&Ts such as cassava possess antinutrients (cyanide) which are likely to cause various ailments, further discouraging its consumption. The fear of contracting thyroid syndrome due to cassava consumption and gastrointestinal disorders caused by sweet potato consumption creates a negative perception of R&Ts among households, therefore reducing their consumption (Koostanto *et al.*, 2016). Moreover, some arrowroot varieties are suspected of harbouring toxic substances, while others have a bitter taste. The highlighted adverse effects associated with some R&Ts varieties, coupled with lack of information concerning the benefits of the crops, create an overall negative perception, discouraging their consumption. There is a need to enhance awareness of the nutritional benefits of different R&Ts to boost their consumption frequency (Hunter *et al.*, 2019; Laurie *et al.*, 2018).

## 4.4 Conclusions and Recommendations

The study evaluated determinants of consumption frequency for selected roots and tubers among urban households using a negative binomial regression (NBR) model. Findings indicated a mean consumption frequency of 17 R&Ts meals in a month; therefore, significant in the diets of many urban households. Larger households had a higher consumption frequency of R&Ts attributed to their affordability. Increased monthly income positively influenced consumption counts for R&Ts, probably because of the household's higher purchasing power. Households with underlying health conditions had a higher frequency of R&Ts consumption because of their medicinal benefits. Own farm production of R&Ts by households reduced food expenditure, increasing the crops' consumption frequency. Decision-makers with nutritional knowledge had a high consumption count for R&Ts, while the availability of different types of R&Ts had a contrary effect.

The findings from this study have food policy implications that seek to enhance consumer awareness of nutritional benefits of R&Ts consumption, various methods of preparing them, and increasing diversity of the crops in food systems. Through sensitisation programs, knowledge regarding R&Ts is passed to households, increasing their consumption frequency. This can be achieved by circulating information through training, advertisements on social, mass, and print media, producer and consumer organisation workshops, and roadside campaigns conducted in local dialects to reach as many households as possible.

Roots and tubers value addition strategies that involve peeling, washing, drying, and packaging them in properly labelled containers could enhance their marketability. Additionally, these strategies could save time required at the initial R&Ts preparation stages before cooking among urban consumers. Finally, food policies such as promoting access to healthy foods that improve R&Ts supply chain efficiency could increase their production and consumption, broaden the food base, and contribute to households' and national nutritional security. This study recommends a need for similar future research that could consider consumer choice of market outlet for R&Ts, which might affect their behavioural preference regarding availability and accessibility of the crops.

# CHAPTER FIVE
# DEMAND ANALYSIS FOR SELECTED ROOTS AND TUBERS AMONG URBAN HOUSEHOLDS

**Abstract**

This study examines Kenya's demand for selected roots and tubers (R&Ts). Data used for the analysis were collected from Nakuru Town East Sub-County. A sample unit of 385 urban households was interviewed at the market outlet immediately after purchasing R&Ts. Linear Approximated Almost Ideal Demand System (LA/AIDS) model was used to estimate demand elasticities, demographics and social-economic factors influencing the consumption patterns of R&Ts. Age, education, household size, and proportion of household members statistically and significantly explained the variations in R&Ts consumption patterns. Empirical results showed negative own-price elasticities for uncompensated and compensated demand analyses, therefore in line with utility theory. Cross-price elasticities had positive and negative signs, indicating the presence of substitutes and complements respectively among R&Ts. Expenditure (income) elasticities for R&Ts had mixed signs ranging from elastic to inelastic. Irish potato and sweet potato were inelastic, with a positive sign classifying them as necessities goods. Cassava and yam were inelastic with a negative sign indicating they were inferior goods, while arrowroot was positive and elastic, therefore a luxury good. These results are broadly consistent with microeconomic theory; consequently, they could inform formulation of effective income growth policies such as raising the minimum wage rate and strategies that promote R&Ts consumption, thereby contributing to household food and nutritional security.

**Keywords:** Budget shares; consumer demand; household consumption; linear approximated almost ideal demand system; root and tuber crops.

## 5.1 Introduction

The importance of roots and tubers (R&Ts) in income generation, sustainable development, and food and nutrition security cannot be overemphasized, especially in tropical countries. In most developing countries, R&Ts are the second most important crop after cereals (Kennedy *et al.,* 2019), contributing to the global food systems (Wijesinha-Bettoni & Mouillé, 2019). They are cheap sources of carbohydrates, vitamins A, B, and C, and essential elements, iron, zinc, and calcium, and serve as staple foods worldwide (Dotto *et al.,* 2018). They store carbohydrates as starch in roots, tubers, corms, rhizomes, and stems consumed as human food, animal feeds, and raw materials in agro-based industries.

In the past few decades, R&Ts production has been increasing, especially in Sub-Saharan Africa (SSA) (Polar *et al.,* 2022; Rusike *et al.,* 2010; Scott, 2000). Moreover, by 2050, the global production of R&Ts is projected to increase by 50%, especially in developing countries (Rosegrant *et al.,* 2017; Thiele & Friedmann, 2020). This increase will be driven by the ability of these crops (cassava, arrowroot, and sweet potato) to grow under harsh climatic conditions, which gives them a competitive edge over other foods therefore consumed as "famine reserve" crops (Petsakos *et al.,* 2019). Their demand among households in many developing countries increases during the famine season as complements or substitutes to scarce staple cereals. The perception that R&Ts are healthy, nutritious, and supply high energy per unit consumed than cereals further increases their demand among the undernourished population who derive 50% of their daily calorie intake from R&Ts consumption (FAO, 2017). Further, the demand for R&T is fuelled by the increasing population growth, urbanisation, and shifts in lifestyles as households seek to bridge the nutritional gap created by the food demand deficit. R&T are often used as a cheaper source of carbohydrates, vitamins, and minerals (Rosegrant *et al.,* 2017; Scott *et al.,* 2000).

Despite the highlighted benefits from R&Ts in meeting food requirements, their demand in Kenya is still below the country's potential (MoALFI, 2019). Moreover, there is insufficient data on current demand for R&Ts. Producers respond to market forces by reducing the production of agricultural commodities when the demand is low. For instance, proxy measures reveal that lack of market for cassava constrains its production by 13-23% (Githunguri & Njiru, 2021). This could be attributed to their bulkiness, perishability, fear of cyanide poisoning (a toxic substance) produced by cassava, and shifts in consumption trends from traditional meals favouring more conveniently prepared alternatives.

Several studies have been conducted on food demand patterns (Gabriel *et al.,* 2017; Korir *et al.,* 2020; Musyoka *et al.,* 2010, 2014). Moreover, demand analysis in most studies has mainly been biased towards aggregate food items than single foods. Few of these studies have focussed on R&Ts demand (Rono *et al.,* 2017; Rozi *et al.,* 2021). Though R&Ts play a significant role in Kenya's economic growth, development and food and nutrition security, systematic studies have not assessed demand for these crops among urban dwellers. Their actual contribution to the shift in demand among urban households remains unaccounted for due to a lack of consumption data. From the foregoing, this study intends to fill this knowledge gap by evaluating the effect of demographic variables, price, and expenditure elasticities on household demand for selected R&Ts among households. Irish potatoes (*Solanum tuberosum* L.), sweet potatoes (*Ipomoea batatas* L. Lam.), cassava (*Manihot esculenta* Crantz), arrowroots (*Maranta arundinacea* L.), and yams (*Dioscorea alata* L.) were selected for this study because they are the main R&Ts commonly produced and consumed in Kenya (MoALFI, 2019). This study's findings could inform the formulation of relevant policies for the R&Ts subsector that promotes their consumption.

## 5.2 Materials and Methods

### 5.2.1 Study area and sampling design

The study was conducted in Nakuru town east sub-county in Nakuru county, Kenya. The sub-county covers an area of approximately 230.9 square km with 193,926 inhabitants and a population density of 840 persons per square km (KNBS, 2019). The sub-county is subdivided into five wards (Bashara, Flamingo, Kivumbini, Menengai, and Nakuru East wards) and enjoys a temperate climate all year round. The sub-county relies on food supplies from other regions since agriculture is not the mainstay activity, and this was the main reason the study area was selected.

Primary data were collected from selected urban dwellers using a stratified multistage sampling technique. The first stage purposively selected Nakuru County because of consumers' heterogeneity. Nakuru Town East Sub-County was purposively selected in the second stage because it hosts the highest number of market outlets for R&Ts. In the third stage, the chosen market outlets were stratified into three (supermarkets, organised open-air markets, and roadside stalls) across all five wards of Nakuru Town East Sub County.

A mixed sampling technique was used in the fourth stage and conducted in two levels. Judgmental sampling was used in the first level because of the infinite population distribution of R&Ts consumers in the study area (Kothari, 2004). Respondents were deliberately and evenly distributed across selected market outlets in all wards. Random sampling was adopted in the second level, where an equal number of respondents were chosen from each market outlet across wards. Kothari (2004) approach was used to obtain 385 respondents distributed evenly across market outlets for all wards. Respondents were interviewed using semi-structured questionnaires attached in Appendix L**: Household Questionnaire** at the market outlets immediately after purchasing R&Ts. Information on gender, age, education level, household size, the proportion of household members 18 years and below, the proportion of household members 19 years and above, R&Ts real monthly expenditure, and R&Ts retail prices were obtained from the respondents. Using IBM SPSS Statistics 20 (IbmCorp, 2011) data analytical software, the collected data were coded, and data entry errors removed. The data were transferred to Stata 12 (StataCorp, 2014) computer program for econometric analysis.

### 5.2.2 Demand Systems Estimation Approach

Demand studies involve the use of either a single equation or systems approach. However, the systems approach has proved to be superior to single-equation approach. The systems approach consists of several equations, each representing one of the selected five R&Ts allowing for commodity substitution. The systems approach can be modelled as a Linear Expenditure System (LES), an Almost Ideal Demand System (AIDS), and Quadratic AIDS (QUAIDS) models. The AIDS model is preferred because it allows for approximate aggregation over consumers while at the same time retaining the theoretical features of flexibility (Deaton & Muellbauer, 1980) and its linear approximate version, the LA/AIDS is more flexible, easy to estimate, and interpret (Alston & Chalfant, 1993; Taljaard *et al.*, 2004). Nonetheless, AIDS is criticised because it linearises Engel curves, but the Quadratic Almost Ideal Demand System (QUAIDS) solves this problem. However, the linear estimation systems have some advantages over the nonlinear systems in empirical works hence the main reason for the continued use of LA/AIDS. For instance, nonlinear parameters are problematic when taking differences to remove nonstationarity in time series (Matsuda, 2006). Unless linearly estimated, nonlinear models AIDS and QUAIDS cannot be used to analyse nonstationary variables such as cointegration (error correction model).

This study used a multistage budgeting approach where the household first allocates its income as per its total expenses over a broad category of commodities (food and non-food items). Thereafter, it allocates the respective income proportions to various subcategories of the previous broad categories (Bett *et al.*, 2012; Edgerton, 1997). To estimate the demand for the selected R&Ts, this study adopts the linear approximated almost ideal demand system (LA/AIDS) model. During the demand analysis, the weak separability assumption was considered viable, therefore, tested. Further, R&Ts were considered a separable subcategory of the food category cascaded at the third budgeting stage. The LA/AIDS model follows the specification made by Deaton and Muellbauer (1980).

The estimation was done in two stages because of the infrequent consumption of R&Ts in the data. The first stage estimated the decision to purchase within a Probit model, and the second stage estimated the inverse Mills ratios (IMRs) from Probit parameters. This is comparable to Heckman's two-step model that corrects selectivity bias (Heckman, 2013). The AIDS model incorporated the estimated IMRs obtained from the first stage (of the Probit model) as an instrumental variable in the second stage of estimation. Demographic and socio-economic characteristics were added to the budget share equation to capture the differences in tastes and preferences across households (Deaton & Muellbauer, 1980; Pollak & Wales, 1981; Willemé, 2008). The share equation based on the AIDS model is specified in equation (5.1);

$$w_i = \alpha_i + \sum_j \gamma_{ij} \mathrm{In}\left(p_j\right) + \beta_i \mathrm{In}\left(\frac{x}{P}\right) + \sum_k \gamma_k Z_k + \omega_i \mathrm{IMR}_i + \varepsilon_i, \tag{5.1}$$

where $(i, j)$ represents the five R&T crops, $w_i$ is the budget share of the $i^{th}$ R&T crop derived as $w_i = p_i q_i / x$ , $q_i$ is the quantity of R&T $i$ purchased, $p_j$ is the price of $j^{th}$ R&T, and $x$ is the total expenditure of all R&Ts. $Z_k$ represents demographic and socio-economic characteristics, $\mathrm{IMR}_i$ is the inverse mills ratio, $\varepsilon_i$ is random variable with zero mean and constant variance. The $P$ is Stones Price Index for aggregate food. This Stones Price Index was corrected for units of measurement invariance following Moschini (1995) approach shown in equation (5.2);

$$\mathrm{In}(P) = \sum_i \bar{w}\ \mathrm{In}\left(p_i\right) \tag{5.2}$$

where $\bar{w}$ represents the mean budget share. To comply with the basic demand theory, adding up, homogeneity, and Slutsky symmetry restrictions (Deaton & Muellbauer, 1980), are imposed as follows;

$$\sum_i \alpha = 1 \qquad \sum_i \gamma ij = 0 \qquad \sum_i \beta_i = 0 \qquad \sum_i \omega_i = 0 \tag{5.3}$$

$$\sum_i K_{ki} = 0,\ j = 1,\ldots,n \quad \text{(Adding up)} \tag{5.4}$$

The adding-up restriction ensures that the expenditure shares always sum to one/unity.

$$\sum_k \gamma_{jk} = 0,\ j = 1,\ldots,n \quad \text{(Homogeneity),} \tag{5.5}$$

Homogeneity restriction ensures that there is no "money illusion", that is, if all prices and income change at the same rate, then the consumed quantities do not change.

$\gamma_{ij}=\gamma_{ji}$ (Symmetry), (5.6)

Also, negativity is tested after estimating the compensated own price elasticities (Green & Alston, 1990; Hayes *et al.*, 1990). Therefore, the expenditure elasticity is estimated as shown in equation (5.7);

$$e_i = 1 + \left(\frac{1}{\bar{w}_i}\right)\left(\frac{\partial \bar{w}_i}{\partial \log x}\right) = 1 + \left(\frac{\beta_i}{\bar{w}_i}\right) \tag{5.7}$$

The Marshallian/ Uncompensated Price Elasticities are estimated as;

$$s_{ii}^{M} = -1 + \left(\frac{\gamma_{ii}}{\bar{w}_i}\right) - \beta_i \quad \text{(Own-price elasticity)} \tag{5.8}$$

$$s_{ij}^{M} = -\delta_{ij} + \left(\frac{\gamma_{ij}}{\bar{w}_i}\right) - \left(\frac{\beta_{ij}}{\bar{w}_i}\right)\bar{w}_j, \quad \text{(Cross-price elasticity),} \tag{5.9}$$

$\forall i, j = 1,\ldots,n$

where $\delta_{ij}$ is a Kronecker delta that equals 1, for $i = j$, otherwise zero, while the Hicksian elasticities are obtained from, $s_{ij}^{H} = s_{ij}^{M} + e_i \bar{w}_i$ and $s_{ij}^{H} = s_{ij}^{M} + e_i \bar{w}_j$ is as follows;

$$s_{ii}^{H} = -1 + \left(\frac{\gamma_{ii}}{\bar{w}_i}\right) - \bar{w}_i \quad \text{(Own-price elasticity)} \tag{5.10}$$

$$s_{ij}^{H} = -\delta_{ij} + \left(\frac{\gamma_{ij}}{\bar{w}_i}\right) \quad j = 1,\ldots,n \quad \text{(Cross-price elasticity),} \tag{5.11}$$

$\forall i, j = 1,\ldots,n$

The estimation process was performed through seemingly unrelated regression (SURE), an iterative estimation model (Zellner, 1962). Because the budget shares add up to unity in the demand system, one of the share equations for R&T was dropped to avoid error covariance matrix singularity. The dropped equation is recovered from the imposed restrictions on the LA/AIDS model (5.1). The SURE system parameter estimates in this study were obtained using Stata 12 (StataCorp, 2014) econometric software under constrained iterated seemingly unrelated regression (ITSUR) procedure. The model's variables and expected influence were selected from previous studies (Ashagidigbi *et al.*, 2012; Bata *et al.*, 2018; Bett *et al.*, 2012; Gido, 2022; Iorlamen *et al.*, 2014; Kostakis, 2014; Tankari & Badiane, 2015). The choice of dependent and independent variables is shown in Table ***5.1***.

**Table 5.1:** Description of variables for the linear approximate almost ideal demand system

| Variable | Description and measurement | Exp. sign |
|---|---|---|
| | **Dependent variable** | |
| $W_i$ | Budget share of the $i^{th}$ R&T | |
| | **Independent variables** | |
| Age | Age of the decision-maker in years (continuous) | ± |
| Gender | Gender of the decision-maker (1=Male; 0=Female) | ± |
| Education | Years of education of the decision-maker(continuous) | ± |
| H_size | Number of household members (continuous) | ± |

| | | |
|---|---|---|
| Prop_house1 | The proportion of household members 18 years and below | ± |
| Prop_house2 | The proportion of the household members 19 years and above | ± |
| Prop_incfood | The proportion of monthly income allocated to food items | ± |
| ln_Rts_exp | Natural log of R&Ts real monthly expenditure in KES | + |
| In (p1,…p5) | Natural log price per kilogram of Irish potatoes, Sweet potatoes, Cassava, Arrowroots, and Yams, respectively | ± |
| IMR | Inverse Mills Ratios | ± |

## 5.3 Results

### 5.3.1 Descriptive results

Table 5.2 provides details of the variables used in empirical data analysis. The mean age of decision-makers was approximately 40 years, with an average of 13 years of schooling. Male decision-makers were 47.79%. Households had an average of four family members. Approximately 31% of the family members were below the age of 18 years while 69% were above. On average, 34% of the household's monthly income was allocated towards purchase of food items.

**Table 5.2:** Description of variables and descriptive statistics

| Variables | Description of variables and their measurements | Range | Mean |
|---|---|---|---|
| Continuous variables | | | |
| Age | Average age of the decision-maker in years | 18.00 –72.00 | 40.00 |
| Education | Average years of education of the decision-maker | 1.00 – 27.00 | 13.00 |
| H_size | Average household size | 1.00 – 12.00 | 4.00 |
| Prop_house1 | Proportion of household members 18 years and below | 0.00 – 0.75 | 0.31 |

**Table 5.3:** Description of variables and descriptive statistics (Continued)

| | | | |
|---|---|---|---|
| Prop_house2 | Proportion of the household members 19 years and above | 0.25 – 1.00 | 0.69 |
| Prop_incfood | Proportion of monthly income allocated to food items | 0.02 – 0.90 | 0.34 |
| lnExp | Natural log of R&Ts real[5] monthly expenditure in KES | 3.25 – 7.99 | 5.69 |
| In (p1,…p5) | Natural log price per kilogram of Irish potatoes, Sweet potatoes, Cassava, Arrowroots, and Yams, respectively | | |

| | | | |
|---|---|---|---|
| IMR | Inverse Mills Ratios | | |
| Categorical variable | | Count | Percentage |
| Gender | Average % of male decision-makers | 184 | 48.00 |

[5] Real monthly expenditure refers to the index scaled expenditures (Stones price index)

The results presented in Table 5.4 show household expenditures on R&T crops. The expenditure share allocation for R&T crops was highest in Irish potato and least in cassava. Similarly, participation (consumption) rates were highest in Irish potato and least in cassava and yam. Sweet potato, arrowroot, and yam had fair shares within the remaining R&T crops. Adding up restriction is confirmed in Table 5.4, where the sum of mean budget shares for all R&Ts sums up to one.

**Table 5.4:** Household R&Ts expenditure

| R&T category | Mean budget shares | Mean expenditure (KES) | Participation rate |
|---|---|---|---|
| Irish potato | 0.4211 | 628.26 | 77.40 |
| Sweet potato | 0.2514 | 380.52 | 60.52 |
| Cassava | 0.0683 | 128.70 | 22.34 |
| Arrowroot | 0.1867 | 394.55 | 41.56 |
| Yam | 0.0725 | 139.09 | 22.34 |

## 5.4 Empirical results

### 5.4.1 Socio-economic and demographic effects

Table 5.5 presents maximum likelihood estimates for socio-economic and demographic effects. The Chi-square values for all R&Ts equations were significant. The $R^2$ for Irish potato, sweet potato, cassava, arrowroot, and yam were 31.67, 26.80, 66.57, 18.21, and 74.87%, respectively. The poor fit was probably due to irregular purchases of some R&Ts. As shown in Table 5.5, few variables had significant influences on R&Ts budget shares. Statistically significant variables influencing the consumption patterns of R&Ts among urban households of Nakuru Town East sub-county include; Age, education, household size, and proportion of household members.

The age of the decision-maker (Table 5.5) significantly influenced shares for sweet potato positively and negatively for cassava. Education significantly and positively influenced the budget shares for sweet potato and yam at 5%, and 10% significant levels respectively and negatively influenced shares for cassava at 1% significant level. Household size had a negative and significant effect on cassava shares at $P \leq 0.01$. The proportion of household members aged 18 years and below significantly influenced shares of cassava positively and negatively for yam. The proportion of household members aged 19 years and above had a similar influence on cassava and yam shares at $P \leq 0.01$. In contrast, all R&Ts (Irish potato, sweet potato, cassava, arrowroot, and yam) had significant inverse Mills' ratios (IMRs). Therefore, ignoring non-consumers for these R&Ts during the LA/AIDS estimation would result in biased and inconsistent parameter estimates.

### 5.4.2 Price and expenditure coefficients

Table 5.6 presents maximum likelihood estimates for price and expenditure effects on R&Ts budget shares. Results indicate that own-price coefficients for Irish potato, sweet potato, cassava, and arrowroot were positive except for shares allocated to yam. The own prices did not significantly influence budget shares for all R&Ts. However, the cross-prices significantly influenced budget shares for arrowroot and sweet potato at $P \leq 0.05$ conforming to the theoretical imposition of symmetry restriction *a priori*. That is, both cross prices had similar effects of -0.083 at $P \leq 0.05$ (Table 5.6), following symmetry fashion ($\gamma_{ij} = \gamma_{ji}$). The expenditure coefficients negatively and significantly influenced budgetary allocations for Irish potato, sweet potato, cassava, and yam, while for arrowroot it was positive at $P \leq 0.01$.

**Table 5.5:** Maximum likelihood estimates of the household socio-economic and demographic effects using LA/AIDS

| Share | Age | Gender | Education | H_size | Prop_house1 | Prop_house2 | Prop_incfood | IMR |
|---|---|---|---|---|---|---|---|---|
| Irish potato | -0.070 | 0.033 | 0.058 | 0.007 | 0.642 | 0.857 | 0.010 | 0.275*** |
| | (0.057) | (0.027) | (0.045) | (0.036) | (0.646) | (0.841) | (0.033) | (0.028) |
| Sweet potato | 0.111** | 0.032 | 0.064** | -0.038 | 0.752 | 0.865 | 0.017 | 0.423*** |
| | (0.048) | (0.023) | (0.032) | (0.032) | (0.562) | (0.732) | (0.028) | 0.043 |
| Cassava | -0.066*** | -0.005 | -0.054*** | -0.039*** | 1.006*** | 1.230*** | 0.009 | -0.285*** |
| | (0.020) | (0.009) | (0.013) | (0.013) | (0.233) | (0.303) | (0.011) | (0.011) |
| Arrowroot | 0.049 | -0.000 | 0.034 | -0.038 | 0.019 | -0.058 | 0.003 | -0.170*** |
| | (0.052) | (0.024) | (0.034) | (0.034) | (0.603) | (0.785) | (0.030) | (0.028) |
| Yam | 0.022 | 0.009 | 0.019* | 0.004 | -0.777*** | -1.080*** | 0.002 | -0.316*** |
| | (0.017) | (0.008) | (0.011) | (0.011) | (0.199) | (0.260) | (0.010) | (0.010) |

***, **, * = Significant at 1%, 5%, and 10%, respectively

**Table 5.6:** Maximum likelihood estimates of the R&Ts categories price and expenditure effects using LA/AIDS

| R&Ts shares | $\alpha_i$ | Prices | | | | | $\beta_{ij}$ |
|---|---|---|---|---|---|---|---|
| | | Price_irish potato | Price_sweet potato | Price_cassava | Price_arrowroot | Price-yam | Expenditure |
| | (Intercept) | (P1) | (P2) | (P3) | (P4) | (P5) | Coef. |
| Irish potato | 0.311 | 0.056 | 0.021 | -0.028 | -0.041 | -0.008 | -0.127*** |
| | (0.624) | (0.085) | (0.046) | (0.036) | (0.068) | (0.032) | (0.020) |
| Sweet potato | -0.589 | 0.021 | 0.065 | 0.001 | -0.083** | -0.004 | -0.108*** |
| | (0.533) | (0.046) | (0.047) | (0.019) | (0.042) | (0.017) | (0.017) |
| Cassava | 0.404* | -0.028 | 0.001 | 0.023 | -0.003 | 0.008 | -0.075*** |
| | (0.214) | (0.036) | (0.019) | (0.042) | (0.036) | (0.031) | (0.007) |
| Arrowroot | -0.216 | -0.041 | -0.083** | -0.003 | 0.098 | 0.028 | 0.053*** |
| | (0.569) | (0.068) | (0.042) | (0.036) | (0.083) | (0.033) | (0.017) |
| Yam | 1.517*** | -0.008 | -0.004 | 0.008 | 0.028 | -0.025 | -0.077*** |
| | (0.194) | (0.032) | (0.017) | (0.031) | (0.033) | (0.041) | (0.006) |

***, **, * = Significant at 1%, 5%, and 10%, respectively

### 5.4.3 Price and expenditure elasticities

The own prices, cross prices, and expenditure elasticities are presented in Table 5.7. The price elasticity matrices comprise Marshallian (uncompensated) and Hicksian (compensated) elasticities. Results indicate that all Marshallian own-price elasticities for various R&Ts were negative, less than zero, conforming to utility theory.

**Table 5.7:** Price and expenditure elasticities

| Expenditure shares | Irish potato | Sweet potato | Cassava | Arrowroot | Yam |
|---|---|---|---|---|---|
| Marshallian/uncompensated elasticities | | | | | |
| Irish potato | **-0.739** | 0.125 | -0.046 | -0.041 | 0.003 |
| Sweet potato | 0.263 | **-0.635** | 0.033 | -0.248 | 0.017 |
| Cassava | 0.048 | 0.288 | **-0.594** | 0.157 | 0.196 |
| Arrowroot | -0.338 | -0.514 | -0.037 | **-0.526** | 0.131 |
| Yam | 0.337 | 0.216 | 0.182 | 0.588 | **-1.268** |
| Hicksian/compensated elasticities | | | | | |
| Irish potato | **-0.446** | 0.301 | 0.001 | 0.090 | 0.054 |
| Sweet potato | 0.503 | **-0.492** | 0.072 | -0.142 | 0.058 |
| Cassava | 0.008 | 0.264 | **-0.601** | 0.139 | 0.189 |
| Arrowroot | 0.202 | -0.191 | 0.051 | **-0.287** | 0.224 |
| Yam | 0.314 | 0.202 | 0.179 | 0.578 | **-1.272** |
| Expenditure elasticities | | | | | |
| | 0.698 | 0.570 | -0.095 | 1.284 | -0.056 |

*In **bold diagonally** are the Marshallian and Hicksian own-price elasticities*

The Hicksian own-price elasticities for Irish potato, sweet potato, cassava, arrowroot, and yam were also negative and consistent with utility theory *a priori*. Yam had more than unity (>1) price elasticity (-1.272) for the Hicksian demand function, hence elastic. All remaining R&Ts categories had less than unity (<1) price elasticities, therefore inelastic. The negative compensated own-price elasticities for all R&Ts satisfies the concavity requirement of utility function; therefore, the Slutsky matrix conforms to the negative semidefinite requirement. The expenditure elasticities range from positive to negative across all R&Ts, implying the presence of normal and inferior R&Ts categories in Nakuru Town East sub-county, Kenya. Moreover, the elasticities were computed using the total expenditure of R&Ts; therefore, they are conditional elasticities.

## 5.5 Discussion

### 5.5.1 Demographics, Price, and Expenditure Effects on Budget Shares

Age of the decision-maker was significant with a positive and negative influence on sweet potato and cassava shares respectively. The nutritional benefits of sweet potato make it more preferred by the ageing population with compromised immunity (Tan & Norhaizan, 2019). Similarly, Ülger *et al.* (2018) revealed high consumption of yellow and orange-fleshed sweet potatoes among the ageing population and attributed it to their endowed medicinal properties. The low cassava budgetary allocation is probably due to the fear of cyanide poisoning (Oloya *et al.,* 2017). Older households are prone to non-communicable diseases and are cautious of their dietary intake, consequently avoiding foods that could put their health at risk. In addition, age positively influenced the consumption patterns for the remaining R&Ts categories but was not significant. The inclusion of age in the analysis can capture variations in purchase behaviour occasioned by fluctuations in consumers' biogenic and psychogenic needs as age changes over time (Aidoo, 2009).

Education of the decision-maker significantly and positively influenced shares for sweet potato and yam and negatively for cassava shares. Educated households are likely to be more informed about dietary benefits of sweet potato and yam; therefore, they allocate more expenditure shares, agreeing with Villano *et al.* (2016) and Aidoo (2009). Consequently, the low cassava budgetary shares could be explained by educated households' higher nutritional knowledge that enables them to shift their consumption from cassava favouring more convenient alternatives through dietary diversity (Zani *et al.,* 2019).

Household size had a significant and negative effect on cassava budget share. Larger households buy foodstuff that is affordable and meets preferences for all members. Since some cassava varieties have a bitter taste (Bechoff *et al.,* 2018), few household members are likely to consume them. Larger households are more likely to have a wider variation in taste and preferences, implying different R&Ts meals are prepared for various household members at the same time. This food preparation process could be tedious, expensive, and time-consuming. In this regard, households are more likely to allocate smaller expenditure shares on cassava in favour of alternative food items acceptable to all members. Contrary, Zani *et al.*

(2019) found a positive and significant influence of family size on cassava expenditure attributed to its affordability and fit in feeding larger households.

Deaton and Muellbauer (1986) observed that household size affected the type of food products consumed, which varies according to the composition of household members. The proportion of household members aged 18 years and below positively and significantly influenced cassava budget share. Likely, this is due to the nutritional and medicinal benefits associated with cassava. For instance, cassava is rich in zinc and iron, enhancing healthy growth and cognitive development among children and the general younger population (Ghislain *et al.,* 2019). Moreover, it provides therapeutic benefits against chronic diseases such as diabetes and cardiovascular ailments among older people (Onodu *et al.,* 2018). Further results revealed that the proportion of household members aged 19 years and above negatively influenced the yam budget share. This could be attributed to its high retail price (Aidoo, 2009), which discourages larger households who are likely to purchase more yam and therefore opt for cheaper alternative R&Ts.

### 5.5.2 Effects of Price and Expenditure Elasticities on Households' R&Ts Consumption Behaviour

### 5.5.3 Marshallian/Uncompensated price elasticities

Generally, the elasticity coefficients found in this study conform to economic theory. All uncompensated (Marshallian) own price elasticities were negative as expected *a priori,* and most (Irish potato, sweet potato, cassava, arrowroot) were less than one, except for the yam share category. Arrowroot had the least own price elasticity in absolute terms, indicating that in case of a uniform general price increase in R&Ts, more income would be allocated to Arrowroot. The elasticities for Irish potato, sweet potato, cassava, and arrowroot lie between -0.526 and -0.739; therefore are price inelastic, which agrees with findings by Rono *et al.* (2017). The elasticities suggest that the quantity demanded for most R&Ts is not sensitive to price change. Every price increase for the R&T crop will reduce its demand either slightly or not at all. For instance, if the price of Irish potato falls by 10%, then its demand would grow by 7.3%, with the price effect accounting for 4.4% while the income effect as a result of price decrease contributing 2.9%. Consequently, a 10% increase in *per capita* income with a corresponding 10% decrease in Irish potato price would result in a 9.8% increase in its demand attributed to the addition of 2.9% to the corresponding expenditure elasticity in Table 5.7.

If the price of arrowroot, a luxury R&Ts category decreases by 10%, then its demand would grow by approximately 5.2% in absolute terms, with the price effect accounting for 2.8% while the income effect is due to price decrease contributing 2.4%. This implies that a 10% increase in *per capita* income alongside a 10% decrease in arrowroot price would result in a 15.2% increase in its demand attributed to the additional 2.4% (income effect) on the corresponding expenditure elasticity (12.8%), Table 5.7. This description applies to the demand for the remaining R&T crops.

All positive Marshallian cross-price elasticities indicate that two corresponding R&Ts are substitutes; that is, as the price of one R&T crop increases, demand for other competing R&T crop increases. In contrast, negative cross-price elasticities indicate that R&Ts are complements such that the demand for one R&T crop increases with a fall in the price of another R&T crop. Similarly, Gido (2022) found negative Marshallian and Hicksian cross-price elasticities for African indigenous vegetables implying that the crops were complimentary otherwise substitutes. Categorically, Irish potato substitutes sweet potato and yam while complementing the rest of the R&Ts. For instance, if the price of Irish potato falls by 10%, the demand for sweet potato would decrease by 1.2% in Table 5.7, while 30.1% of this decline would consist of pure price effect. Alternatively, for Irish potato complements like cassava, a 10% decrease in Irish potato price would result in a 5% rise in demand for cassava. The same assessment applies to other substitutes and complements. Therefore, all substitutes and complements in the Marshallian demand system are gross substitutes and complements, respectively (De Jaegher, 2009).

### 5.5.4 Hicksian/Compensated price elasticities

The compensated own-price elasticities for all R&Ts in Nakuru Town East sub-county were negative as expected *a priori*. All R&Ts had elasticities less than unity; therefore, price inelastic, except yam, which had a more than unity elasticity, therefore, price elastic. Arrowroot had the least own price elasticity in absolute terms. The elasticities of Irish potato, sweet potato, cassava, and arrowroot lie between -0.287 and -0.601; therefore, price inelastic. However, yam has an elasticity of -1.272, hence price elastic. The finding conforms with Rono *et al.* (2017), who found negative own-price elasticities for all R&Ts as expected *a priori*. Contrary, Manyong *et al.* (2007) found a positive own price elasticity for cassava flour and *fufu* attributed to the crops' consumption as substitutes and other factors.

For cross-price elasticities, the observations are similar to Marshallian demand. Positive cross-price elasticity indicates substitution effect, while negative cross-price elasticities imply complementarity. For instance, this study found a positive cross-price elasticity between Irish potato and sweet potato, meaning that the two R&Ts were substitutes, agreeing with Rono *et al.* (2017). The signs shift from negative to positive for some cross-price elasticities, implying greater income effects on households (Ansah *et al.,* 2020). Therefore, considering substitution for different R&Ts categories, Hicksian demand is preferred because it provides the best estimates due to a purely substitution effect, unlike the Marshallian demand, which has substitution and income effects, giving less efficient estimates.

### 5.5.5 Expenditure elasticities

The results indicate that expenditure elasticities for the R&Ts in the study area had mixed signs. The expenditure elasticities for Irish potato, sweet potato, and arrowroot were positive, therefore normal foods. The expenditure elasticity for arrowroot was greater than unity (1.284), consequently elastic and considered luxurious food to R&Ts consumers. This means that consumption of arrowroot will more than proportionately increase with an increase in expenditure (income). The expenditure elasticities for Irish potato and sweet potato were less than unity (0.698 and 0.570 respectively), therefore inelastic and regarded as necessity foods. Similarly, Ikudayisi and Okoruwa (2021) found that R&Ts across urban categories were expenditure inelastic implying that a 1% rise in the households' income was likely to reduce the demand for R&Ts by less than 1%. Therefore, consumption of these R&Ts categories will increase at a lower proportion than the proportionate increase in expenditure. Contrary, the expenditure elasticities for cassava and yam were negative and less than unity (-0.095 and -0.056, respectively); therefore, inelastic and inferior categories of R&Ts, where income increase results in a decrease in quantity demand. Probably, higher income levels give households higher purchasing power that enables them to diversify consumption patterns to; wheat products, fruits, meat products, and beverages which agrees with Rozi *et al.* (2021). The aforementioned decrease in cassava and yam consumption supports the conventional argument that urban households shift consumption towards soft cereals supported by increased preferences for alternative starch sources such as wheat as their income increases (Musyoka *et al.,* 2014).

For necessary R&Ts (Irish potato and sweet potato), an expenditure elasticity of 0.698 and 0.570 respectively implies that an increase in income by 10% would increase demand for Irish potato by 6.9% and sweet potato by 5.7%. For luxury R&T (arrowroot), an expenditure elasticity of 1.284 implies that a 10% increase in household income would increase demand for arrowroot by 12.84%. Finally, for inferior R&Ts (Cassava and yam), expenditure elasticities of -0.095 and -0.056, respectively, would imply a 10% increase in income would decrease their demand by 0.9 and 0.6%, respectively.

These findings contradict Rono *et al.* (2017), who found positive expenditure elasticities for all R&Ts crops and possibly considered them as normal to luxury commodities as expected *a priori*. The observed variations in expenditure elasticities could be explained by socio-economic, institutional and cultural factors affecting households' consumption behaviour (Bett *et al.*, 2012). Theoretically, income elasticities range from positive to negative signs. The positive and negative signs imply the presence of normal and inferior commodities respectively (Browne *et al.,* 2007; Lewbel, 2006). For instance, as income rises, households substitute the consumption of inferior commodities, in this case, cassava and yam, for superior or normal alternatives. This shift in consumption is called the income effect (Nsabimana *et al.,* 2020).

## 5.6 Conclusion and recommendations

The demand estimates in this study conform to economic theory, similar to many other studies that use the AIDS model. Findings reveal existence of varied interrelationships among R&Ts for Nakuru Town Eat sub-county. There is observed substitution between R&T crops, with Irish potato substituting sweet potato, while cassava substitutes Irish potato, sweet potato, and arrowroot. Irish potato and sweet potato are necessities among the available R&Ts. Arrowroot is a luxury R&T while cassava and yam exhibit characteristics of inferior commodities. Moreover, elasticity estimates are necessary to formulate policies and strategies that target the R&Ts industry in general to improve the country's R&Ts production, thereby meeting local demand and exporting the surplus.

These results have important policy implications in the R&Ts sub-sector. Arrowroot was found to be a luxury R&T commodity, evidenced by its income/expenditure elasticity of more than unity (1.284) in absolute terms, while its corresponding Marshallian own-price elasticity was 0.526 in absolute terms. Household income is likely to impact more on its consumption than prices. The magnitudes of household income are higher than those of prices. Therefore, for arrowroot, income policy appears to be likely more effective than price policy. Current estimates indicate that policies such as a general increase in R&Ts prices seeking to protect producers would not significantly affect households' consumption patterns as those favouring income growth. Formulating income-related policies such as those favouring income growth (raising the minimum wage rate) would imply that consumers are likely to purchase more R&Ts in particular arrowroot which is identified to have a higher expenditure elasticity and therefore considered a luxury good. Furthermore, Irish potato and sweet potato are a necessity and therefore play a significant role in households' dietary diversity. In this regard, policy formulation should consider not imposing taxes on Irish potato and sweet potato products, making them affordable among households (see Appendix J**: Publication abstract**).

# CHAPTER SIX

# GENERAL DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

## 6.1 Critical review

The world's population increase coupled with urbanisation exerts pressure on the dietary systems of many households, especially urban dwellers, resulting in hunger and malnutrition. As a result, roots and tubers (R&Ts) are championed as alternative meals to turn around healthy diets for enhanced food and nutrition security. By ranking, R&Ts are the second most frequently consumed crops after cereals in Kenya and include but are not limited to Irish potatoes, sweet potatoes, cassava, arrowroots, yams, cocoyams/taro, beets, carrots, and turnips.

Roots and tubers have the advantage of sustainable production, are readily available, affordable and provide high nutritional value giving them a competitive edge in addressing food and nutrition security problems in Kenya. Roots and tubers provide food for households, feed for animals, and raw materials for industries. In addition, R&Ts have nutritional, health, and medicinal benefits such as antiobesity, hypocholesterolemic, and immunomodulatory activities. Therefore, have a higher potential to improve household welfare by curbing malnutrition and fighting dietary-related diseases. In Kenya, R&Ts production has increased from 2.4M MT in 2015 to 3.68M MT in 2018. Therefore, increasing the dietary choices of food baskets among households.

Despite the highlighted benefits, R&Ts consumption is likely low. Their actual contribution to food and nutrition by urban dwellers remains unknown, making them some of the most underutilised foods among urban households. From the preceding, this study sought to identify factors influencing household preference for selected R&Ts, consumption frequency, and demand analysis for the crops to enhance their consumption and improve Kenyan urban consumers' food and nutrition security. Irish potatoes (*Solanum tuberosum* L.), sweet potatoes (*Ipomoea batatas* L. Lam.), cassava (*Manihot esculenta* Crantz), arrowroots (*Maranta arundinacea* L.), and yams (*Dioscorea alata* L.) were selected for this study because they are the main R&Ts commonly produced and consumed in the study area and Kenya in general.

## 6.2 Consolidated discussion of the results

From the analysis in general, the study revealed that R&Ts purchase was made mainly by women, implying that women are main food consumption decision-makers as expected *a* *priori*. This could be explained by the fact that women mainly make food consumption decisions. The study revealed that most R&Ts consumers sampled were youthful, averaging 39.85 years, implying the increased significance in the consumption of these crops among the middle urban dwellers. Moreover, the current study showed that the consumers' nutritional knowledge and awareness level for cassava and yam was low and inadequate.

Consumer preference for selected R&Ts was analysed using the multivariate probit (MVP) model. Of 18 covariates, 14 had positive or negative significant influences on R&Ts preference among urban residents and the remaining 4, age, gender, household size, and household health, did not influence consumer preference for R&Ts. Education, monthly income, cultural orientation, nutritional knowledge, Covid-19 pandemic, market distance, farming of R&Ts, retail prices, production location, availability of R&Ts, size, quality, taste, and preparation time influenced preferences for R&Ts by urban households. Generally, the preference levels for R&Ts were relatively high indicating importance among many urban households and likely attributed to affordability making them favoured meals for the urban poor, whose larger proportion of income goes to food. For instance, increased monthly income, nutritional knowledge among decision-makers and affordable R&Ts retail prices more likely influenced preference for the crops.

Consumption frequency for R&Ts was analysed using the negative binomial regression (NBR) model. The mean consumption frequency for R&Ts was seventeen times a month. Households recording higher consumption frequency for R&Ts utilised them as substitute for wheat products during breakfast and food for infants throughout the day. No zero consumption count was revealed during the survey implying that all households consumed R&Ts at least once per month. Household size, monthly income, household health, farming of R&Ts, nutritional knowledge, and availability of different types of R&Ts influenced their consumption frequency among urban households. For instance, enhanced nutritional knowledge among households influenced consumption frequency for R&Ts. Through enhanced nutritional knowledge, decision-makers know the recommended daily consumption of different food items enabling them to consume a balanced diet by incorporating R&Ts in meals. Moreover, nutritional knowledge assists households in selecting R&Ts with high nutritive value and developing different recipes which are acceptable to all the family members.

The demand analysis for R&Ts among urban residents was analysed using Linear Approximated Almost Ideal Demand System (LA/AIDS) model. Empirical results showed negative own-price elasticities (and less than one in absolute terms) for uncompensated and compensated demand analyses, implying that the quantity demanded for most R&Ts is not sensitive to price change, therefore in line with utility theory. Cross-price elasticities had positive and negative signs, indicating the presence of substitutes and complements respectively among R&Ts. Expenditure (income) elasticities for R&Ts had mixed signs ranging from elastic to inelastic. Irish potato and sweet potato were inelastic, with a positive sign classifying them as necessities goods. Cassava and yam were inelastic with a negative sign indicating they were inferior goods, while arrowroot was positive and elastic, therefore a luxury good. Compared to previous studies, R&Ts display varying elasticities likely explained by the dynamic nature of human behaviour, especially among urban households. Households in urban areas face diverse cultures and food choices, which influence the type of food they eat, shifting their consumption patterns as observed in the literature.

## 6.3 Conclusions

i. The study established that households with underlying health conditions seem to create a market opportunity that is adequately informed about the medicinal benefits of R&Ts. Therefore, the findings suggest that R&Ts should be incorporated into household meals because they provide significant amounts of essential macro and micronutrients that improve nutrition and help fight against various diseases due to their medicinal properties to support increased household consumption.

ii. Larger households had higher R&Ts consumption counts likely attributed to their affordability. The findings suggest adopting value-addition strategies to ensure availability of high-quality and affordable R&Ts in the market acceptable by all the family members to enhance their consumption.

iii. The expenditure elasticities reveal that Irish potato and sweet potato are necessities among the available R&Ts. Arrowroot is a luxury R&T while cassava and yam exhibit characteristics of inferior commodities. Therefore, elasticity estimates are necessary in formulating policies and strategies targeting R&Ts industry to improve their production, thereby enhancing producer and consumer welfare.

## 6.4 Recommendations

The following strategies and policies could be formulated based on the findings above.

i. Effective consumer awareness campaigns should be undertaken to reverse the negative consumer perception that R&Ts are foods for low-income earners and the poor in society. The increased consumer awareness could boost nutritional knowledge geared towards encouraging diversification of diets hence attaining food and nutrition security among households. The awareness campaigns should involve a multi-sectorial approach from producer and consumer organisations to the Kenyan government through relevant ministries.
ii. Government policies should be geared towards enhanced set up of value-addition industries in R&Ts growing areas to ensure efficient supply and availability of acceptable high-quality R&Ts, boosting the R&Ts sector. For instance, tax policies such as tax breaks should be given to newly started R&Ts industries involved in value addition to encouraging more industries to be created. Moreover, value-addition strategies such as canning could help prolong shelf life for R&Ts, ensuring their continuous supply throughout the year. The steady supply of R&Ts help in stabilising food prices as they act as substitute food when prices of other volatile foods hike.
iii. As earlier observed, an increase in household income led to increased consumption of R&Ts. Therefore, policies that favour income growth, such as raising the minimum wage rate, could help boost the consumption of R&Ts. Moreover, through price regulation policies by the government, both producers and consumers will be protected hence improving their welfare in the long run.

## 6.5 Areas of Further Research

The study established that yam was mainly found in organised open-air markets and supermarkets. Moreover, R&Ts found in the supermarkets were labelled depending on variety hence easier for respondents to make informed purchase decisions. From the preceding, the study recommends the need for similar future research that could consider consumer preference for choice of market outlets for R&Ts. The expected results could help explain consumer purchasing behaviour concerning the preferred market outlet for R&Ts. Moreover, findings could inform the formulation of relevant policies, development of an efficient supply chain and value-addition strategies tailored toward the specific needs of R&Ts consumers.

## REFERENCES


Abdel-Ghany, M., Silver, J. L., & Gehlken, A. (2002). Do consumption expenditures depend on the household's relative position in the income distribution? *International Journal of Consumer Studies*, *26*(1), 2–6. https://doi.org/10.1046/j.1470-6431.2002.00203.x

Adeosun, K. P., Amaechina, E. C., & Nnaji, A. P. (2017). Determinants of households consumption preference for processed cocoyam in Enugu State, Nigeria. *Journal of Development and Agricultural Economics*, *9*(6), 137–144. https://doi.org/10.5897/jdae2016.0782

Afolami, I., Mwangi, M. N., Samuel, F., Boy, E., Ilona, P., Talsma, E. F., Feskens, E., & Melse-Boonstra, A. (2021). Daily consumption of pro-vitamin A biofortified (yellow) cassava improves serum retinol concentrations in preschool children in Nigeria: A randomized controlled trial. *The American Journal of Clinical Nutrition*, *113*(1), 221–231. https://doi.org/10.1093/ajcn/nqaa290

Aidoo, R. (2009). *An analysis of yam consumption patterns in Ghanaian urban communities*. PhD Thesis. Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology. Kumasi, Ghana

Akinleye, S. O., & Rahji, M. A. (2006). Nutritional implications of the demand for food in Nigeria. *Agrosearch*, *8*(1), 35–46.

Alexandratos, N., & Bruinsma, J. (2012). *World agriculture towards 2030/2050: The 2012 revision.* ESA Working Paper No. 12-03.

Almekinders, C. J., Walsh, S., Jacobsen, K. S., Andrade-Piedra, J. L., McEwan, M. A., de Haan, S., Kumar, L., & Staver, C. (2019). Why interventions in the seed systems of roots, tubers, and banana crops do not reach their full potential. *Food Security*, *11*(1), 23–42.

Alonso, E. B., Cockx, L., & Swinnen, J. (2018). Culture and food security. *Global Food Security*, *17*, 113–127. https://doi.org/10.1016/j.gfs.2018.02.002

Alston, J. M., & Chalfant, J. A. (1993). The silence of the lambdas: A test of the almost ideal and Rotterdam models. *American Journal of Agricultural Economics*, *75*(2), 304–313. https://doi.org/10.2307/1242914

Aman, F., & Masood, S. (2020). How Nutrition can help to fight against COVID-19 Pandemic. *Pakistan Journal of Medical Sciences*, *36*(COVID19-S4), S121–S123. https://doi.org/10.12669/pjms.36.COVID19-S4.2776

Amante, P. R., Santos, E. C. Z., Correia, V. T. da V., & Fante, C. A. (2021). Research Notes: Benefits and Possible Food Applications of Arrowroot (*Maranta Arundinaceae* L.). *Journal of Culinary Science & Technology*, *19*(6), 513–521. https://doi.org/10.1080/15428052.2020.1791295

Amaza, S. P. (2009). An analysis of traditional African vegetables and sweet potato consumer demand in Kenya and Tanzania. *Farm Concern, The World Vegetable Centre, International Potato Centre and Urban Harvest, Arusha, Tanzania, Project Report*.

Ansah, I. G. K., Marfo, E., & Donkoh, S. A. (2020). Food demand characteristics in Ghana: An application of the quadratic almost ideal demand systems. *Scientific African, 8*, e00293. https://doi.org/10.1016/j.sciaf.2020.e00293

Armstrong, G., Adam, S., Denize, S., & Kotler, P. (2014). *Principles of marketing* (6th ed.). Pearson Australia.

Ashagidigbi, W. M., Yusuf, S. A., & Okoruwa, V. O. (2012). Determinants of households' food demand in Nigeria. *World Rural Observations*, *4*(4), 17–28.

Asiedu, R., & Sartie, A. (2010). Crops that feed the world 1. Yams. *Food Security*, *2*(4), 305–315.

Ayanwale, A. B., Amusan, C. A., Adeyemo, V. A., & Oyedele, D. J. (2016). Analysis of household demand for underutilized indigenous vegetables. *International Journal of Vegetable Science*, *22*(6), 570–577. https://doi.org/10.1080/19315260.2015.1103350

Baek, Y. and Chitekwe, S. (2019). Sociodemographic factors associated with inadequate food group consumption and dietary diversity among infants and young children in Nepal. *PloS One*, *14*(3), e0213610. https://doi.org/10.1371/journal.pone.0213610

Baker, J. M. (1947). *Consumer preferences in sweet potatoes*. LSU Agricultural Experiment Station Reports No. 514; Louisiana Bulletin No. 409, pp. 1–17. Department of Agricultural Economics and Agribusiness, Louisiana State University. https://digitalcommons.lsu.edu/agexp/514

Barlagne, C., Cornet, D., Blazy, J.-M., Diman, J.-L., & Ozier-Lafontaine, H. (2017). Consumers' preferences for fresh yam: A focus group study. *Food Science & Nutrition*, *5*(1), 54–66. https://doi.org/10.1002/fsn3.364

Barrett, C. B. (2010). Measuring food insecurity. *Science, 327*(5967), 825–828.

Bata, M., Aliero, H. M., & Gatawa, D. N. M. (2018). An Empirical Study of the Determinants of Household Food Consumption Expenditure in Gombe State.

*International Journal of Humanities and Social Science Invention (IJHSSI)*, *7*(9), 36–49.

Bechoff, A., Tomlins, K., Fliedel, G., Becerra Lopez-Lavalle, L. A., Westby, A., Hershey, C., & Dufour, D. (2018). Cassava traits and end-user preference: Relating traits to consumer liking, sensory perception, and genetics. *Critical Reviews in Food Science and Nutrition*, *58*(4), 547–567. https://doi.org/10.1080/10408398.2016.1202888

Begum, S., Khan, M., Farooq, M., Begum, N., & Shah, I. U. (2010). Socio-economic factors affecting food consumption pattern in rural area of district Nowshera, Pakistan. *Sarhad J. Agric*, *26*(4), 649–653.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B., & Veugelers, R. (2004). Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization*, *22*(8–9), 1237–1263. https://doi.org/10.1016/j.ijindorg.2004.08.001

Ben-Akiva, M., & Lerman, S. R. (2018). *Discrete choice analysis: Theory and application to travel demand.* Vol. 1–412. MIT Press Cambridge, Massachusetts.

Bett, H. K., Musyoka, M. P., Peters, K. J., & Bokelmann, W. (2012). Demand for meat in the rural and urban areas of Kenya: A focus on the indigenous chicken. *Economics Research International*, *2012*, 1–10. https://doi.org/10.1155/2012/401472

Bhatta, G. D., Doppler, W., & Bahadur, K. (2009). Consumers' willingness and preferences towards organic vegetables: A conjoint approach. *Conference on International Research on Food Security, Natural Resource Management and Rural Development, 6-8 October 2009, University of Hamburg, Germany*.

Birol, E., Meenakshi, J. V., Oparinde, A., Perez, S., & Tomlins, K. (2015). Developing country consumers' acceptance of biofortified foods: A synthesis. *Food Security*, *7*(3), 555–568. https://doi.org/10.1007/s12571-015-0464-7

Boquin, M. M., Moskowitz, H. R., Donovan, S. M., & Lee, S.-Y. (2014). Defining perceptions of picky eating obtained through focus groups and conjoint analysis. *Journal of Sensory Studies*, *29*(2), 126–138.

Bozoglu, M., Bilgic, A., Yen, S. T., & Huang, C. L. (2013). *Household food expenditures at home and away from home in Turkey*. Paper presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

Browne, M., Ortmann, G. F., & Hendriks, S. (2007). Expenditure elasticities for rural households in the Embo ward, Umbumbulu, KwaZulu-Natal: Winner of the AEASA

Best Student Essay Award for 2007. *Agrekon*, *46*(4), 566–583. https://doi.org/10.1080/03031853.2007.9523787

Cardinal, P., Flores, A., Contarini, A., & Hough, G. (2003). Focus group research on sensory language used by consumers to describe mayonnaise. *Journal of Sensory Studies*, *18*(1), 47–59.

Cascetta, E. (2009). *Transportation systems analysis: Models and applications*. 2nd ed., Vol. 29. Springer Science & Business Media.

Chandrasekara, A., & Kumar, T. J. (2016). Roots and tuber crops as functional foods: A review on phytochemical constituents and their potential health benefits. *International Journal of Food Science*, *2016*, 1–15. https://doi.org/10.1155/2016/3631647

Charles, N. (2022). Generalizations linked to socio-economic roles and production constraints of cassava among smallholder farmers in Nyaribari Chache Sub County, Kisii County. *Journal of Advanced Education and Sciences*, *2*(3), 12–16.

CIP. (2020). As COVID-19 threatens global food security, fresh potato is back on the tables of millions. *Global Blog: International Potato Center.* Retrieved July 16, 2021 from https://Cipotato.Org/Blog/Covid-19-Global-Food-Security-Potato-Is-Back/

Cockx, L., Colen, L., De Weerdt, J., & Paloma, G. Y. (2019). *Urbanization as a driver of changing food demand in Africa: Evidence from rural-urban migration in Tanzania*. pp. 1–51. Technical report by the Joint Research Centre (JRC). Publications Office of the European Union.

Cohen, M. J., & Garrett, J. L. (2010). The food price crisis and urban food (in)security. *Environment and Urbanization*, *22*(2), 467–482. https://doi.org/10.1177/0956247810380375

Colander, D. C. (2008). *Economics* (9th ed.). McGraw-Hill/Irwin, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas. https://moam.info/david-c-colander-mcgraw-hill_59d469461723ddb62864f2c0.html

Ćwieląg-Drabek, M., Piekut, A., Gut, K., & Grabowski, M. (2020). Risk of cadmium, lead and zinc exposure from consumption of vegetables produced in areas with mining and smelting past. *Scientific Reports*, *10*(1), 1–9. https://doi.org/10.1038/s41598-020-60386-8

Dawson, I. K., Hedley, P. E., Guarino, L., & Jaenicke, H. (2009). Does biotechnology have a role in the promotion of underutilised crops? *Food Policy*, *34*(4), 319–328. https://doi.org/10.1016/j.foodpol.2009.02.003

De Jaegher, K. (2009). Asymmetric substitutability: Theory and some applications. *Economic Inquiry*, *47*(4), 838–855. https://doi.org/10.1111/j.1465-7295.2008.00158.x

de Ridder, D., Kroese, F., Evers, C., Adriaanse, M., & Gillebaart, M. (2017). Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychology & Health*, *32*(8), 907–941. https://doi.org/10.1080/08870446.2017.1316849

de Sousa, J. R., Botelho, R., Akutsu, R. de C. C., & Zandonadi, R. P. (2019). Nutritional quality of breakfast consumed by the low-income population in Brazil: A nationwide cross-sectional survey. *Nutrients*, *11*(6), 1418. https://doi.org/10.3390/nu11061418

Deaton, A., & Muellbauer, J. (1980). An almost ideal demand system. *The American Economic Review*, *70*(3), 312–326.

Deaton, A. S., & Muellbauer, J. (1986). On measuring child costs: With applications to poor countries. *Journal of Political Economy*, *94*(4), 720–744. https://doi.org/10.1086/261405

Dereje, B., Girma, A., Mamo, D., & Chalchisa, T. (2020). Functional properties of sweet potato flour and its role in product development: A review. *International Journal of Food Properties*, *23*(1), 1639–1662. https://doi.org/10.1080/10942912.2020.1818776

Dotto, J., Matemu, A. O., & Ndakidemi, P. A. (2018). Potential of cooking bananas in addressing food security in East Africa. *International Journal of Biosciences (IJB), 13*(4), 278–294.

Edgerton, D. L. (1997). Weak Separability and the Estimation of Elasticities in Multistage Demand Systems. *American Journal of Agricultural Economics*, *79*(1), 62–79. https://onlinelibrary.wiley.com/doi/abs/10.2307/1243943

Fang, M., Lizotte, E., & Malone, T. (2019). A Hard Nut to Crack: Identifying Factors Relevant to Chestnut Consumption. *Journal of Food Distribution Research*, *50*(2), 27–47. https://doi.org/10.22004/ag.econ.300075

FAO. (2004). *The state of food insecurity in the world 2004: Monitoring progress towards the World Food Summit and Millennium Development Goals. Food and Agriculture Organization of the United Nations.* FAO & Economic and Social Department. Retrieved December 07, 2020, from https://www.fao.org/3/y5650e/y5650e00.htm

FAO. (2017). *FAOSTAT Database.* Food and Agriculture Organization of the United Nations. Retrieved March 20, 2021, from https://www.fao.org/faostat/en/#home

FAO. (2019). *The state of food security and nutrition in the world 2019: Safeguarding against economic slowdowns and downturns. Rome, Italy:* Food and Agriculture

Organization of the United Nations (FAO). Retrieved December 07, 2020, from https://www.fao.org/3/ca5162en/ca5162en.pdf.

FAO, IFAD, UNICEF, WFP & WHO. (2020). *The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets*. Rome, Italy. FAO, IFAD, UNICEF, WFP and WHO. https://www.fao.org/publications/sofi/2020/en/

FAO & W. IFAD. (2011). The state of food insecurity in the world: How does international price volatility affect domestic economies and food security. *Food and Agriculture Organization of the United Nations, Rome, Italy. Retrieved December 07, 2020, from https://www.fao.org/publications/card/en/c/b9dff790-3555-55c3-a8c6-c5efc0e5c304/*.

Ferraro, V., Piccirillo, C., Tomlins, K., & Pintado, M. E. (2016). Cassava (*Manihot esculenta* Crantz) and yam (*Dioscorea* spp.) crops and their derived foodstuffs: Safety, security and nutritional value. *Critical Reviews in Food Science and Nutrition*, *56*(16), 2714–2727. https://doi.org/10.1080/10408398.2014.922045

Forsythe, L., Njau, M., Martin, A., Bechoff, A., & Tomlins, K. (2017). *Staple food cultures: A case study of cassava ugali preferences in Dar es Salaam, Tanzania*. Natural Resources Institute and CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper. Kent, UK.

Francis, T., & Jayalakshmi, S. A. A. (2021). Use of Arrowroot in Dentistry-A Review. *Annals of the Romanian Society for Cell Biology*, *25*(3), 6275–6287.

Gabriel, M., Samuel, M., Mary, K., & Mwambia, K. (2017). Analysis of household food demand patterns in Laikipia County, Kenya. *African Journal of Rural Development (AFJRD)*, *1*(3), 323–330.

García, T., & Grande, I. (2010). Determinants of food expenditure patterns among older consumers. The Spanish case. *Appetite*, *54*(1), 62–70. https://doi.org/10.1016/j.appet.2009.09.007

Gayao, B. T., Meldoz, D. T., & Backian, G. S. (2018). Indigenous knowledge and household food security: The role of root and tuber crops among indigenous peoples in the Northern Philippines. In A. Niehof, H. N. Gartaula & M. Quetulio-Navarra (Eds.), *Diversity and change in food wellbeing: Vol. Chapter 3*. (pp. 43–69). Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-864-3_3

Gc, A., & Yeo, J.-H. (2019). Perception to Adaptation of Climate Change in Nepal: An Empirical Analysis Using Multivariate Probit Model. *Scilit*, *1*(1), 1-12. https://doi.org/10.3390/sci2040087

Gething, K., Henderson, C., McIntyre, A., & Dennien, S. (2012). *Sweet potato consumer research: Insights to increasing consumption. Technical Report*. Queensland Government. Brisbane, Australia. https://era.daf.qld.gov.au/id/eprint/3572/

Ghislain, M., Muzhingi, T., & Low, J. W. (2019). Zinc and iron fortification in cassava. *Nature Biotechnology*, *37*(2), 130–132. https://doi.org/10.1038/s41587-019-0014-5

Gido, E. O. (2022). Household demand system of African indigenous vegetables in Kenya. *Review of Agricultural and Applied Economics, 25*(1). https://doi.org/10.15414/raae.2022.25.01.94-103

Gido, E. O., Ayuya, O. I., Owuor, G., & Bokelmann, W. (2017a). Consumer acceptance of leafy African indigenous vegetables: Comparison between rural and urban dwellers. *International Journal of Vegetable Science, 23*(4), 346–361. https://doi.org/10.1080/19315260.2017.1293758

Gido, E. O., Ayuya, O. I., Owuor, G., & Bokelmann, W. (2017b). Consumption intensity of leafy African indigenous vegetables: Towards enhancing nutritional security in rural and urban dwellers in Kenya. *Agricultural and Food Economics, 5*(1), 1–16. https://doi.org/10.1186/s40100-017-0082-0

Gido, E. O., Sibiko, K. W., Ayuya, O. I., & Mwangi, J. K. (2015). Demand for agricultural extension services among small-scale maize farmers: Micro-level evidence from Kenya. *The Journal of Agricultural Education and Extension*, *21*(2), 177–192. https://doi.org/10.1080/1389224x.2013.872045

Githunguri, C. M., & Njiru, E. N. (2021). Role of Cassava and Sweet potato in Mitigating Drought in Semi-Arid Makueni County in Kenya. In N. Oguge, D. Ayal, L. Adeleke & I. da Silva (Eds.), *African Handbook of Climate Change Adaptation.* pp. 241–259. Springer International Publishing. https://doi.org/10.1007/978-3-030-45106-6_11

Gitonga, H. W. (2013). *Consumer preference for bean attributes: A study in Kiambu county, Kenya.* PhD Thesis. Department of Agribusiness Management and Trade, Kenyatta University. Kiambu, Kenya. https://core.ac.uk/display/160041779

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science, 327*(5967), 812–818.

Godfray, H. C. J., & Garnett, T. (2014). Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1639), 20120273. https://doi.org/10.1098/rstb.2012.0273

Goldberg, I., & Roosen, J. (2005). Measuring Consumer Willingness to Pay for a Health Risk Reduction of Salmonellosis and Campylobacteriosis. *'The Future of Rural Europe in the Global Agri-Food System,' No. 724-2016-49185*. https://ageconsearch.umn.edu/record/24512/

Gould, B. W. (2002). Household composition and food expenditures in China. *Agribusiness: An International Journal*, *18*(3), 387–407.

Green, R., & Alston, J. M. (1990). Elasticities in AIDS models. *American Journal of Agricultural Economics*, *72*(2), 442–445. https://doi.org/10.2307/1242346

Greene, W. H. (2002). *Econometric analysis.* (5th Edition). Prentice Hall. Upper Saddle River, New Jersey.

Greene, W. H. (2008). *Econometric Analysis* (7th Edition). Prentice Hall. Upper Saddle River, New Jersey.

Gujarati, D., & Porter, D. C. (2004). *Basic Econometrics, 2004* (4th ed.). McGraw-Hill Irwin. Boston, MA.

Gurmu, S., & Trivedi, P. K. (1996). Excess zeros in count models for recreational trips. *Journal of Business & Economic Statistics*, *14*(4), 469–477. https://doi.org/10.1080/07350015.1996.10524676

Gweyi-Onyango, J. P., Sakha, M. A., & Jefwa, J. (2020). Agricultural Interventions to Enhance Climate Change Adaptation of Underutilized Root and Tuber Crops. *African Handbook of Climate Change Adaptation*, 1–26. https://doi.org/10.1007/978-3-030-42091-8_40-1

Gwladys, M. T., Yvette, N. Y., André, N. N., Farida, A., & Precillia, T. N. (2020). Ethnic Origin Influence on Urban Households Potato Purchase: Evidence from Yaoundé, Cameroon. *Journal of Humanities and Social Sciences Studies*, *2*(4), 213–220.

Haddad, L. J., Achadi, E., Ag Bendech, M., Ahuja, A., Bhatia, K., Bhutta, Z., Blössner, M., Borghi, E., Colecraft, E., & de Onis, M. (2014). *Global Nutrition Report 2014: Actions and accountability to accelerate the world's progress on nutrition*. Intl Food Policy Res Inst.

Haghjou, M., Hayati, B., Pishbahar, E., Mohammad, R. R., & Dashti, G. (2013). *Factors Affecting Consumers' potential Willingness to Pay for Organic Food Products in Iran: Case Study of Tabriz*.

Hawkins, D. I., & Mothersbaugh, D. L. (2010). *Consumer behavior: Building marketing strategy*. Boston: McGraw-Hill Irwin.

Hayes, D. J., Wahl, T. I., & Williams, G. W. (1990). Testing restrictions on a model of Japanese meat demand. *American Journal of Agricultural Economics*, *72*(3), 556–566. https://doi.org/10.2307/1243024

Heckman, J. (2013). Sample selection bias as a specification error. *Applied Econometrics*, *31*(3), 129–137.

Helgi Analytics. (2022). *Potato Consumption (Total) in Kenya.* Faostat, National Statistical Office, Helgi Analytics calculation. Retrieved March 15, 2022 from https://www.helgilibrary.com/indicators/potato-consumption-total/kenya/

Hill, C., & Schiller, B. (2015). *The Micro Economy Today*. McGraw-Hill Higher Education.

Huffman, W. E., & Orazem, P. F. (2007). Agriculture and human capital in economic growth: Farmers, schooling and nutrition. *Handbook of Agricultural Economics, 3,* 2281–2341.

Hunter, D., Borelli, T., Beltrame, D. M., Oliveira, C. N., Coradin, L., Wasike, V. W., Wasilwa, L., Mwai, J., Manjella, A., & Samarasinghe, G. W. (2019). The potential of neglected and underutilized species for improving diets and nutrition. *Planta*, *250*(3), 709–729. https://doi.org/10.1007/s00425-019-03169-4

IBMCorp. (2011). *IBM SPSS Statistics for Windows.* version 20.0. Computer software. IBM Corp. Armonk, New York.

Ikudayisi, A., & Okoruwa, V. O. (Eds.). (2021). *Urban Differential Effects on Food Demand in Nigeria*. https://doi.org/10.22004/ag.econ.315142

Iorlamen, T. R., Abu, G. A., & Lawal, W. L. (2014). Assessment of expenditure on food among urban households and its implication for food security: Evidence from Benue State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *14*(2), 8748–8760. https://doi.org/10.18697/ajfand.62.10905

Jacobson, D., Mavrikiou, P. M., & Minas, C. (2010). Household size, income and expenditure on food: The case of Cyprus. *The Journal of Socio-Economics*, *39*(2), 319–328.

Jacoby, J. (2003). Consumer Psychology: An Octennium. *Annual Review of Psychology*, *27*, 331–358. https://doi.org/10.1146/annurev.ps.27.020176.001555

Jae, M. K., Ryu, J. S., & Abdel-Ghany, M. (2000). Family characteristics and convenience food expenditure in urban Korea. *Journal of Consumer Studies & Home Economics*, *24*(4), 252–256.

Jekanowski, M. D., & Binkley, J. K. (2000). Food purchase diversity across US markets. *Agribusiness: An International Journal*, *16*(4), 417–433.

Kaguongo, W., Lungaho, C., Borus, D., Kipkoech, D., & Ng'ang'a, N. (2013). *A policymakers' guide to crop diversification: The case of the potato in Kenya*. Food and Agriculture Organization of the United Nations. https://doi.org/10.13140/2.1.3433.6963

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F., & Mekuria, M. (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technological Forecasting and Social Change*, *80*(3), 525–540. https://doi.org/10.1016/j.techfore.2012.08.007

Kathiravan, G., & Churaman, J. (2021). Volume and price behaviour of root and tuber crops: The case of Trinidad and Tobago. *Journal of Entomology and Zoology Studies*, *9*(1), 405–410.

Keats, S., & Wiggins, S. (2019). *Future diets: Implications for agriculture and food prices*.

Kennedy, G., Raneri, J., Stoian, D., Attwood, S., Burgos, G., Ceballos, H., Ekesa, B., Johnson, V., Low, J. W., & Talsma, E. F. (2019). Roots, tubers and bananas: Contributions to food security. In P. Ferranti, J. R. Anderson & E. M. Berry (Eds.), *Encyclopedia of Food Security and Sustainability*. Vol. 3, pp. 231–256. Elsevier.

Kenyon, L., Anandajayasekeram, P., Ochieng, C., Ave, C., & Uk, K. M. E. (2006). A synthesis/lesson-learning study of the research carried out on root and tuber crops commissioned through the DFID RNRRS research programmes between 1995 and 2005. *DFID, United Kingdom*.

Kimambo, J. J., Kavoi, M. M., Macharia, J., & Nenguwo, N. (2018). Assessment of factors influencing farmers' nutrition knowledge and intake of traditional African vegetables in Tanzania. *African Journal of Food, Agriculture, Nutrition and Development*, *18*(2), 13353–13371. https://doi.org/10.18697/ajfand.82.17035

KNBS. (2019). *The 2019 Kenya Population and Housing Census Volume I: Population by County and Sub-County*. Kenya National Bureau of Statistics. Nairobi, Kenya. https://tech-ish.com/wp-content/uploads/2019/11/volume-1-kphc-2019.pdf

Koostanto, H., Zakky, M., & Soebandino, S. (2016). *Addressing the economic and health challenges facing smallholder communities through roots and tubers in Maluku and Maluku Utara, Indonesia-results of a scoping study*. FoodSTART+. https://hdl.handle.net/10568/89470

Korir, L., Rizov, M., & Ruto, E. (2020). Food security in Kenya: Insights from a household food demand model. *Economic Modelling*, *92*, 99–108. https://doi.org/10.1016/j.econmod.2020.07.015

Kostakis, I. (2014). The Determinants of Households' food Consumption in Greece. *International Journal of Food and Agricultural Economics (IJFAEC)*, *2*(2), 17–28.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International. New Delhi, India. https://www.academia.edu/40027517

Kotler, P., & Keller, K. (2011). *Marketing management 14th edition*. Prentice Hall.

Kourouniotis, S., Keast, R. S. J., Riddell, L. J., Lacy, K., Thorpe, M. G., & Cicerale, S. (2016). The importance of taste on dietary choice, behaviour and intake in a group of young adults. *Appetite*, *103*, 1–7. https://doi.org/10.1016/j.appet.2016.03.015

Lacaze, V., Lupín, B., & Rodríguez, E. M. (2012). Factors affecting the frequency of fresh potatoes' purchasing: An urban study case in Argentina. *Factors Affecting the Frequency of Fresh Potatoes' Purchasing: An Urban Study Case in Argentina*, *14*(2), 139–152. https://doi.org/10.3280/ecag2012-002007

Lambein, F., & Diasolua, N. D. (2019). On the prevention of konzo, lessons learned from neurolathyrism. *Cassava Cyanide Diseases & Neurolathyrism Network News, 28th June 2019*. Zurich, Switzerland. https://ipbo.vib-ugent.be/en/projects/ccdn

Laurie, S. M., Faber, M., & Claasen, N. (2018). Incorporating orange-fleshed sweet potato into the food system as a strategy for improved nutrition: The context of South Africa. *Food Research International*, *104*, 77–85. https://doi.org/10.1016/j.foodres.2017.09.016

Lebot, V. (2019). *Tropical Root and Tuber Crops*. CABI.

Lee, C. M., & Lee, S.-Y. (2007). Consumer insights on healthy breakfast cereal–a focus group research. *Journal of Sensory Studies*, *22*(4), 417–432.

Lewbel, A. (2006). *Engel curves entry for the New Palgrave dictionary of economics*. 2nd Edition. Boston College. Chestnut Hill, Massachusetts.

Liu, M., Kasteridis, P., & Yen, S. T. (2013). Breakfast, lunch, and dinner expenditures away from home in the United States. *Food Policy*, *38*, 156–164.

Loudon, D. L., & Della Bitta, A. J. (1984). *Consumer behavior: Concepts and applications*. McGraw-Hill Companies.

Low, J., Lynam, J., Lemaga, B., Crissman, C., Barker, I., Thiele, G., Namanda, S., Wheatley, C., & Andrade, M. (2009). Sweet potato in Sub-Saharan Africa. In G. Loebenstein & G. Thottappilly (Eds.), *The Sweet potato.* pp. 359–390. Springer Netherlands. https://doi.org/10.1007/978-1-4020-9475-0_16

Magbalot-Fernandez, A., & Umar, M. (2019). A Review on root crops processing for food security and health. *Journal of South Pacific Agriculture*, *21*, 26–33.

Mansfield, E. (1982). How Economists See R&D. *Research Management*, *25*(4), 23–29. https://doi.org/10.1080/00345334.1982.11756738

Manyong, V. M., Bamire, A. S., & Zuckerman, P. S. (2007). Rural household expenditures for roots and tubers in South Western Nigeria: An almost ideal demand system analysis. *Proceedings of the 13th International Society for Tropical Root Crops (ISTRC) Symposium*. Arusha, Tanzania. 601–613.

Mason-D'Croz, D., Bogard, J. R., Sulser, T. B., Cenacchi, N., Dunston, S., Herrero, M., & Wiebe, K. (2019). Gaps between fruit and vegetable production, demand, and recommended consumption at global and national levels: An integrated modelling study. *The Lancet Planetary Health*, *3*(7), e318–e329. https://doi.org/10.1016/s2542-5196(19)30095-6

Matsuda, T. (2006). Linear approximations to the quadratic almost ideal demand system. *Empirical Economics*, *31*(3), 663–675. https://doi.org/10.1007/s00181-005-0044-3

Matuschke, I. (2009). *Rapid urbanization and food security: Using food density maps to identify future food security hotspots*.

Mbwana, H. A., Kinabo, J., Lambert, C., & Biesalski, H. K. (2016). Determinants of household dietary practices in rural Tanzania: Implications for nutrition interventions. *Cogent Food & Agriculture*, *2*(1), 1224046. https://doi.org/10.1080/23311932.2016.1224046

McFadden, B. R., & Lusk, J. L. (2016). What consumers don't know about genetically modified food, and how that affects beliefs. *The FASEB Journal*, *30*(9), 3091–3096.

McFadden, D. (1973). *Conditional logit analysis of qualitative choice behavior*.

Menza, M., Girmay, G., & Woldeyes, F. (2014). Enhancing Household Food Security through Irish Potato Production in Gamo Highlands of Southern Ethiopia. *Scholarly Journal of Agricultural Science*, *4*(7), 410–419.

Minami, M., Lennert-Cody, C. E., Gao, W., & Román-Verdesoto, M. (2007). Modeling shark by catch: The zero-inflated negative binomial regression model with smoothing. *Fisheries Research*, *84*(2), 210–221. https://doi.org/10.1016/j.fishres.2006.10.019

Mkamilo, G. S., & Jeremiah, S. C. (2005). Current status of cassava improvement programme in Tanzania. *African Crop Science Conference Proceedings*, *7*(pt. 03 of 03), 1311–1315.

Mmasa, J. J., Msuya, E. E., & Mlambiti, M. (2012). Social Economic Factors Affecting Consumption of Sweet Potato Products: An Empirical Approach. *Research on Humanities and Social Sciences*, *2*(8), 96–103.

MoALFI. (2019). *National Root and Tuber Crops Development Strategy 2019-2022*. Ministry of Agriculture, Livestock, Fisheries and Irrigation. Nairobi, Kenya. https://repository.kippra.or.ke/bitstream/handle/123456789/3083/Roots-and-Tuber-Crops-Strategy-2019-2022.pdf

Mohamed, S., Wambiya, E., Kisia, L., Ilboudo, P., & Kipruto, S. (2021). *Cost of eating healthy in Kenya: Quantitative secondary analysis*. Study Report. African Population and Health Research Center.

Mombo, S., Dumat, C., Shahid, M., & Schreck, E. (2017). A socio-scientific analysis of the environmental and health benefits as well as potential risks of cassava production and consumption. *Environmental Science and Pollution Research*, *24*(6), 5207–5221. https://doi.org/10.1007/s11356-016-8190-z

Moon, W., Florkowski, W. J., Beuchat, L. R., Resurreccion, A. V., Paraskova, P., Jordanov, J., & Chinnan, M. S. (2002). Demand for food variety in an emerging market economy. *Applied Economics*, *34*(5), 573–581.

Moschini, G. (1995). Units of measurement and the Stone index in demand system estimation. *American Journal of Agricultural Economics*, *77*(1), 63–68. https://doi.org/10.2307/1243889

Mukras, M. S., Alphonce, O. J., & Momanyi, G. (2013). Determinants of demand for sweet potatoes at the farm, retail and wholesale markets in Kenya. *Advances in Economics and Business*, *1*(2), 150–158. https://doi.org/10.13189/aeb.2013.010211

Mullahy, J. (1986). Specification and testing of some modified count data models. *Journal of Econometrics*, *33*(3), 341–365. https://doi.org/10.1016/0304-4076(86)90002-3

Murage, A. W., Guthiga, P., Gichangi, A. W., Ndubi, J., & Njarui, D. M. (2019). *Determinants of household food and nutrition security among the dairy farmers in Machakos and Kirinyaga Counties, Kenya*.

Musyoka, M. P., Kavoi, M. M., & Omiti, J. M. (2014). Food consumption patterns and distributional welfare impact of import tariff reduction on cereals in Kenya. *African Journal of Agricultural and Resource Economics*, *09*(3), 1–17.

Musyoka, M. P., Lagat, J. K., Ouma, D. E., Wambua, T., & Gamba, P. (2010). Structure and properties of urban household food demand in Nairobi, Kenya: Implications for urban food security. *Food Security*, *2*(2), 179–193. https://doi.org/10.1007/s12571-010-0063-6

Muthamilarasan, M., & Prasad, M. (2021). Small Millets for Enduring Food Security Amidst Pandemics. *Trends in Plant Science*, *26*(1), 33–40. https://doi.org/10.1016/j.tplants.2020.08.008

Muthoni, J., & Nyamongo, D. O. (2010). Traditional food crops and their role in food and nutritional security in Kenya. *Journal of Agricultural & Food Information*, *11*(1), 36–50.

Naico, A. T. A. (2009). *Consumer preference for orange and white-fleshed sweet potato: Results from a choice experiment conducted in Maputo and Gaza provinces, Mozambique.* MS Thesis. Faculty of the Graduate College, Oklahoma State University. Stillwater, Oklahoma.

Nanbol, K., & Namo, O. (2019). The Contribution of Root and Tuber Crops to Food Security: A Review. *Journal of Agricultural Science and Technology B*, *9*(4), 221–233.

NCIDP. (2018). *Nakuru County Integrated Development Plan (NCIDP)*. County Government of Nakuru, Nakuru, Kenya. http://10.0.0.19/handle/123456789/947

Ngenoh, G. C. (2021). *Effects of Marketing Strategies on Product Line Margins Among the Cassava Microenterprises in Migori County, Kenya*. PhD Thesis. Department of Agricultural Economics and Agribusiness Management, Egerton University, Kenya.

Niehof, A., Gartaula, H. N., & Quetulio-Navarra, M. (Eds.). (2018). *Diversity and change in food wellbeing: Cases from Southeast Asia and Nepal*. Wageningen Academic

Publishers. Wageningen, The Netherlands. https://doi.org/10.3920/978-90-8686-864-3

Nsabimana, A., Swain, R. B., Surry, Y., & Ngabitsinze, J. C. (2020). Income and food Engel curves in Rwanda: A household microdata analysis. *Agricultural and Food Economics*, *8*(1), 1–20. https://doi.org/10.1186/s40100-020-00154-4

Nweke, F. I. (2004). *New challenges in the cassava transformation in Nigeria and Ghana* (Vol. 118). Intl Food Policy Res Inst.

Ochieng, J., Afari-Sefa, V., Lukumay, P. J., & Dubois, T. (2017). Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania. *PloS One*, *12*(12), e0189022. https://doi.org/10.1371/journal.pone.0189022

Ogbonna, A. I., Adepoju, S. O., Ogbonna, C. I. C., Yakubu, T., Itelima, J. U., & Dajin, V. Y. (2017). Root tuber of Tacca leontopetaloides L.(kunze) for food and nutritional security. *Microbiology: Current Research*, *1*(1), 7–13. https://doi.org/10.4066/2591-8036.16-2241

Okareh, O. T., Ajayeoba, T. A., Ugbekile, O. F., & Hammed, T. B. (2021). The use of cassava leaves as food and medicinal herbs in rural communities and the perceived health risks. *Bionature*, *41*(1), 19–38.

Oke, O. L., Redhead, J., & Hussain, M. A. (1990). Roots, tubers, plantains and bananas in human nutrition. *FAO Food and Nutrition Series*, *24*.

Okoruwa, V. O., & Adebayo, E. F. (2006). Household food demand analysis in Adamawa State, Nigeria. *Global Journal of Agricultural Sciences*, *5*(2).

Okrent, A. M., & Alston, J. M. (2012). The effects of farm commodity and retail food policies on obesity and economic welfare in the United States. *American Journal of Agricultural Economics*, *94*(3), 611–646.

Olatona, F. A., Airede, C. A., Aderibigbe, S. A., & Osibogun, A. (2019). Nutritional knowledge, dietary habits and nutritional status of diabetic patients attending teaching hospitals in Lagos, Nigeria. *Journal of Community Medicine and Primary Health Care*, *31*(2), 90–103. https://ir.unilag.edu.ng/handle/123456789/9237

Oloya, B., Adaku, C., Ntambi, E., & Andama, M. (2017). Cyanogenic Potential of Selected Cassava Varieties in Zombo District, Uganda. *International Journal of Nutrition and Food Sciences*, *6*(3), 144–148. https://doi.org/10.11648/J.IJNFS.20170603.16

Onodu, B. C., Culas, R. J., & Nwose, E. U. (2018). Facts about dietary fibre in cassava: Implication for diabetes' medical nutrition therapy. *Integrative Food, Nutrition and Metabolism*, *5*(3), 1–5.

Onodu, B., Culas, R., & Nwose, E. (2020). *Nutritional and health values of indigenous root and tuber crops compared to imported carbohydrate (such as wheat): A case study example from Delta state Nigeria*. 64th AARES Annual Conference, Perth, Western Australia. https://ageconsearch.umn.edu/record/305252

Ormazabal, K. M. (1995). The law of diminishing marginal utility in Alfred Marshall's principles of economics. *Journal of the History of Economic Thought*, *2*(1), 91–126. https://doi.org/10.1080/10427719500000096

Petsakos, A., Prager, S. D., Gonzalez, C. E., Gama, A. C., Sulser, T. B., Gbegbelegbe, S., Kikulwe, E. M., & Hareau, G. (2019). Understanding the consequences of changes in the production frontiers for roots, tubers and bananas. *Global Food Security*, *20*, 180–188. https://doi.org/10.1016/j.gfs.2018.12.005

Phillips, T. P., Taylor, D. S., Sanni, L. O., & Akoroda, M. O. (2004). *A cassava industrial revolution in Nigeria: The potential of a new industrial crop*.

Pieterse, D. E., & Parnell, S. (2014). *Africa's urban revolution*. Zed Books Ltd.

Piyasiri, A., & Ariyawardana, A. (2002). Market potentials and willingness to pay for selected organic vegetables in Kandy. *Sri Lankan Journal of Agricultural Economics*, *4*(1), 107–119. https://doi.org/10.4038/sjae.v4i0.3486

Polar, V., Teeken, B., Mwende, J., Marimo, P., Tufan, H. A., Ashby, J. A., Cole, S., Mayanja, S., Okello, J. J., Kulakow, P., & Thiele, G. (2022). Building Demand-Led and Gender-Responsive Breeding Programs. In G. Thiele, M. Friedmann, H. Campos, V. Polar & J. W. Bentley (Eds.), *Root, Tuber and Banana Food System Innovations: Value Creation for Inclusive Outcomes* (pp. 483–509). Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-92022-7_16

Pollak, R. A., & Wales, T. J. (1981). Demographic variables in demand analysis. *Econometrica: Journal of the Econometric Society*, *49*(6), 1533–1551. https://doi.org/10.2307/1911416

Raper, K. C., Wanzala, M. N., & Nayga Jr, R. M. (2002). Food expenditures and household demographic composition in the US: A demand systems approach. *Applied Economics*, *34*(8), 981–992.

Rashid, D. A., Smith, L. C., & Rahman, T. (2011). Determinants of dietary quality: Evidence from Bangladesh. *World Development*, *39*(12), 2221–2231.

Reincke, K., Vilvert, E., Fasse, A., Graef, F., Sieber, S., & Lana, M. A. (2018). Key factors influencing food security of smallholder farmers in Tanzania and the role of cassava as a strategic crop. *Food Security*, *10*(4), 911–924. https://doi.org/10.1007/s12571-018-0814-3

Ricciuto, L., Tarasuk, V., & Yatchew, A. (2006). Socio-demographic influences on food purchasing among Canadian households. *European Journal of Clinical Nutrition*, *60*(6), 778–790.

Ritchie, H., & Roser, M. (2018). Urbanization. *Our World in Data*.

Ritson, C., & Petrovici, D. (2001). The economics of food choice: Is price important? In *Food, people and society* (pp. 339–363). Springer.

Rizov, M., Cupak, A., & Pokrivcak, J. (2014). *Food security and household consumption patterns in Slovakia*.

Rono, P. K., Rahman, S., & Benaissa, C. (2017). *An Analysis of Demand for Roots and Tubers in Kenya using the Linear Approximation Almost Ideal Demand System (LA-AIDS)*. 2017 Annual Meeting, 4-7 February, Mobile, Alabama.

Rosegrant, M. W., Sulser, T. B., Mason-D'Croz, D., Cenacchi, N., Nin-Pratt, A., Dunston, S., Zhu, T., Ringler, C., Wiebe, K. D., & Robinson, S. (2017). *Quantitative foresight modeling to inform the CGIAR research portfolio*. Project report. International Food Policy Research Institute (IFPRI). Washington, DC.

Rozi, F., Krisdiana, R., & Sutrisno, I. (2021). Pattern of Cassava Demand as the Promising Commodity in the Future. *1st International Conference on Sustainable Agricultural Socio-Economics, Agribusiness, and Rural Development (ICSASARD 2021)*, *199*, 31–36.

Ruel, M. T., Garrett, J. L., Hawkes, C., & Cohen, M. J. (2010). The food, fuel, and financial crises affect the urban and rural poor disproportionately: A review of the evidence. *The Journal of Nutrition*, *140*(1), 170S-176S.

Rusike, J., Mahungu, N. M., Jumbo, S., Sandifolo, V. S., & Malindi, G. (2010). Estimating impact of cassava research for development approach on productivity, uptake and food security in Malawi. *Food Policy*, *35*(2), 98–111. https://doi.org/10.1016/j.foodpol.2009.10.004

Sabates, R., Gould, B. W., & Villarreal, H. J. (2001). Household composition and food expenditures: A cross-country comparison. *Food Policy*, *26*(6), 571–586.

Saghaian, S., & Mohammadi, H. (2018). Factors Affecting Frequency of Fast Food Consumption. *Journal of Food Distribution Research*, *49*(1), 22–29. https://EconPapers.repec.org/RePEc:ags:jlofdr:274600

Salmensuu, O. (2021). Potato importance for development focusing on prices. *Journal of Risk and Financial Management*, *14*(3), 137–151. https://doi.org/10.3390/jrfm14030137

Sanginga, N., & Mbabu, A. (2015). Root and tuber crops (cassava, yam, potato and sweet potato). *Proceedings of the, "an Action Plan for African Agricultural Transformation Conference", Dakar, Senegal*, 21–23.

Sanusi, M. M., & Babatunde, D. A. (2017). Analysis of Potato Consumption among Households in Odeda Local Government Area, Ogun State, Nigeria. *Agricultura Tropica et Subtropica*, *2*(50), 89–99. https://doi.org/10.1515/ats-2017-0010

Saranraj, P., Behera, S. S., & Ray, R. C. (2019). Traditional foods from tropical root and tuber crops: Innovations and challenges. In C. M. Galanakis (Ed.), *Innovations in traditional foods* (pp. 159–191). Elsevier. Duxford, United Kingdom. https://doi.org/10.1016/b978-0-12-814887-7.00007-1

Satterthwaite, D., McGranahan, G., & Tacoli, C. (2010). Urbanization and its implications for food and farming. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2809–2820.

Scott, G. J. (2000). *Roots and tubers in the global food system: A vision statement to the year 2020*. International Potato Center (CIP). Lima, Peru.

Scott, G. J., Rosegrant, M. W., & Ringler, C. (2000). *Roots and tubers for the 21st century: Trends, projections, and policy options*. Food, Agriculture, and the Environment Discussion Paper No. 31; pp. 1–64. International Food Policy Research Institute (IFPRI). Washington, D.C.

Sekhampu, T. J. (2012). *Socio–economic determinants of household food expenditure in a low income township in South Africa*.

Siman, S., Tawakal, M. A., Risamasu, P. I. M., & Kadir, R. (2020). Effect of household size, working hours, health and income on consumption expenditure of poor household. *Enfermeria Clinica*, *30*(4), 512–515. https://doi.org/10.1016/j.enfcli.2019.10.131

Simi, M. C., Aneena, E. R., Panjikkaran, S. T., Sharon, C. L., & Sheela, K. B. (2016). Standardisation and quality evaluation of Queensland arrowroot (*Canna edulis* L.) based custard powder. *Journal of Tropical Agriculture*, *54*(1), 35–40.

Solomon, M. R. (2010). *Consumer behaviour: A European perspective*. Pearson education.

StataCorp. (2014). *Stata statistical software: Release 12*. StataCorp LP. College Station, TX.

Steensland, A., & Zeigler, D. M. (2018). *Global Harvest Initiative*, (GAP Report). Virginia Tech College of Agriculture and Life Sciences.

Stewart, H., & Harris, J. M. (2005). Obstacles to overcome in promoting dietary variety: The case of vegetables. *Review of Agricultural Economics*, *27*(1), 21–36.

Suárez, M. H., Hernández, A. I. M., Galdón, B. R., Rodríguez, L. H., Cabrera, C. E. M., Mesa, D. R., Rodríguez-Rodríguez, E. M., & Romero, C. D. (2016). Application of multidimensional scaling technique to differentiate sweet potato (*Ipomoea batatas* (L.) Lam) cultivars according to their chemical composition. *Journal of Food Composition and Analysis*, *46*, 43–49. https://doi.org/10.1016/j.jfca.2015.10.008

Szabo, S. (2016). Urbanisation and Food Insecurity Risks: Assessing the Role of Human Development. *Oxford Development Studies*, *44*(1), 28–48. https://doi.org/10.1080/13600818.2015.1067292

Taljaard, P. R., Alemu, Z. G., & Van Schalkwyk, H. D. (2004). The demand for meat in South Africa: An almost ideal estimation. *Agrekon*, *43*(4), 430–443. https://doi.org/10.1080/03031853.2004.9523659

Tan, B. L., & Norhaizan, M. E. (2019). Carotenoids: How effective are they to prevent age-related diseases? *Molecules*, *24*(9), 1801. https://doi.org/10.3390/molecules24091801

Tan, S. L. (2015). *Cassava–silently, the tuber fills*.

Tankari, M. R., & Badiane, O. (2015). Determinants of households' food diversity demand in Uganda. *Paper presented at the International Association of Agricultural Economists, 9-14 August 2015 Conference*, Milan, Italy. 1–19.

Tasciotti, L., & Wagner, N. (2015). Urban agriculture and dietary diversity: Empirical evidence from Tanzania. *The European Journal of Development Research*, *27*(5), 631–649. https://doi.org/10.1057/ejdr.2014.38

Tefft, J., & Jonasova, M. (2020). Food systems transformation in an urbanizing world. In *Handbook on Urban Food Security in the Global South* (pp. 34–61). Edward Elgar Publishing. Cheltenham, Gloucestershire, United Kingdom.

Tekgüç, H. (2012). Separability between own food production and consumption in Turkey. *Review of Economics of the Household*, *10*(3), 423–439.

Teklewold, H., Kassie, M., Shiferaw, B., & Köhlin, G. (2013). Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. *Ecological Economics*, *93*, 85–93. https://doi.org/10.1016/j.ecolecon.2013.05.002

Teweldemedhin, M. Y., & Mulonda, G. M. (2016). Factors influencing consumer preference for sweat potato in Namibia, Case Study from Windhoek. *British Journal of Economics, Management and Trade*, *14*(4), 1–9. https://doi.org/10.9734/BJEMT/2016/27336

Thiele, G., & Friedmann, M. (2020). *The vital importance of RTB crops in the One CGIAR portfolio.* RTB Research Brief No. 02. CGIAR Research Program on Roots, Tubers and Bananas. Lima, Peru. https://hdl.handle.net/10568/109915

Thiele, G., Khan, A., Heider, B., Kroschel, J., Harahagazwe, D., Andrade, M., Bonierbale, M., Friedmann, M., Gemenet, D., & Cherinet, M. (2017). Roots, tubers and bananas: Planning and research for climate resilience. *Open Agriculture*, *2*(1), 350–361. https://doi.org/10.1515/opag-2017-0039

Thiele, S., & Weiss, C. (2003). Consumer demand for food diversity: Evidence for Germany. *Food Policy*, *28*(2), 99–115.

Thorne, F., Fox, J. A., Mullins, E., & Wallace, M. (2017). Consumer willingness-to-pay for genetically modified potatoes in Ireland: An experimental auction approach. *Agribusiness*, *33*(1), 43–55. https://doi.org/10.1002/agr.21477

Tonsor, G. T., Olynk, N. J., & Wolf, C. A. (2009). Consumer preferences for animal welfare attributes: The case of gestation crates. *Journal of Agricultural and Applied Economics*, *41*(1379-2016–112907), 714–730.

Tran, T., Zhang, X., Ceballos, H., Moreno, J. L., Luna, J., Escobar, A., Morante, N., Belalcazar, J., Becerra, L. A., & Dufour, D. (2021). Correlation of cooking time with water absorption and changes in relative density during boiling of cassava roots. *International Journal of Food Science & Technology*, *56*(3), 1193–1205. https://doi.org/10.1111/ijfs.14769

Tsegai, D. W., & Kormawa, P. M. (2009). The determinants of urban households' demand for cassava and cassava products in Kaduna, Northern Nigeria: An application of the AIDS model. *The European Journal of Development Research*, *21*(3), 435–447.

Ülger, T. G., Songur, A. N., Çırak, O., & Çakıroğlu, F. P. (2018). Role of vegetables in human nutrition and disease prevention. In M. Asaduzzaman and T. Asao (Eds.), *Vegetables—Importance of Quality Vegetables to Human Health; IntechOpen: London, UK* (pp. 7–32).

United Nations. (2019). *World Population Prospects 2019: Highlights*. United Nations Department of Economic and Social Affairs, Population Division.

Van Kleef, E., Van Trijp, H. C., & Luning, P. (2005). Consumer research in the early stages of new product development: A critical review of methods and techniques. *Food Quality and Preference*, *16*(3), 181–201.

van Rensburg Willem, J., Van Zijl, J. J. B., & Sonja, L. V. (2007). The importance of traditional leafy vegetables in South Africa. *African Journal of Food, Agriculture, Nutrition and Development*, *7*(4), 1–13.

Vanlauwe, B., Mutuo, P., Mahungu, N., & Pypers, P. (2013). Boosting the productivity of cassava-based systems in DR Congo. *IITA. R4D Review*, *9*.

Vigani, M., Dudu, H., Ferrari, E., & Mainar Causapé, A. (2019). *Estimation of food demand parameters in Kenya; A Quadratic Almost Ideal Demand System (QUAIDS) approach.* Joint Research Centre (JRC) Technical Report No. JRC115472. Publications Office of the European Union, Luxembourg.

Villano, R., Chang, H.-S. C., Kewa, J., & Irving, D. (2016). Factors affecting consumers' willingness to pay for good quality sweet potato in Papúa New Guinea. *Australasian Agribusiness Review*, *24*(3), 1–17. https://hdl.handle.net/1959.11/19998

Vitaliano, D. F. (2010). Engel curves and the unitary theory of the household. *International Journal of Consumer Studies*, *34*(1), 69–72.

Wahyudi, A., Kuwornu, J. K., Gunawan, E., Datta, A., & Nguyen, L. T. (2019). Factors Influencing the Frequency of Consumers' Purchases of Locally Produced Rice in Indonesia: A Poisson Regression Analysis. *Agriculture*, *9*(6), 117-134. https://doi.org/10.3390/agriculture9060117

Wallace, T. C., Bailey, R. L., Blumberg, J. B., Burton-Freeman, B., Chen, C. O., Crowe-White, K. M., Drewnowski, A., Hooshmand, S., Johnson, E., & Lewis, R. (2020). Fruits, vegetables, and health: A comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. *Critical Reviews in Food Science and Nutrition*, *60*(13), 2174–2211. https://doi.org/10.1080/10408398.2019.1632258

Wanyama, R. N. (2019). *Food Security and Dietary Patterns among the Urban Poor in Africa*. PhD dissertation. Faculty of Agricultural Sciences, Georg-August-University Göttingen. Germany. https://doi.org/10.53846/goediss-7447

Westenhoefer, J. (2005). Age and gender dependent profile of food choice. In *Diet diversification and health promotion.* Vol. 57, pp. 44–51. Karger Publishers.

WHO. (2016). *World health statistics 2016: Monitoring health for the SDGs sustainable development goals*. World Health Organization Press. Geneva, Switzerland. https://apps.who.int/iris/bitstream/10665/206498/1/9789241565264_eng.pdf

Wiebe, K., Sulser, T. B., Dunston, S., Rosegrant, M. W., Fuglie, K., Willenbockel, D., & Nelson, G. C. (2021). Modeling impacts of faster productivity growth to inform the CGIAR initiative on Crops to End Hunger. *PloS One, 16*(4), e0249994. https://doi.org/10.1371/journal.pone.0249994

Wiggins, S., & Keats, S. (2014). *Future diets: Implications for agriculture and food prices*. Project report for the Overseas Development Institute (ODI) project Shock watch: Managing Risk and Building Resilience in an Uncertain World. London.

Wijesinha-Bettoni, R., & Mouillé, B. (2019). The contribution of potatoes to global food security, nutrition and healthy diets. *American Journal of Potato Research*, *96*(2), 139–149. https://doi.org/10.1007/s12230-018-09697-1

Willemé, P. (2008). *Working Paper 04-08—Estimating private health expenditures within a dynamic consumption allocation model*. Federal Planning Bureau. Belgium.

Yeong-Sheng, T. E. Y. (2008). *Household expenditure on food at home in Malaysia*. University Library of Munich, Germany.

Zainal Badari, S. A., Arcot, J., Haron, S. A., Paim, L., Sulaiman, N., & Masud, J. (2012). Food variety and dietary diversity scores to understand the food-intake pattern among selected Malaysian households. *Ecology of Food and Nutrition*, *51*(4), 265–299.

Zani, M., Saediman, H., Abdullah, S., Daud, L., & Yunus, L. (2019). Determinants of household food expenditure in a cassava growing village in Southeast Sulawesi. *Academic Journal of Interdisciplinary Studies*, *8*(3), 302–310. https://doi.org/10.36941/ajis-2019-0028

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association*, *57*(298), 348–368. https://doi.org/10.1080/01621459.1962.10480664

Zwaagstra, L., Sharif, Z., Wambile, A., Leeuw, J. de, Said, M. Y., Johnson, N. L., Njuki, J., Ericksen, P. J., & Herrero, M. T. (2010). *An assessment of the response to the 2008—2009 drought in Kenya.* A report to the European Union Delegation to the Republic of Kenya. International Livestock Research Institute (ILRI).

# APPENDICES

## Appendix A: Standard Poisson results

**Table 6.1:** Standard Poisson results on factors influencing consumption frequency for R&Ts

| | Variables for Cons_frequency | Coef. | Std.Err. |
|---|---|---|---|
| Socio-economic factors | Age | -0.001 | 0.001 |
| | Gender | -0.054** | 0.025 |
| | Education | -0.006 | 0.004 |
| | Household size | 0.042*** | 0.007 |
| | Household income | 0.156*** | 0.026 |
| | Culture | -0.018 | 0.013 |
| | Household health | 0.049*** | 0.016 |
| | Covid-19 | 0.026* | 0.014 |
| Institutional factors | Market distance | -0.004* | 0.002 |
| | Farming R&Ts | 0.125*** | 0.018 |
| | Nutrition knowledge | 0.094*** | 0.017 |
| | Prices for R&Ts | 0.001 | 0.016 |
| | Production place | -0.019 | 0.012 |
| | Availability R&Ts | -0.107*** | 0.031 |
| Product related factors | Size of R&Ts | 0.061*** | 0.023 |
| | Quality of R&Ts | 0.03 | 0.022 |
| | Taste for R&Ts | 0.053*** | 0.019 |
| | Preparation time | 0.012 | 0.013 |
| | Constant | 0.757*** | 0.23 |

LR test for the model $chi^2(18)$ = 785.65 Prob > $chi^2$ = 0.0000***

Akaike crit. (AIC) = 3370.943 Bayesian crit. (BIC) = 3446.054

***, **, * = Significant at 1%, 5%, and 10%, respectively

**Appendix B: Test for goodness of fit**

**Table 6.2:** Standard Poisson regression model test for goodness of fit

| Test for goodness of fit ( model is not fit) | Test for over dispersion |
|---|---|
| Deviance goodness-of-fit = 1595.388 | Deviance gof [1] /df = 1595.388/366 = 4.36 |
| Prob > $chi^2(366)$ = 0.0000*** | > 1 implies over distribution |
| Pearson goodness-of-fit = 1796.69 | Pearson gof /df = 1796.69/366 = 4.91 |
| Prob > $chi^2(366)$ = 0.0000*** | > 1 implies over distribution |

[1] gof refers to goodness of fit of the model

**Appendix C: Over dispersion test for the standard Poisson model**

**Table 6.3:** Over dispersion test using conditional mean and variance for the standard Poisson model

| Availability R&Ts | mean | variance | N |
|---|---|---|---|
| No | 16.079 | 106.168 | 127 |
| Yes | 17.787 | 131.803 | 258 |
| Total | 17.223 | 123.695 | 385 |

The variance is greater than the mean across, implying presence of data over dispersion

**Appendix D: Test for goodness of fit between Poisson and nbreg**

**Table 6.4:** AIC and BIC test for goodness of fit between Poisson and nbreg

| Model | Obs | ll(null) | ll(model) | df | AIC | BIC |
|---|---|---|---|---|---|---|
| poisson | 385 | -2059.296 | -1666.471 | 19 | 3370.943 | 3446.054 |
| nbreg | 385 | -1395.724 | -1320.351 | 20 | 2680.703 | 2759.768 |

Lower values of either AIC or BIC indicate a better fit

**Appendix E: ZIP model results**

**Table 6.5:** ZIP model results on factors influencing consumption frequency for R&Ts

| Variables classification | Variables for Cons_frequency | Coef. | Std.Err. |
|---|---|---|---|
| | Standard Poisson regression | | |
| Socio-economic factors | Age | -0.001 | 0.001 |
| | Gender | -0.054** | 0.025 |
| | Education | -0.006 | 0.004 |
| | Household size | 0.042*** | 0.007 |
| | Household income | 0.156*** | 0.026 |
| | Culture | -0.018 | 0.013 |
| | Household health | 0.049*** | 0.016 |
| | Covid-19 | 0.026* | 0.014 |
| Institutional factors | Market distance | -0.004* | 0.002 |
| | Farming R&Ts | 0.125*** | 0.018 |
| | Nutrition knowledge | 0.094*** | 0.017 |
| | Prices for R&Ts | 0.001 | 0.016 |
| | Production place | -0.019 | 0.012 |
| | Availability  R&Ts | -0.107*** | 0.031 |
| Product related factors | Size of R&Ts | 0.061*** | 0.023 |
| | Quality of R&Ts | 0.03 | 0.022 |
| | Taste for R&Ts | 0.053*** | 0.019 |
| | Preparation time | 0.012 | 0.013 |
| | Constant | 0.757*** | 0.23 |
| | Logistic regression for zero inflation | | |
| | Age | -2228.591 | . |
| | Gender | -96164.124 | . |
| | Education | -7051.493 | . |
| | Household size | -18326.45 | . |
| | Market distance | -7812.849 | . |
| | Prices for R&Ts | -38902.759 | . |
| | Production place | -45234.745 | . |
| | Constant | -96229.874 | . |

LR test of alpha=0: *chi*bar$^2$(01) =. Prob>=*chi*bar$^2$ =.

**Table 6.6:** ZIP model results on factors influencing consumption frequency for R&Ts (Continued)

| | | | |
|---|---|---|---|
| Vuong test of zip vs. standard Poisson: z =. | | Prob > | z =. |
| LR test for the model $chi^2(18)$ | = 785.65 | Prob > $chi^2$ | = 0.0000*** |
| Akaike crit. (AIC) | = 3370.943 | Bayesian crit. (BIC) = | 3446.054 |

***, **, * = Significant at 1%, 5%, and 10%, respectively

## Appendix F: AIC and BIC test for goodness of fit

**Table 6.7:** AIC and BIC test for goodness of fit between Poisson, nbreg, and zip

| Model | Obs | ll(null) | ll(model) | df | AIC | BIC |
|---|---|---|---|---|---|---|
| poisson | 385 | -2059.296 | -1666.471 | 19 | 3370.943 | 3446.054 |
| nbreg | 385 | -1395.724 | -1320.351 | 20 | 2680.703 | 2759.768 |
| zip | 385 | -2059.296 | -1666.471 | 19 | 3370.943 | 3446.054 |

Lower values of either AIC or BIC indicate a better fit

## Appendix G: ZINB model results

**Table 6.8:** ZINB model results on factors influencing consumption frequency for R&Ts

| | Variables for Cons_frequency | Coef. | Std.Err. |
|---|---|---|---|
| | Negative Binomial regression | | |
| Socio-economic factors | Age | -0.003 | 0.003 |
| | Gender | -0.057 | 0.052 |
| | Education | -0.007 | 0.009 |
| | Household size | 0.047*** | 0.015 |
| | Household income | 0.14*** | 0.053 |
| | Culture | -0.002 | 0.028 |
| | Household health | 0.069* | 0.037 |
| | Covid-19 | 0.012 | 0.029 |
| Institutional factors | Market distance | -0.003 | 0.004 |
| | Farming R&Ts | 0.139*** | 0.04 |
| | Nutrition knowledge | 0.095*** | 0.036 |
| | Prices for R&Ts | 0.006 | 0.035 |
| | Production place | -0.023 | 0.026 |
| | Availability  R&Ts | -0.124** | 0.063 |
| Product related factors | Size of R&Ts | 0.054 | 0.047 |
| | Quality of R&Ts | 0.039 | 0.045 |
| | Taste for R&Ts | 0.06 | 0.04 |
| | Preparation time | 0.009 | 0.028 |
| | Constant | 0.951** | 0.461 |
| | Logistic regression for zero inflation | | |
| | Age | 0.00 | 376.068 |
| | Gender | 0.00 | 7551.433 |
| | Education | 0.00 | 1072.673 |
| | Household size | 0.00 | 2145.366 |
| | Market distance | 0.00 | 620.33 |
| | Prices for R&Ts | 0.00 | 3755.689 |
| | Production place | 0.00 | 3739.744 |
| | Constant | -22.408 | 22199.142 |
| | /lnalpha | -1.713*** | 0.095 |

**Table 6.9:** ZINB model results on factors influencing consumption frequency for R&Ts (Continued)

| | | |
|---|---|---|
| Alpha | 0.18 | 0.017 |
| Likelihood-ratio test of alpha=0: *chi*bar$^2$(01) = 692.24 | | Prob>=*chi*bar$^2$ = 0.0000*** |
| Vuong test of zinb vs. standard negative binomial: z = -0.01 | | Prob > z = 0.5052 |
| LR test for the model *chi*$^2$(18) = 150.75 | | Prob > *chi*$^2$ = 0.0000*** |
| Akaike crit. (AIC) = 2696.703 | | Bayesian crit. (BIC) = 3446.054 |

***, **, * = Significant at 1%, 5%, and 10%, respectively

**Appendix H: Test for goodness of fit between Poisson, nbreg, zip, and zinb models**

**Table 6.10:** AIC and BIC test for goodness of fit between Poisson, nbreg, zip, and zinb models

| Model | Obs | ll(null) | ll(model) | df | AIC | BIC |
|---|---|---|---|---|---|---|
| poisson | 385 | -2059.296 | -1666.471 | 19 | 3370.943 | 3446.054 |
| nbreg | 385 | -1395.724 | -1320.351 | 20 | 2680.703 | 2759.768 |
| zip | 385 | -2059.296 | -1666.471 | 19 | 3370.943 | 3446.054 |
| zinb | 385 | -1395.724 | -1320.351 | 28 | 2696.703 | 2807.394 |

Lower values of either AIC or BIC indicate a better fit

# Appendix I: Publication abstract

INTERNATIONAL JOURNAL OF VEGETABLE SCIENCE
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## Consumer preference for selected roots and tubers among urban households

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**ABSTRACT**

Consumption of roots and tubers (R&Ts) among urban households can be low. Understanding factors influencing consumption decisions for R&Ts is important in enhancing their utilization. This study assessed determinants of consumer preference for selected R&Ts using a multivariate Probit model. A stratified multistage sampling technique was adopted to select 385 respondents, and data collected using a pretested semi-structured questionnaire. Irish potatoes (*Solanum tuberosum* L.) had the highest preference level (70%), followed by sweet potatoes (*Ipomoea batatas* L. Lam.) at 61%. Arrowroot (*Maranta arundinacea* L.) had a preference of 42%. Cassava (*Manihot esculenta* Crantz) and yams (*Dioscorea alata* L.) were the least preferred at 22% each. Education, monthly income, cultural orientation, nutritional knowledge, Covid-19 pandemic, market distance, farming of R&Ts, retail prices, production location, availability of R&Ts, size, quality, taste, and preparation time influenced preferences for R&Ts by urban households. Inadequate time to prepare R&T meals at home and availability of conveniently prepared alternatives likely explains their low preference by urban residents.

**KEYWORDS**

Dietary diversity; essential elements; household consumption; multivariate Probit model; sub-Saharan Africa

Due to their potential in adapting to different climatic conditions roots and tubers (R&Ts) are a reliable source of food, found throughout sub-Saharan Africa (SSA) and include cassava (*Manihot esculenta* Crantz), Irish potatoes (*Solanum tuberosum* L.), sweet potatoes (*Ipomoea batatas* L. Lam.), yams (*Dioscorea alata* L.), arrowroots (*Maranta arundinacea* L.), and ginger (*Zingiber officinale* Rosc.) (Anonymous, 2019; Ferraro et al., 2016). Introduction of new varieties for R&Ts increased yields but their consumption is below their potential (Scott et al., 2000). The negative perception as a poor man's food (Reincke et al., 2018), presence of toxic antinutrients produced by cassava (Lambein and Diasolua, 2019), and lack of nutritional knowledge regarding R&Ts likely explain the low usage (Ayanwale et al., 2016; Tefft and Jonasova, 2020).

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## Appendix J: Publication abstract

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cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

# Demand analysis for selected roots and tubers among urban households of Nakuru County, Kenya

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Additional information is available at the end of the article

**Abstract:** This study examines Kenya's demand for selected roots and tubers (R&Ts). Data used for the analysis were collected from Nakuru Town East Sub-County. A sample unit of 385 urban households was interviewed at the market outlet immediately after purchasing R&Ts. Linear Approximated Almost Ideal Demand System (LA/AIDS) model was used to estimate demand elasticities, demographics and social-economic factors influencing the consumption patterns of R&Ts. Age, education, household size, and proportion of household members statistically and significantly explained the variations in R&Ts consumption patterns. Empirical results showed negative own-price elasticities for uncompensated and compensated demand analyses, therefore in line with utility theory. Cross-price elasticities had positive and negative signs, indicating the presence of substitutes and complements respectively among R&Ts. Expenditure (income) elasticities for R&Ts had mixed signs ranging from elastic to inelastic. Irish potato and sweet potato were inelastic with a positive sign classifying them as necessities goods. Cassava and yam were inelastic with a negative sign indicating they were inferior goods, while arrowroot was positive and elastic, therefore a luxury good. These results are broadly consistent with microeconomic theory; consequently, they could

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Mr. Fredrick Ouma Nuani is an African Economic Research Consortium (AERC) scholar pursuing a Collaborative Master of Science degree in Agricultural and Applied Economics at Egerton University, Kenya and University of Pretoria, South Africa. Dr. Eric Obedy Gido has a PhD in Agricultural Economics and currently serves as a lecturer in the Department of Agricultural Economics and Agribusiness Management, Egerton University. His main area of interest is on consumer studies and has taught several courses over the years. Dr. Oscar Ingasia Ayuya is a senior lecturer in the Department of Agricultural Economics and Agribusiness Management, Egerton University. He holds a PhD in Agricultural Economics with teaching and research experience running for many years. Dr. Michael Philliph Musyoka has a PhD in Agricultural Economics and works as a private Economic Development Consultant and Technical Advisor County Government of Makueni (CGM), Kenya.

### PUBLIC INTEREST STATEMENT

Roots and tubers (R&Ts) are affordable and cheap sources of carbohydrates, vitamins A, B, and C, and essential elements; iron, zinc, and calcium, and serve as staple foods worldwide. In this paper, we show the factors influencing demand for R&Ts among urban consumers who are most vulnerable. This is significant because it seeks to encourage their consumption, especially by the urban poor. We also believe that the findings presented in this paper will appeal to the general public to enhance R&Ts demand. The estimates in this paper add to the growing literature on root and tuber demand using the LA-AIDS framework. LA-AIDS model showed that the own-price elasticities of the selected five root and tubers are valued to be negative, meaning that every price increase will reduce the demand. Moreover, cross-price elasticities are a mixture of positive and negative values, implying the R&Ts are a mixture of substitutes and compliments.

## Appendix K: Research Permit

REPUBLIC OF KENYA

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Date of Issue: 15/April/2021

### RESEARCH LICENSE

**This is to Certify that Mr.. Fredrick Ouma Nuani of Egerton University, has been licensed to conduct research in Nakuru on the topic: CONSUMPTION PATTERNS FOR SELECTED ROOTS AND TUBERS AMONG HOUSEHOLDS IN NAKURU COUNTY, KENYA for the period ending : 15/April/2022.**

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**Appendix L: Household Questionnaire**

**A. Questionnaire Identification**

I am **Nuani Fredrick Ouma,** pursuing an MSc degree in Agricultural and Applied Economics at Egerton University. I am researching on **Determinants of consumption patterns for selected roots & tubers among urban households in Nakuru Town East Sub County, Kenya.** The purpose of this study is purely academic.

**Consent**

I humbly request you to take part in this interview since the information you will provide will assist in meeting my study objectives. I assure you that your information will be treated as confidential as possible. Thank you.

Signature…………………………………………...

Date………………………………………………...

Name of interviewee ………………………………..……………….……….....................

Questionnaire number …………………………………………………………………...…..…

Name of interviewer/Enumerator…………………………...……………………………...…

**B. Geographical Location of the Household Head**

Type of the market outlet for the roots and tuber …………...…………………………………….

Ward …………………………………………………………………………………...…..................

Location ……………………………………………………………………………………...........

**C. Household Key Decision Maker's Demographic Characteristics (***Tick where appropriate***)**

1.0 Gender of the decision-maker.

1 = Male, ☐ 0 = Female, ☐

1.1 Age of the decision-maker (in years) …………………..………………….…………….........

1.2 How many years have you spent on your schooling/education?..........................................

1.3 How many members are there in your household? ……………………………………......

1.4 Number of household members by age distribution? (*Select appropriately in the table below*)

| **Age Ranges** | **Females** | **Males** | **Total** |
|---|---|---|---|
| 0-18 | | | |
| >=19 | | | |

1.5 From what sources do you earn your income?

1 = Employed, ☐ 2 = Self-employed, ☐ 3 = Both, ☐

1.6 Please specify other income sources…………………………………………………………..

1.7 What is your annual average income?......................................................... (in Kenya shillings).

1 = Yes, ☐ 2 = No, ☐

1.8 What proportion of your expenditure is allocated to R&Ts?............................................... (in Kenya shillings).

1.9 Does your household participate in the farming/production of root and tuber crops?

1 = Yes, ☐ 2 = No, ☐

**D. Household's Socio-Economic and Institutional Characteristics (***Tick where appropriate***)**

2.0 Do you have any information concerning the benefits of consuming root and tuber crops?

1 = Yes, ☐ 2 = No, ☐

2.1 If **Yes,** in question (2.0) above, what was the source of information?

Personal communization, i.e. family, friends, fellow consumers ☐

Nutritional experts (Experts in food, nutrition, and dietetics) ☐

Mass media, i.e. Tv, Radio, magazine, newspaper, Internet, websites ☐

Social media, i.e. Twitter, Facebook, WhatsApp, texts ☐

2.2 Do you have knowledge of identifying the nutritional composition of root and tuber crops?

1 = Yes, ☐ 2 = No, ☐

2.3 Does knowledge of nutritional composition for the selected root and tuber crops influence your preference?

1 = Yes, ☐ 2 = No, ☐

2.4 Below is a table with nutritional composition for root and tuber crops; please select the ones that you know to be found in these crops.

| **Core Nutrients** | | **Other Phytochemicals** | |
|---|---|---|---|
| Carbohydrates | ☐ | Sodium | ☐ |
| Vitamin A | ☐ | Potassium | ☐ |
| Vitamin B | ☐ | Calcium | ☐ |
| Vitamin C | ☐ | Manganese | ☐ |
| Proteins | ☐ | Iron | ☐ |

| | | | |
|---|---|---|---|
| Fibre | ☐ | Bioactive compounds, i.e. (Phenolic acid, Anthocyanin, Ascorbic acid) | ☐ |

2.5 What is your level of nutritional knowledge for the selected root and tuber crops you consume? (*Tick where applicable*).

| **Likert scale** | **Poor** | **Fair** | **Average** | **Good** | **Excellent** |
|---|---|---|---|---|---|
| **Measurement** | **1** | **2** | **3** | **4** | **5** |
| Irish potatoes | | | | | |
| Sweet potatoes | | | | | |
| Yams | | | | | |
| Arrow roots | | | | | |
| Cassava | | | | | |

2.6 Does prices for the selected root and tuber crops influence your preference?

1 = Yes, ☐ 2 = No, ☐

2.7 Does the place of production for the selected root and tuber crops influence your preference?

1 = Yes, ☐ 2 = No, ☐

2.8 Does the presence of different root and tuber crops influence your preference?

1 = Yes, ☐ 2 = No, ☐

2.9 Does the size of the selected root and tuber crops influence your preference?

1 = Yes, ☐ 2 = No, ☐

3.0 How satisfied are you with the nutritional quality of your preferred root and tuber crops? (*Tick,where necessary and leave blank where it is not applicable*)

| **Likert scale** | **Very dissatisfied** | **Dissatisfied** | **Neutral** | **Satisfied** | **Very satisfied** |
|---|---|---|---|---|---|
| **Measurement** | **1** | **2** | **3** | **4** | **5** |
| Irish potatoes | | | | | |
| Sweet potatoes | | | | | |
| Yams | | | | | |
| Arrow roots | | | | | |
| Cassava | | | | | |

3.1 Does the level of external damage for the selected root and tuber crops influence their preference?

1 = Yes, ☐ 2 = No, ☐

3.2 Does knowledge of nutritional composition for the selected root and tuber crops influence your frequency of consumption?

1 = Yes, ☐ 2 = No, ☐

3.3 Does the presence of different types of root and tuber crops influence your consumption frequency?

1 = Yes, ☐ 2 = No, ☐

3.4 Does the role played by the selected root and tuber crops in managing Covid-19 influence its frequency of consumption?

1 = Yes, ☐ 2 = No, ☐

3.5 Is there any member of your household with an underlying health condition(s) that necessitates your frequent consumption of the selected roots and tubers?

1 = Yes, ☐ 2 = No, ☐

3.6 Does prices for the selected root and tuber crops influence your consumption frequency?

1 = Yes, ☐ 2 = No, ☐

3.7 Does the taste of the selected root and tuber crops influence your frequency of consumption?

1 = Yes, ☐ 2 = No, ☐

3.8 Does preparation time (Duration of cooking) for the selected root and tuber crops influence your frequency of consumption?

1 = Yes, ☐ 2 = No, ☐

3.9 What is the distance from your area of residence to the nearest root and tuber market?...............……………………………............ (Distance in Kilometers).

4.0 How much time do you spend moving from your area of residence to the preferred market for roots and tubers? …………………………………… (In walking minutes).

4.1 How often does your household consume any of the root and tuber crops listed below? (*Fill Appropriately and remember to leave blank where the crop was not eaten*).

| **Root & tuber type** | **Tick here** | **Frequency of consumption (In a month)** |
|---|---|---|
| Irish potatoes | | |
| Sweet potatoes | | |
| Yams | | |
| Arrow roots | | |
| Cassava | | |

4.2 Please indicate the quantity and price for each of the listed roots and tubers you consume in a month. (*Indicate only the crops your household consumes in a month*).

| **Type of root and tuber** | **How are the products packaged/sold in the market** | **Quantity (Kg)** | **Unit price** | **Total** |
|---|---|---|---|---|
| Irish potatoes | | | | |
| Sweet potatoes | | | | |
| Yams | | | | |
| Arrow roots | | | | |
| Cassava | | | | |

4.3 In your opinion, what is your perception of the prices of your preferred roots and tubers?

| **Likert scale** | **Highly unaffordable** | **Unaffordable** | **Neutral** | **Affordable** | **Highly affordable** |
|---|---|---|---|---|---|
| **Measurement** | **1** | **2** | **3** | **4** | **5** |
| Irish potatoes | | | | | |
| Sweet potatoes | | | | | |
| Yams | | | | | |
| Arrow roots | | | | | |
| Cassava | | | | | |

4.4 If the roots and tubers were priced within your budget, how interested would you be in purchasing them?

| **Likert scale** | **Selected root and tuber crops** | | | | |
|---|---|---|---|---|---|
| | **Irish potatoes** | **Sweet potatoes** | **Yams** | **Arrow roots** | **Cassava** |
| 1=Not interested | | | | | |
| 2=Undecided | | | | | |
| 3=Interested | | | | | |
| 4=Very Interested | | | | | |

**E. Roots and Tubers' Role in Food and Nutrition Security**

5.0 In your opinion, do the roots and tubers play a role in improving food and nutrition security of a nation?

1 = Yes, ☐ 2 = No, ☐

5.1 If **Yes,** which among the listed reasons makes the preferred root and tuber crops play a role in improving the food and nutrition of Kenya?

| **Roots and tubers** | **Reasons** | | | |
|---|---|---|---|---|
| **Irish potatoes** | Availability | ☐ | Utilization | ☐ |
| | Accessibility | ☐ | Stability | ☐ |
| **Sweet potatoes** | Availability | ☐ | Utilization | ☐ |
| | Accessibility | ☐ | Stability | ☐ |
| **Yams** | Availability | ☐ | Utilization | ☐ |
| | Accessibility | ☐ | Stability | ☐ |
| **Arrow roots** | Availability | ☐ | Utilization | ☐ |
| | Accessibility | ☐ | Stability | ☐ |
| **Cassava** | Availability | ☐ | Utilization | ☐ |
| | Accessibility | ☐ | Stability | ☐ |

## The End
## Thank You Very Much for Your Participation