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Consumption intensity of leafy African indigenous vegetables: towards enhancing nutritional security in rural and urban dwellers in Kenya

Eric Obedy Gido[1,2*], Oscar Ingasia Ayuya[2], George Owuor[2] and Wolfgang Bokelmann[1]

* Correspondence:
gidoeric@gmail.com
[1]Department of Agricultural
Economics and Social Sciences,
Humboldt University of Berlin,
Invalidenstrasse 42, 10115 Berlin,
Germany
[2]Department of Agricultural
Economics and Agribusiness
Management, Egerton University,
P.O. Box 536-20115, Egerton, Kenya

Abstract

Estimation of consumption intensity of African indigenous vegetables (AIVs) is important to understand how their utilization can be enhanced at the household level. The study evaluated consumption intensity of leafy AIVs using the zero-inflated negative binomial regression model. A multistage sampling technique was used to select a random sample of 450 rural and urban respondents, and data were collected using a pre-tested semi-structured questionnaire. The findings revealed that consumption intensity of leafy AIVs were higher in rural than in urban dwellers with a mean of four and two times a week, respectively. Age, occupation, household size, diversity of AIV leaves, market distance, awareness of AIV's medicinal benefits and proportion of income allocated to food purchases significantly influenced consumption intensity of leafy AIVs. Strategies that could promote the transfer of AIVs' traditional knowledge to uninformed consumer segments such as male and younger decision-makers could increase the consumption intensity of leafy AIVs in rural dwellers. Similarly, the consumption intensity of leafy AIVs in urban dwellers could increase through the promotion of the value addition activities of sorting and plucking vegetable leaves from their stalks before marketing. Finally, in both rural and urban dwellers, promotion of AIV diversity in food systems through diversified production and well-coordinated market supply chains could increase consumption intensity of leafy AIVs.

Keywords: African indigenous vegetables, Consumption intensity, Micronutrients, Negative binomial regression, Rural, Urban, Vegetable leaves

Background

The nutritional condition of any population depends on the consumption of fruits and vegetables (van der Lans et al. 2012). Health complications of non-communicable diseases are clear indications of inadequate intake of fruits and vegetables (WHO 2002, 2003, 2015; Smith and Eyzaguirre 2007). About 400 g of fruits and vegetables are recommended for consumption per person per day by the World Health Organization (Ruel et al. 2005). However, households in Kenya consume inadequate fruits and vegetables, with the lowest levels reported in the poorest people (Ruel et al. 2005; Ayieko et al. 2008; van der Lans et al. 2012). Urban and rural dwellers in Kenya consume

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about 147 and 73 kg of vegetables per capita per year, respectively (Onim and Mwaniki 2008). Additionally, about 26% of the household food budget is expended on fruits and vegetables by urban dwellers in Kenya (Ayieko et al. 2008).

Vegetable consumption in Kenya is constrained by factors related to demographics, socio-psychological, and food characteristics in addition to government and industrial actions (van der Lans et al. 2012). For instance, more women than men prefer vegetables for consumption (Kimiywe et al. 2007; Vorster et al. 2007). A rise in income increases the quantity of fruits and vegetables consumed per adult equivalent, with a prominent increase in fruits and sweet and Irish potatoes than for vegetables (Ayieko et al. 2008). Van der Lans et al. (2012) confirmed that lower disposable income hinders vegetable intake. Moreover, diversity in vegetable consumption is a necessary condition for a healthy diet, which requires a proper integration of dark, deep yellow, and starchy vegetables as well as tomatoes and beans in household meals (Oniang'o et al. 2003).

African indigenous vegetables (AIVs) are sources of high-quality nutrition (Abukutsa 2007). They are easily accessible, inexpensive for poor people, and contain minerals and vitamins in levels exceeding those found in most exotic vegetables (Abukutsa 2007; Odhav et al. 2007; Uusiku et al. 2010; Singh et al. 2013). In this regard, AIVs are anticipated to contribute significantly to the global initiative of WHO in increasing the consumption of fruits and vegetables in African countries (Smith and Eyzaguirre 2007). For several decades, AIVs have been consumed in African diets (Smith and Eyzaguirre 2007). Their expansion in production, marketing, and consumption could be attributed to increasing consumer awareness about their health and nutritional benefits (Schippers 2000). High marketing returns have motivated commercialization of AIVs by small-scale farmers, who produce and supply them either individually or collectively in groups (Ngugi et al. 2007; Muhanji et al. 2011; Weinberger et al. 2011). Currently, most food retail outlets sell AIV leaves, and their availability and diversity in high-valued retail outlets such as supermarkets have further induced their consumption in urban areas (Ngugi et al. 2007; Irungu et al. 2008). Changes in lifestyle and availability of cooling-storage facilities have also boosted their consumption levels in urban dwellers (Ruel et al. 2005). Moreover, ethnic background, cultural preferences, inter-marriages, and urbanization are important cultural interactions for enhancing AIV consumption among people from different ethnic origins (Maundu 1997; Kimiywe et al. 2007).

A greater proportion of fresh AIV leaves sold in urban markets is supplied from various rural areas at different periods of the year due to variation in production seasons (Ngugi et al. 2007). Thus, availability of fresh leafy AIVs in urban areas is fairly constant across the year (Yang and Keding 2009). Their regular supply in urban markets is also enhanced through irrigation systems, commonly practiced by urban and peri-urban farmers (Yang and Keding 2009). Besides agro-ecological variations, oscillations in AIV production in rural farmers are prompted by a high dependency on rain-fed agriculture (Nekesa and Meso 1997). Significantly, this contributes to supply fluctuations, resulting in a cyclical reduction in the consumption of fresh leafy AIVs, especially in rural dwellers (Smith and Eyzaguirre 2007; Amaza 2009). According to Banwat et al. (2012), seasonal availability influence the

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consumption of fresh vegetables. Fresh leafy AIVs are usually consumed in large quantities during rainy seasons due to increased diversity and affordable prices (Kimiywe et al. 2007). Even though the supply of fresh vegetables is limited during dry spells, preserved and dried AIV leaves are major sources of nutrition in rural dwellers (Vorster et al. 2007; Yang and Keding 2009). However, nutritional benefits are limited from the consumption of dried rather than fresh leafy AIVs if they are poorly preserved during the drying process (Mibei and Ojijo 2011).

More often, AIV leaves accompany starchy food stuff as side dishes (Maundu 1997; Kimiywe et al. 2007; Vorster et al. 2007). Thus, consumption frequency of starch meals could be important in explaining their regularity in household diets. Despite this, AIV consumption depends on household socio-economic variables, vegetable seasonality, retail price, market accessibility, availability of exotic vegetables in food systems, and degree of urbanization (Nekesa and Meso 1997; Yang and Keding 2009). Weinberger and Msuya (2004) revealed that AIV consumption frequency ranges from daily to several times a week during peak seasons and once a week to several times a week during off-peak seasons. Similarly, Amaza (2009) indicated an average AIV consumption frequency of two to three times a week.

Strategies for enhancing food security have emphasized on the production of cereal-based crops (Dimara and Skuras 2003; Cavatassi et al. 2011). Even though cereals significantly contribute to dietary energy requirements (Oniang'o et al. 2003; Koenders 2010; Schipmann and Qaim 2010), they contain inadequate levels of micronutrients (Uusiku et al. 2010; Aaron et al. 2012). Consumption of cereals alone could accelerate occurrence of micronutrient-related diseases. Increasing vegetable consumption intensity is acknowledged as a strategic intervention for addressing micronutrient deficiency and reduces risks associated with degenerative diseases (Hughes and Keatinge 2013; Kamga et al. 2013; Birol et al. 2015). Leafy AIVs are superior vegetables with adequate dietary micronutrients (Singh et al. 2012, 2013). However, their consumption levels and frequency are still low to guarantee such benefits (Ruel et al. 2005; Kimiywe et al. 2007; Ngugi et al. 2007).

It is from the foregoing that the study evaluated determinants of consumption intensity of leafy AIVs in Kenya. The study provides empirical evidence comparison on how socio-economic variables determine consumption intensity of leafy AIVs in rural and urban dwellers to cater for spatial heterogeneity in the population. Findings from this study could be important in informing policy formulation and implementation as well as vegetable marketers as they strive to increase AIV consumption to fight micronutrient deficiency and degenerative diseases.

Methods

Study area and sampling design

A stratified multistage sampling approach was used in selecting respondents. In the first stage, a purposive sample of Nairobi, Nakuru, Kisii, and Kakamega counties in Kenya was obtained. Due to heterogeneity in consumer characteristics, Nairobi and Nakuru counties were chosen to represent urban dwellers and Kisii and Kakamega counties were chosen to represent rural dwellers. Kisii and Kakamega are among the counties with large AIV production levels in Kenya; Nakuru and Nairobi

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counties are some of the final major markets where AIVs from different production zones are sold. The second and third stages were stratified based on information obtained from sub-county agricultural offices. In the second stage, one sub-county from each county identified as major areas where large volumes of AIVs are produced and/or consumed was chosen.

The third stage involved stratification of market outlets. In urban areas, markets were stratified into supermarkets, green groceries, and local open-air retail outlets. In rural areas, farm gate, green groceries, and local open-air retail outlets were identified. In the fourth stage, simple random sampling method was used to select an equal number of respondents from each retail outlet. Determination of sample size was based on a proportionate to size sampling formulae (Groebner and Shannon 2005). Eventually, 450 respondents were selected, distributed proportionately to the population size at the county level resulting to 168 and 282 respondents in rural and urban areas, respectively.

Data were obtained through a consumer survey in July 2015 using a semi-structured questionnaire. Respondents were interviewed at retail outlets after purchasing leafy vegetables. Respondents were interviewed to obtain information on age, gender, education level, occupation, household size, household income, market distance, duration of AIV consumption, diversity of leafy AIVs at retail outlets, and perceptions regarding AIV retail prices as well as medicinal and nutritional awareness. Nutritional and medicinal awareness of leafy AIVs were assessed using the questions "Is consumption of a diet with leafy AIVs considered; (a) highly nutritious? (b) of great health benefits?" The answers were classified as "Yes" (indicating awareness) and "No" (indicating unawareness). This was followed by further interrogations on positive response, where respondents were asked to name key nutrients found in various leafy AIVs and identify medicinal uses associated with commonly consumed leafy AIVs. The term "nutritional awareness" as used in this study is meant to capture the "participant self-perception of the importance of nutritious leafy AIVs in household diet," which was adapted from Alkerwi et al. (2015). Similarly, "medicinal awareness" is meant to capture the respondent's self-perception on therapeutic importance associated with leafy AIVs, which was adapted from previous studies (Olembo et al. 1995; Vaishali and Varsha 2013; Muhammad and Shinkafi 2014).

The coded data were analyzed using the Stata 12 (StataCorp, 2011) computer program. Leafy AIVs identified as commonly consumed vegetables were cowpea (*Vigna unguiculata* L. Walp.), amaranth (*Amaranthus cruentus* L.), spider plant (*Cleome gynandra* L.), African night shade (*Solanum scabrum* Mill.), jute mallow (*Corchorus olitorius* L.), and slender leaf (*Crotalaria brevidens* Benth).

Econometric estimation of consumption intensity of leafy AIVs

Consumption intensity in this study was measured as a number of times a household had consumed leafy AIV per week regardless of the type of AIV crop due to variation in consumer taste and preferences. Daily vegetable consumption is a health recommendation. Adequate benefits from the consumption of leafy AIVs can be realized if a more frequent consumption interval is maintained, and this can increase the vegetable consumption level, which is found to be low in

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developing countries. A duration of 1 week was presumed an adequate period for analyzing consumption intensity, and the results generated could enhance the formulation of reliable policies for improving vegetable consumption in developing countries. In this regard, count data models were more suitable for evaluating consumption intensity in this study (Gujarati 2004). From count data model analysis, the probability distribution function of standard Poisson regression follows Greene (2002) and Gujarati (2004) as illustrated in Eq. (1).

$$f(Y_i = y_i | X_i) = \frac{\mu_i^{Y_i} e^{-\mu}}{Y_i^!} \qquad Y_i = 0, 1, 2, \ldots\ldots; \quad \lambda > 0$$

(1)

where $f(.)$ is the probability that the Y_i value takes a non-negative integer, $y_i |$ is the consumption outcome made by household i, X_i is a vector of explanatory variables, and μ_i is a parameter of Poisson distribution associated with X_i. The Y factorial means:

$$Y_i^! = Y * (Y-1) * (Y-2) * 2 * 1$$

(2)

The main limitation of standard Poisson regression is the assumed equality between the conditional mean of the data and the variance function (Greene 2002; Gujarati 2004). However, this problem is overcome by estimating the negative binomial regression (NBR) model, in which a cross-section heterogeneity is naturally formulated by introducing an unobserved effect into the conditional mean (Greene 2002). The NBR model is equally inadequate in circumstances where zero outcomes are qualitatively different from positive ones (Greene 2002). Hence, the zero-inflated Poisson (ZIP) model becomes superior to NBR due to its ability to correct the latter problem. The ZIP model has two processes. A binary regression, which characterizes zero outcomes in stage one and a truncated Poisson regression that describes positive outcomes in stage two (Lambert 1992; Greene 2002). Lambert (1992) specified the probability function of the ZIP model as follows:

$$f(y_i) = P\delta_0(y_i) + (1-P)q(y_i)$$

(3)

where P is the probability of $\delta_0(y_i)$, $1 - P$ is the probability of $q(y_i)$, $q(y_i)$ is the probability function on non-negative integers, and $\delta_0(y_i)$ is the probability function of delta distribution on zero (distribution that takes only zero value) such that:

$$\delta_0(y_i) = \begin{cases} 1 & \text{if} \quad y_i = 0 \\ 0 & \text{if} \quad y_i = 1, 2, 3, \ldots\ldots \end{cases}$$

(4)

The characterization process distinguishes zero outcomes into two regimes. The first regime comprises of true zeros (perfect state), which indicates a household is a real non-consumer of leafy AIVs. The second regime (imperfect state) indicates a household often consumes leafy AIVs. However, he/she did not consume these vegetables during the study period, and such an outcome is considered a count (Lambert 1992).

Even though NBR and ZIP models correct for equality of the conditional mean and variance of the distribution, they also induce an over-dispersion problem (Mullahy 1986; Greene 2002). Over-dispersion is a condition in which observed variance of a response is greater than the conditional mean while excess zeros arise

from the non-consumption of leafy AIVs (Gurmu and Trivedi 1996). Therefore, over-dispersion and excess zero limitations can simultaneously be resolved by zero-inflated negative binomial (ZINB) regression, which is a more flexible extension of the ZIP model (Minami et al. 2007). Just like the ZIP model, the ZINB model has two combined hurdles that generate the expected counts. These include a binary logit regression to identify zero outcomes associated with count data and NBR to model the count process. The probability distribution function for the ZINB model follows Minami et al. (2007) as shown in Eq. (5).

$$f(y_i|B_i, G_i, \beta, \gamma, \theta) = \begin{cases} P_i + (1-P_i) \ q(0|\mu_i, \theta) & \text{for} \quad y_i = 0 \\ (1-P_i) \ q(y_i|\mu_i, \theta) & \text{for} \quad y_i = 1, 2, 3, \ldots\ldots \end{cases} \tag{5}$$

where B_i and G_i are row vectors of covariate values for the ith observation in imperfect and perfect states, respectively. β and γ are parameter estimates for imperfect and perfect states respectively, θ is the precision or size parameter, and μ_i is the conditional mean for the count data, which is defined as $\mu_i = e^{X_i^!\beta}$. From the ZINB regression, the first hurdle (binary logit model) is given as:

$$\text{Logit}(P_i) = \ln\left(\frac{P_i}{1-P_i}\right) = G_i'\gamma \tag{6}$$

while a second hurdle is a distribution for the imperfect state, which assumes the density for a truncated NBR as follows:

$$q(y_i|\mu_i, \theta) = \frac{\Gamma(\theta + y_i)}{\Gamma(\theta)\Gamma(y_i + 1)} \left(\frac{\theta}{\theta + \mu_i}\right)^{\theta} \left(\frac{\mu_i}{\theta + \mu_i}\right)^{y_i} \quad \text{for} \quad y_i = 0, 1, 2, 3, \ldots \tag{7}$$

in which $\Gamma(.)$ is a gamma distribution function and the log-likelihood functions of μ_i are given as $\ln\mu_i = B_i'\beta$. To generate the β, γ, and θ estimates, a log-likelihood function for the ZINB regression is optimized using the maximum likelihood method as in Eq. (8).

$$L(\beta, \gamma, \theta|Y, B, G) = \sum_{i=1}^{n} \ln f(y_i|B_i, G_i, \beta, \gamma, \theta) \tag{8}$$

Therefore, to identify the determinants influencing the consumption intensity of leafy AIVs, the ZINB model was used in this study. The ZINB model has previously been adopted in studies that involved count data analysis (Yau et al. 2003; Sheu et al. 2004; Minami et al. 2007; Williams 2012; Gido et al. 2015). Explanatory variables used in analyzing the determinants of the consumption intensity of leafy AIVs in rural and urban dwellers (Table 1) were derived from previous studies (Modi et al. 2006; Dovie et al. 2007; Vorster et al. 2007; Amaza 2009; Faber et al. 2010; Weinberger et al. 2011; Matenge et al. 2012; Ayanwale et al. 2016; Gido et al. 2017). These variables were found to significantly influence acceptance, choice, demand, consumption, and other utilization of indigenous vegetables in Sub-Saharan Africa.

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Table 1 Definition of variables used in econometric analysis and descriptive statistics

Variable	Definition of variables and its measurement	Rural dwellers	Urban dwellers	Significance
Continuous variables		Mean		*t* value[a]
Age	Age of the decision-maker[b] in years	43.22	40.62	2.03**
Educ	Years of schooling of the decision-maker	9.45	10.37	−1.88*
H_size	Number of members in the household	5.56	4.38	5.65***
Yr_cons	Years of AIV consumption by the household	23.45	18.78	3.62***
P_income	Proportion of income allocated to food items (in Kenyan shillings)	0.45	0.35	2.29**
V_diversity	Number of different AIV leaves stocked at preferred retail outlets	5.67	6.00	−1.69*
Mrkt_dist	Distance to the nearest preferred retail outlets (in walking minutes)	35.39	18.00	7.41***
Categorical variables		Percentage		χ^2 ratio[c]
Gender	% of male decision-makers	34.32	30.08	0.72
Occup	% of respondents with household cook[d] formally employed	19.26	21.77	0.43
Nutrit	% of respondents informed about nutritional benefits of leafy AIVs	45.49	43.94	0.36
Medic	% of respondents informed about medicinal benefits allied to leafy AIVs	53.42	46.27	4.83*
Price_Per	% of respondents who perceive prices of leafy AIVs are affordable	74.63	85.22	5.37***

*, **, ***Significant at 10, 5, and 1%, respectively
[a]*t* test was used to determine significant differences in continuous variables, between rural and urban dwellers
[b]Decision-maker is a household member responsible for making key decisions on matters concerning food consumption
[c]χ^2 ratio was used to determine relationships in categorical variables, between rural and urban dwellers
[d]Household cook is the person responsible for preparing household meals

Results and discussion

Descriptive results

Descriptive and summary statistics between the rural and urban dwellers varied (Table 1). On average, rural decision-makers were significantly elderly and less educated. Rural dwellers had more members with wider experience in AIV consumption and allocated larger proportions of income for food use. While access to a greater diversity of leafy AIVs was higher in urban dwellers, distance to preferred market outlets was significantly longer in rural areas. Moreover, rural dwellers were more informed about the medicinal benefits associated with indigenous vegetables, and the perceived retail prices for leafy AIVs were more affordable.

The average consumption intensity of leafy AIVs in both rural and urban dwellers was thrice a week (Table 2). Rural dwellers had a significantly higher

Table 2 Weekly consumption intensity of leafy AIVs among rural and urban dwellers

Sample	Mean	Minimum	Maximum	Standard deviation
Rural dwellers	3.92	0	7	1.89
Urban dwellers	2.32	0	4	1.34
Rural and urban dwellers	2.89	0	7	1.74
t value	8.80*			

*Significant at 1%

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consumption intensity of about four times a week compared to urban dwellers with a mean of twice a week. Interestingly, the highest consumption intensity in urban dwellers was about four times a week while some rural dwellers were found to consume leafy AIVs on daily basis during the study period. To the lower end, zero consumption level was revealed in both rural and urban dwellers.

Determinants of consumption intensity of leafy AIVs

Four count data models were consecutively estimated to determine a regression that best fits the data in explaining the consumption intensity of leafy AIVs. Firstly, the standard Poisson regression was estimated (Appendix 1). To determine the appropriateness of the standard Poisson regression, there was a need to estimate the NBR model (Appendix 1). Results from the NBR revealed evidence of over-dispersion, since alpha was greater than zero with a significant likelihood ratio test, implying that NBR was more appropriate for the data than the standard Poisson model. Thirdly, ZIP regression was estimated (Appendix 2). Results showed that z-test for Vuong was significant indicating the ZIP model was more appropriate than the standard Poisson regression. Lastly, ZINB regression was estimated (Table 2), where the statistical suitability of the model was tested using the zip option test for ZINB over ZIP and the Vuong test for ZINB over standard NBR. The zip option test had a significant likelihood ratio test for an alpha of zero, suggesting that ZINB regression was more appropriate than ZIP regression. The z-test for Vuong was also significant, implying the ZINB model was better than standard NBR. A comparison of model statistics from the four regressions indicated that the ZINB model was more suitable for the data collected in this study.

The bottom half of Table 3 shows the logistic model results on evaluation of the perfect state. Gender and education level of the decision-maker significantly predicted true zeros in consumption intensity of leafy AIVs. In rural dwellers, male decision-makers increased the likelihood of a count being zero for the consumption intensity of leafy AIVs. This finding was not surprising since earlier studies (Amaza 2009; Weinberger et al. 2011) revealed that traditional knowledge about AIVs was more likely in women than men. Women are more informed about healthier diets and are found to consume more vegetables than men (Baker and Wardle 2003). Moreover, vegetable preparation activities of sorting and plucking leaves from their stalks are presumed more tedious and time involving (Abukutsa 2010; Matenge et al. 2012). Thus, men are unlikely to devote sufficient time for AIV preparation compared to women.

Likewise, a count for consumption intensity of leafy AIVs was less likely a true zero in urban dwellers with more educated decision-makers. This result was interesting, indicating that earlier campaign efforts of promoting consumption of leafy AIVs in urban areas were not in vain. Perhaps this is because better-educated households are more likely to attain dietary information on nutritious and healthier food items like indigenous vegetables (Sanlier and Karakus 2010; Gido et al. 2017). Contrary to findings in this study, Gido et al. (2017) revealed that African night shade was less likely to be accepted for consumption by more-educated urban decision-makers. However, spider plant, African night shade, and slender leaf were

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Table 3 ZINB model results on determinants of consumption intensity of leafy AIVs

Variables	Rural dwellers		Urban dwellers	
	Coef.	Std. err.	Coef.	Std. err.
Negative binomial regression				
Gender	−0.0871	0.1124	−0.0436	0.0944
H_size	−0.0438*	0.0240	−0.0142	0.0258
Age	0.0173***	0.0058	0.0066	0.0046
Educ	−0.0068	0.0130	−0.0030	0.0114
Occup	−0.2771	0.1418	−0.3346**	0.1125
P_income	−0.1736***	0.0599	0.0857	0.0591
Yr_cons	0.0001	0.0045	−0.0008	0.0046
V_diversity	0.0407*	0.0241	0.0504**	0.0219
Mrkt_dist	0.0128	0.0534	0.0998*	0.0586
Nutrit	−0.1557	0.2685	0.0705	0.2199
Medic	0.4704*	0.2622	0.0869	0.1450
Price_Per	−0.1817	0.1311	−0.0737	0.1118
Constant	0.9820**	0.4204	1.3299***	0.4012
Logistic regression for zero-inflation				
Gender	1.4748*	0.7858	−0.2638	0.4344
H_size	0.1195	0.1334	−0.0651	0.1138
Educ	−0.0640	0.0810	−0.1119***	0.0432
P_income	−0.1796	0.3252	−0.2035	0.2594
Price_Per	−1.4133	0.8750	0.6698	0.6915
Constant	−1.3626	1.8718	−0.0859	1.5666
/lnalpha	−2.2581***	0.3486	−2.2572***	0.2687
Alpha	0.1046	0.0364	0.1046	0.0281
	$\chi^2(01) = 19.79$		$\chi^2(01) = 32.33$	
LR test of alpha = 0	$Pr \geq \chi^2 = 0.0000$***		$Pr \geq \chi^2 = 0.0000$***	
Vuong test	$z = 2.70$		$z = 5.58$	
	$Pr > z = 0.0034$***		$Pr > z = 0.0000$***	

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

more likely to be accepted by their rural counterparts for consumption. There is a need for further investigation on this aspect.

The top portion of Table 3 contains NBR results on counties that were an imperfect state. Several variables significantly influenced the consumption intensity of leafy AIVs. Household size significantly and negatively influenced the consumption intensity of leafy AIVs in rural dwellers. This indicates that the consumption intensity of leafy AIVs was less likely in large rural households and this outcome was as predicted due to the anticipated wider variation in taste and preferences for different leafy AIVs. Large household size indicates that more quantities of AIV leaves are required, and this implies that more income would be necessary for such voluminous purchases (Dovie et al. 2007; Ayanwale et al. 2016). Consequently, more time is required to pluck sufficient quantities of leaves from AIV stalks in readiness for cooking, thereby reducing consumption intensity in large households due to the tedious process of vegetable preparation. Findings by Ayanwale et al. (2016) indicated that households with large membership were more likely to

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increase the consumption of fluted pumpkin and reduce the consumption of English spinach because it was less prevalent in the market compared to other underutilized indigenous vegetables. Similarly, the bitter taste in slender leaf constrained its acceptance for consumption in urban dwellers with a large household size (Gido et al. 2017).

In rural dwellers, the intensity of AIV consumption significantly increased with advancement in age of the decision-maker. Elderly rural dwellers are more likely to possess adequate cultural knowledge on AIVs as opposed to the youth and urbanized dwellers (Jansen van Rensburg et al. 2007; Faber et al. 2010; Matenge et al. 2012). Moreover, traditional knowledge of AIV preparation and cooking alongside their medicinal and nutritional benefits are likely higher in elderly rural people. Perhaps adequacy in indigenous knowledge enhances consumption intensity of leafy AIVs in elderly rural dwellers (Okeno et al. 2003; Smith and Eyzaguirre 2007; Waudo et al. 2007). Ayanwale et al. (2016) found similar results, where the demand for fluted pumpkin and English spinach were high in elderly consumers. However, demand for garden egg was lower in elderly consumers because the process of preparing it for consumption was tedious.

Formal employment of the household cook significantly and negatively influenced the consumption intensity of leafy AIVs in urban dwellers. Even though household meals have traditionally been prepared by women in most African countries, such cultural obligations are slowly changing due to changes in gender roles (WHO 2000; Fontana and Natali 2008). Most urban dwellers with formal employment attain such opportunities far away from their residential homes and more often return home late from work. This implies that they are left with little time for food preparation (Gido et al. 2017). Given that leafy AIV crops require more time for preparation and cooking (Ruel et al. 2005; Matenge et al. 2012), their consumption intensity is less likely in households where the family cook has employment opportunity. According to Kimiywe et al. (2007), business and full-time employed people consume less indigenous vegetables compared to non-employed people and casual laborers. Gido et al. (2017) found similar results, where amaranth and spider plant vegetables were less accepted for consumption by rural dwellers with the household cook formally employed.

In rural dwellers, consumption intensity was negatively influenced by the proportion of income allocated for food use. This indicates that households with larger budgetary allocation for food use reduce consumption intensity of leafy AIVs. However, this does not imply AIV leaves are inferior goods since the quantity purchased was not emphasized in this study. Past studies found that AIVs are perceived by wealthier people and urbanized dwellers as food meant for "poor-rural man" (Modi et al. 2006; Jansen van Rensburg et al. 2007; Faber et al. 2010). Similar findings were revealed by Frazao et al. (2007), where an increase in household income does not necessarily increase vegetable consumption. This suggests that an improvement in household welfare, through a general increase in income, might not favor consumption of leafy AIVs as opposed to other food commodities like meat products (Bett et al. 2012).

The diversity of leafy AIV crops at retail outlets significantly increased their consumption intensity in rural and urban dwellers. These findings demonstrate that

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availability of numerous AIV crops in markets stimulates their regularity in consumption. Probably this is because access to more AIV leaves presents a wider range of alternative crops for households to choose vegetables preferable by all household members (Gido et al. 2017). A higher diversity of leafy AIVs encourages consumption of crops which substitute or complement each other in a vegetable recipe. Moreover, it enhances vegetable rotation in household diets, thereby reducing the monotony of consuming a few vegetable crops. Increasing diversity of AIV leaves in consumption has advantages of ensuring that key micronutrients are attained given that each crop has unique micronutrient composition (Singh et al. 2012, 2013).

The time taken to reach preferred vegetable retail outlets was positive and significantly influenced consumption intensity of leafy AIVs in urban dwellers. The findings were surprising since distant market outlets are expected to constrain consumer access to household goods (Vorster et al. 2007). Markets are major sources of food for most urban dwellers, and consumers prefer higher-quality vegetables, which are perceived to be sold in high-valued retail outlets such as supermarkets and groceries (Ngugi et al. 2007; Irungu et al. 2008). Such retail outlets are sparsely distributed in urban areas, subjecting consumers to walk longer distances to access quality vegetables. Results by Gido et al. (2017) complement these findings where consumers were more likely to obtain complementary leafy AIVs from distant retail outlets. Contrary to these findings, consumers are less willing to shop from far distant markets that involve more time for traveling (Maruyama and Wu 2014; Gido et al. 2016).

Awareness of medicinal benefits associated with indigenous vegetables was positive and significantly influenced the consumption intensity of leafy AIVs in rural dwellers. These findings were in agreement with the study expectations and imply that informed rural dwellers about curative and therapeutic components found in AIVs were likely to consume them more regularly. Such traditional knowledge regarding the selection and utilization of leafy AIVs is highly expected in rural areas (Gido et al. 2017). In particular, rural dwellers are more equipped with skills relating to identifying vegetables that contain oxidant compounds for protecting and healing malnutrition-related diseases (Yang and Keding 2009; Singh et al. 2013).

Conclusions

The study evaluated determinants of consumption intensity of leafy AIVs in rural and urban dwellers using the zero-inflated negative binomial regression model. Findings indicated a higher consumption intensity of leafy AIVs in rural dwellers compared to urban dwellers with a mean of four and two times a week, respectively. Higher diversity of leafy AIVs at retail outlets increased their consumption intensity in both rural and urban dwellers. In urban dwellers, formal employment of the household cook reduced the consumption intensity of leafy AIVs while increased distance to retail outlets had a contrary effect. In rural dwellers, elderly decision-makers with more information on AIVs' medicinal benefits increased vegetable consumption intensity. However, large households with a greater proportion of income allocated for food use reduced vegetable consumption intensity.

The findings from this study have relevant policy implications regarding value addition strategies, sensitization of consumers on traditional knowledge about AIV utilization and increasing diversity of indigenous vegetables in food systems.

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Interventions that could promote awareness programs where traditional knowledge regarding indigenous vegetables is transferred to uninformed consumer segments such as male and younger decision-makers could increase the consumption intensity of leafy AIVs in rural dwellers. This can be achieved through the circulation of brochures written in commonly used dialects and an establishment of AIV "food clinics," where consumers can seek information about AIVs and other indigenous food items in general. In addition, integrating awareness programs on local or ethnic radio and television stations, where consumers are informed about traditional knowledge regarding AIVs in languages they understand well, could be important.

Strategies that could promote vegetable value addition activities can increase consumption intensity of leafy AIVs in urban dwellers. This could involve retailers to stock AIV leaves already sorted and plucked from their stalks, thereby reducing the time required for the preliminary stages of vegetable preparation before cooking. Finally, policies that could increase the diversity of AIV leaves at retail outlets through diverse production and well-coordinated market supply chains could increase vegetable consumption intensity in both rural and urban dwellers. This study recommends the need for a similar future research that could consider seasonal variation in vegetable availability, which might affect consumer behavior regarding the consumption intensity of leafy AIVs.

Appendix 1

Table 4 Standard Poisson regression and NBR results on determinants of consumption intensity of leafy AIVs

Variable	Standard Poisson regression				Negative binomial regression (NBR)			
	Rural dwellers		Urban dwellers		Rural dwellers		Urban dwellers	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Gender	−0.1840**	0.0836	−0.1918	0.1428	0.0347	0.1495	0.0144	0.0695
H_size	−0.0502***	0.0174	−0.0488	0.0308	0.0050	0.0408	0.0113	0.0179
Age	0.0141***	0.0041	0.0140*	0.0075	0.0029	0.0073	0.0039	0.0034
Educ	0.0015	0.0094	0.0002	0.0165	0.0121	0.0184	0.0110	0.0084
Occup	−0.2884***	0.1077	−0.2440	0.1845	−0.1626	0.1797	−0.1824**	0.0869
P_income	−0.1313***	0.0408	−0.1274*	0.0755	0.1396	0.0942	0.1455***	0.0448
Yr_cons	0.0019	0.0031	0.0016	0.0057	−0.0007	0.0073	−0.0024	0.0034
V_diversity	0.0458***	0.0173	0.0472	0.0320	0.0472	0.0365	0.0495	0.0166
Mrkt_dist	0.0177	0.0369	−0.0029	0.0656	0.0667	0.0913	0.0652	0.0440
Nutrit	−0.1143	0.1919	−0.1642	0.3221	0.1191	0.3486	0.1390	0.1625
Medic	0.7309***	0.1874	0.7140**	0.2981	0.0775	0.2408	0.0756	0.1135
Price_Per	−0.0459	0.0944	−0.0774	0.1687	−0.1673	0.1833	−0.1630*	0.0842
Constant	0.5966*	0.3117	0.7503	0.5266	1.1863*	0.6343	1.1532***	0.2990
/lnalpha					−1.1629	0.2321	−0.5039	0.1512
Alpha					0.3126	0.0725	0.6042	0.0914
					$\chi^2(01) = 73.83$		$\chi^2(01) = 247.79$	
LR test of alpha = 0					Pr $\geq \chi^2$ = 0.0000***		Pr $\geq \chi^2$ = 0.0000***	

*, **, ***indicates significance level at 10, 5, and 1%, respectively

Appendix 2

Table 5 ZIP model results on determinants of consumption intensity of leafy AIVs

Variables	Rural dwellers		Urban dwellers	
	Coef.	Std. err.	Coef.	Std. err.
Negative binomial regression				
Gender	−0.0818	0.0842	−0.0522	0.0702
H_size	−0.0431**	0.0175	−0.0097	0.0191
Age	0.0169***	0.0042	0.0066*	0.0034
Educ	−0.0055	0.0095	−0.0032	0.0083
Occup	−0.2795***	0.1073	−0.3406***	0.0869
P_income	−0.1734***	0.0445	0.0833*	0.0441
Yr_cons	0.0001	0.0032	−0.0008	0.0034
V_diversity	0.0372**	0.0175	0.0488***	0.0158
Mrkt_dist	0.0200	0.0399	0.1115**	0.0445
Price_Per	−0.1594*	0.0959	−0.0687	0.0838
Medic	0.4328**	0.1952	0.0757	0.1081
Nutrit	−0.1583	0.1961	0.0824	0.1607
Constant	1.0022***	0.3151	1.2892***	0.3014
Logistic regression for zero-inflation				
Gender	1.3484*	0.7102	−0.2624	0.4251
H_size	0.1120	0.1260	−0.0632	0.1113
Educ	−0.0586**	0.0744	−0.1094	0.0425
P_income	−0.1313	0.3038	−0.2074	0.2547
Price_Per	−1.3257	0.8059	0.6444	0.6600
Constant	−1.2665	1.7958	−0.0565	1.5180
Vuong test	$z = 3.03$; Pr ≥ 0.0012***		$z = 3.03$; Pr ≥ 0.0012***	

*, **, ***indicates significance level at 10, 5, and 1%, respectively

The z-test is significant across, indicating that the ZIP model is more appropriate for the data than the standard Poisson regression model

Authors' contributions

Four authors contributed to the success of this work. EOG and WB conceptualized the paper. EOG and OIA managed the literature searches and designed the methodology. EOG, OIA and WB designed the questionnaire. EOG coordinated the field survey, data analysis and write up of the first draft. EOG, OIA, GO and WB managed interpretation of the analysis. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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