REGULAR ARTICLE

CONSUMPTION FREQUENCY FOR SELECTED ROOTS AND TUBERS AMONG URBAN HOUSEHOLDS OF NAKURU COUNTY, KENYA

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ABSTRACT

Research background: 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. R&Ts 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.
Purpose of the article: This study evaluated factors influencing consumption frequency for selected R&Ts among urban households of Nakuru county, Kenya.
Methods: 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 collected primary data were analysed using a negative binomial regression (NBR) model.
Findings, Value added & Novelty: 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 that improve R&Ts supply chain efficiency could increase their production and consumption, consequently broadening the food base at household and national levels.

Keywords: consumption frequency; negative binomial regression; nutrition security; root and tuber crops; urban households.
JEL Codes: D11; D12; I15; Q18

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.

R&Ts 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)**.

R&Ts global production is projected to reach 1400 million tons by 2050, with SSA accounting for the largest proportion **(Petsakos *et al.,* 2019; Thiele and 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 **(MoALFI, 2019; Suárez *et al.,* 2016; Dawson *et al.,* 2009)**. In addition, when frequently consumed at moderate intervals, they provide medicinal benefits that curb dietary-related diseases such as obesity and diabetes **(Saranraj *et al.,* 2019; Gayao *et al.,* 2018; Niehof *et al.,* 2018; Chandrasekara and Kumar, 2016)**.

R&Ts 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 and 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. Therefore, this paper helps understand the influence of frequent R&Ts consumption on household health and nutrition security.

LITERATURE REVIEW

Despite their highlighted potential in contributing to food and nutrition security, curbing dietary-related ailments through their medicinal properties and acting as a source of income among households, R&Ts consumption is constrained by socio-demographics, institutional, economic, cultural, and food characteristics **(Baek and 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 and 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 count for R&Ts. Another unique aspect is the application of a one-month exposure period leading to non-zero R&Ts consumption. Findings from the study 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.

DATA AND METHODS

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 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 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 five 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.

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 variation 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. 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 and Porter, 2004)**. The survey analysed all the four-count models to identify the one that best fit the study.

The standard Poisson regression model was the first to be analysed **(Gujarati and 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 and 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 the 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 (Equation 1);

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

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

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; Wahyudi *et al.,* 2019; Kimambo *et al.,* 2018; Saghaian and Mohammadi, 2018; Gido *et al.,* 2017, 2015; Gitonga, 2013; Teklewold *et al.,* 2013; Lacaze *et al.,* 2012; Minami *et al.,* 2007)**.

RESULTS AND DISCUSION

Descriptive results

Descriptive and summary statistics (Table 1) 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)**. A majority of the decision-makers earned low incomes and had fewer household members. The 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 the frequent consumption of R&Ts probably due to their medicinal benefits **(CIP, 2020)**.

Table 1 Description of variables and descriptive statistics

Variable	Description of variables and their measurements	Mean
Continuous variables		
Age	Age of the decision-maker[1] in years	39.85
Education	Years of education of the decision-maker	12.61
Household Income	Monthly income of the decision-maker in KES[2]	31,822.73
Household size	Number of household members	4.31
Market distance	Distance from home to the market outlet for R&Ts[3] (in km[4])	6.58
Categorical variablesPercentage		
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
Covid19	% 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 who were 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

[1] Decision-maker is the household member responsible for making food consumption decisions
[2] KES refers to the Kenyan shilling (official Kenyan currency); the exchange rate to US$ is 1 $US = KES. 113.05
[3] R&Ts = Roots and Tubers
[4] km refers to the distance in kilometers

The average consumption frequency of R&Ts among urban households was seventeen times a month (Table 2). 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. R&Ts 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 2 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

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 (Appendix 1). To determine its appropriateness, a test for goodness of fit was done (Appendix 2) and a test for overdispersion (Appendix 3). For comparison, NBR model was estimated (Table 3). Its results revealed an overdispersion 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 Akaike information criterion (AIC) and Bayesian information criterion (BIC) was done to ascertain the goodness of fit for the NBR model (Appendix 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.

Table 3 NBR model results on factors influencing consumption frequency for R&Ts

	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: $chibar^2(01)$	= 692.240	Prob >= chibar2	= 0.000***
LR test for the model $chi^2(18)$	= 150.750	Prob > chi2	= 0.000***
Akaike crit. (AIC)	= 2680.703	Bayesian crit. (BIC)	= 2759.768

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

The third level estimated the ZIP model (Appendix 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 overdispersed 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 (Appendix 6). Finally, the ZINB model was estimated (Appendix 7), 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 (Appendix 8) indicated that the NBR model was more suitable for this study; therefore, it was adopted. The NBR results are shown in Table 3. 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. R&Ts 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.
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 and Wagner, 2015)**, contributing to household's food and nutrition security **(Cohen and 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, the 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, therefore, 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)**.

CONCLUSION 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.

R&Ts 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 that improve R&Ts supply chain efficiency could increase their production and consumption, consequently broadening the food base, and contributing 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.

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Appendix 1

Table 4: 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 2

Table 5: Standard Poisson regression model test for goodness of fit

Test for the goodness of fit (model is not fit)	Test for overdispersion
Deviance goodness-of-fit = 1595.388	Deviance gof [1] /df = 1595.388/366 = 4.358984
Prob > chi2(366) = 0.0000***	> 1 implies over distribution
Pearson goodness-of-fit = 1796.69	Pearson gof /df = 1796.69/366 = 4.908989
Prob > chi2(366) = 0.0000***	> 1 implies over distribution

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

Appendix 3

Table 6: Overdispersion 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 the presence of data overdispersion

Appendix 4

Table 7: 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 5

Table 8: ZIP model results on factors influencing consumption frequency for R&Ts

	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: chibar2(01)	=.		Prob>=chibar2 = .
Vuong test of zip vs. standard Poisson: z =.			Prob > z =.
LR test for the model chi2(18)	= 785.65		Prob > chi2 = 0.0000***
Akaike crit. (AIC)	= 3370.943		Bayesian crit. (BIC) = 3446.054

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

Appendix 6

Table 9: 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 7

Table 10: 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
	Alpha	0.18	0.017
Likelihood-ratio test of alpha=0: $chibar^2(01)$	= 692.24	Prob>=chibar2 = 0.0000***	
Vuong test of zinb vs. standard negative binomial: z = -0.01		Prob > z = 0.5052	
LR test for the model chi2(18)	= 150.75	Prob > chi2 = 0.0000***	
Akaike crit. (AIC)	= 2696.703	Bayesian crit. (BIC) = 3446.054	

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

Appendix 8

Table 11: 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.

Authors' contributions

Three authors contributed to the success of this study. FON conceptualised the paper, managed the literature review, designed the methodology and the questionnaire with the close help and guidance of EOG and OIA. EOG and OIA coordinated the field survey, data analysis, write-up of the first draft, and interpretation of the results. All authors read and approved the final manuscript.

Authors' contributions

The authors declare that they have no competing interests.

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