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PROTEIN AND ENERGY CONTRIBUTION OF AFRICAN INDIGENOUS VEGETABLES: Evidence from selected rural and peri-urban counties of Kenya

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ABSTRACT

Although positive steps have been taken towards reducing food insecurity, it remains a serious and recurrent issue, especially in developing countries. Food insecurity is aggravated by the world's growing population and global ecological changes and calls for novel agriculture-based hunger eradication strategies. It is argued that production and consumption of indigenous vegetables (IVs) enhances accessibility and availability of nutritious food in households. Indigenous vegetables (IVs) contain significant amounts of macronutrients and high levels of micronutrients. As their agro-economic advantages make them relatively easy for uptake by resource-poor households, they represent a direct solution to 'hidden hunger'. Household-based survey data collected from 1232 IV producers in rural and peri-urban areas of five selected counties in Kenya in 2014 were used to examine the dietary contribution of IVs. Five priority indigenous vegetables were analysed: amaranth, cowpea, African nightshade, spider plant and Ethiopian kale. Quantitative analysis was performed using food security indicators from the ADePT-Food security Module data analytical software. This study's findings indicated African nightshade was the most consumed indigenous vegetable, providing the largest share of dietary energy consumption (average of 43 kcal/person/day). Amaranth was found to provide the highest share and cheapest source of dietary protein consumption, an average of 4.9 g/person/day, thus meeting 8% of the adult daily protein requirement. These results showed the clear dominance of indigenous vegetables over exotic vegetables in terms of protein contribution, achieved both by amaranth's high protein content compared to cabbage, as well as the low per unit cost of protein in indigenous vegetables compared to exotic vegetables. Given that, IVs have a significant protein content that adds variety to staple diets at comparatively low median dietary unit values and that they are important sources of dietary energy, efforts should be made to increase their consumption by undertaking further research, raising awareness and instituting policies.

Key words: food security; indigenous vegetables; macronutrients; protein; energy, Kenya, diet, consumption

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INTRODUCTION

Food security remains a concern for governments, research institutions and international organisations. Although considerable efforts have been made to reduce hunger, the Sustainable Development Goals (SDGs) of 'Zero Hunger' has not been achieved in all parts of the world. About one in nine people in the world still have insufficient food for an active and healthy life, and an estimated 12.9% of the population in developing countries remain critically underfed [1–3]. The United Nations' new Sustainable Development Goals (SDGs) to end hunger and malnutrition and enhance sustainable agricultural production by 2030 is a new initiative to combat this huge problem [4].

It is estimated that up to 26% of the Kenyan population is undernourished and 10 million people food insecure [1]. This is attributed to sluggish economic growth, a high poverty rate and poor rural infrastructures. The most vulnerable are pregnant and lactating women, the elderly and children, with malnutrition being the single largest cause of child mortality. Food security exists when all people have physical, social and economic access at all times to sufficient, safe and nutritious food that meets their dietary needs [5]. There are many components of food security, including availability, accessibility, food system stability, utilisation and composition of the diet in terms of nutritional balance. Therefore, food insecurity comes about from insufficient purchasing power, a poor food distribution network or inadequate use of food at the household and individual levels [6].

Dietary modification is one of the viable food-based strategies for combatting malnutrition. It increases the amount of nutrients consumed in diets, and this can be achieved by incorporating vegetables as a significant diet component. The World Health Organization (WHO) recommends a vegetable intake of 400 g per capita per day [7]. Therefore, diversification of diets to include Indigenous Vegetables (IVs) is a way of improving nutrition and reducing hidden hunger, especially among rural and lower income populations.

Indigenous vegetables (IVs) are defined as leafy green vegetables that were originally domesticated or have been cultivated in Africa for centuries [8]. Several IVs have been domesticated and planted in fields as intercrops in gardens and homes. Even though over 376 species of IVs exist, Kenyans prefer to consume only 40 different species [9]. The choice of the preferred species is based on characteristics such as leaf size associated with ease of harvesting and preparation, bitterness and hairy surfaces or due to indigenous knowledge transfer. These IVs are sources of important macronutrients such as proteins and energy [10–12] and can provide approximately 10% of the recommended daily allowance (RDA) of protein for females aged between 19-30 and 8% for males of the same age range [13,14]. The dietary fibre and fat contents were in the range of 1-8 g/100 g and 1-5 g/100 g edible portion, respectively, while the protein content of various IVs range between 1-7 g/100 g edible portion [15]. Some IVs have higher protein and iron content than exotic vegetables [16]. Indigenous vegetables can provide up to 40% of the protein needs of growing children and lactating mothers [17].

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Dietary intake indicators are used to measure the contribution of IVs in household diets; average dietary energy consumption measures the amount of calories consumed by the household. Referenced against the minimum energy requirement for the given demographic class, it is used to estimate food energy deficiency [18]. Other relevant indicators include average dietary unit value, which is the average cost of 1,000 kcal in local currency. Average protein consumption per day and the respective protein unit value are also used to determine the quantity and food source of proteins consumed in a household. In order to capture diversity in diets, the contribution of nutritionally significant food groups to total nutrient consumption as a percentage of dietary energy consumption is used [18,19]. Standard sources of food include purchases, own production, food consumed away from home and others, such as gifts, aid or payment in kind [18]. The source of food is a significant determinant of food security. For example, reliance on own-produced food makes households vulnerable to climate variations and natural events. In this respect, IVs have been shown to be tolerant to many biotic and abiotic stresses [20] and thus households producing IVs are likely to cope with economic and climatic shocks.

Although there are many components to food security, this research focuses on accessibility and availability of food. The main objective of the study is to assess the macronutrient (protein and energy) contribution of IVs at the household level. In particular, the dietary macronutrient intake at household level is given emphasis. This has the advantage of not having the masking effects of national estimates. Research on the significance of IVs for nutritional wellbeing is critical to providing greater insight and closing existing knowledge gaps with regard to the protein and energy contribution of IVs. This will help inform the development of policies that ensure an adequate dietary supply of IVs and promote their exploitation for food security.

MATERIALS AND METHODS

Sampling

Data were obtained from the Horticultural Innovation and Learning for Improved Nutrition and Livelihood in East Africa (HORTINLEA) survey conducted in rural and peri-urban areas of Kenya between September and October 2014. The survey centred on five IVs: amaranth, cowpea, African nightshade, spider plant and Ethiopian kale. Specific survey sites were selected following expert consultation in terms of where most IVs are produced both for home consumption and markets. The rural sites were located in the two counties of Kisii and Kakamega, while the peri-urban sites were in Kiambu and Nakuru counties. A total of 1232 IVs producers were interviewed.

Households for the survey were selected using a multi-stage sampling approach. First, a purposive sampling technique was applied to select four counties with rural and peri-urban sites. It was purposive in that respondents within these counties are involved in production, marketing or consumption of at least one of the aforementioned IVs. From each division, locations/wards and then households within locations were randomly selected. Prior to the main survey, a pilot survey was conducted in Nakuru County. Based on this, the questionnaire was revised to produce a final version. In all the locations, the survey was conducted by means of face-to-face interview with farmers.

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Data sets – Tools for analysis

This study used ADEPT food security module software developed by the World Bank in 2014 to measure food security indicators from food consumption data [21]. The ADEPT software requires four types of datasets. Of the four datasets, three were generated by the HORTINLEA household survey and the fourth came from food consumption tables. The following data sets were used as described by Moteldo *et al*. [21]. Household dataset, Individual data set, and food data set. A fourth data set called Country Nutrient Conversion Table was also constructed for use.

The Country nutrient conversion table contained Specific food calorie and nutrient values of food items collected in the survey in terms of energy and nutrients per 100 grams edible portion. Moisture, fibre, fat, protein and alcohol content of the edible portion were extracted from national and/or regional food composition tables (FCTs). To estimate the nutrient content of the actual quantity consumed, the refuse factor was used. This is expressed as the percentage of the non-edible portion. Some FCT reported only the edible coefficient of food items .This was converted into the refuse factor using the equation below from [21] :

$$Edible\ Food\ Quantity\ = Food\ Quantity * \left(1 - \frac{Refuse\ Factor}{100}\right)$$

Or

$$Edible\ Food\ Quantity = Food\ Quantity * Edible\ Coefficient$$

Where, the edible coefficient is the proportion of the food item being eligible after removal of unwanted parts, and the food quantity is the amount reported in the survey. Considerations were made when choosing the FCT, including completeness of information, geographical and cultural proximity between the countries of study and where the FCT was written, and the year of publication of values. Each food item listed in the survey was matched with a food item described in the country FCT. The primary FCT used for conversion of calories was the Tanzanian FCT [25]. Information on the nutrients of traditional food plants was used for nutrient values of the five specific IVs [26]. Nutrient data that were still missing were completed by data on similar foods using values from food conversion tables for use in Africa [27] and the USDA nutrient database for standard reference [28]. Conversion factors provided by the FAO were used for the FAO's food balance sheet calculations and Ugandan food composition tables [29]. The gram of available carbohydrates in 100 g of food was then calculated as [21]:

$$Carbohydrates = (100 - Water - Ash - Protein - Fat - Fibre - Alchohol)g/100g$$

Other parameters used included:

Estimation of dietary energy; The human body can access required energy through the intake of energy-yielding macronutrients from foods that contain proteins, fats and carbohydrates, including fibres and alcohol, all of which proportionately contribute to

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total calories. It is measured in kilocalories (kcal). The Atwater formula is used to calculate dietary energy values as follows:

$$Calories_{Kcal} = (Protein_g * 4) + (Fats_g * 9) + (Average\ Carbohydrates_g * 4) + (Fiber_g * 2) + (Alcohol_g * 7)$$

Therefore, macronutrient consumption was estimated by multiplying food quantities collected from the survey by nutrient values from the relevant food composition table using the above formula [21].

Exogenous parameters; under-five mortality rate and birth rate are used as national standards that are incorporated to estimate dietary energy requirements. To estimate the prevalence of undernourishment (PoU), dietary energy consumption, minimum energy requirement and average dietary energy requirement are needed. These are customised in the Adept software.

The analysis of IVs; The FAO guidelines provide for 19 classes of food groups, but allow for streamlining according to country-specific surveys and studies [21]. For the purpose of this research, the foods consumed were classified into 13 food groups, clearly separating exotic vegetables from the IVs, with emphasis on the five priority IVs. These were further analysed for their role in households' nutrition and food security, and compared with other food items and classes. To estimate the sources of food and dietary diversity, average dietary energy consumption was used because it is representative in the calculation of the Atwater formula [21]. The ADEPT software generates outputs in terms of tables out of which simple mean, median and percentages could be used to describe the contribution of IVs to macronutrients intake.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

The average size of land owned by farmers is 1.58 acres (Table 1). About 79% of households are headed by men and most have obtained secondary education (41%). Most of the interviewees resided in rural areas (66%). Although they have diverse sources of income, most of them rely on agriculture (63%). It is clear from the sampling section that the HORTINLEA survey was conducted in 2014. The fact that the data set used is from a survey conducted four years ago does not provide a challenge since the focus of this study is on analysing the macronutrient contribution of IVs which is not subject to change in the four years' time span. However, it is acknowledged that a more recent dataset would have been preferable for example describing the demographic characteristics of the sample respondents.

Contribution of IVs to dietary energy consumption and median dietary energy unit values

Indigenous Vegetables were estimated to contribute 2.8% of the total dietary energy consumption. Rural households derived more dietary energy from IVs (4.1%) than peri-urban households (2.4%). Among the IVs, African nightshade provided the greatest share

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of energy at 43 kcal/person/day and 49 kcal/person/day in peri-urban and rural areas, respectively. This is attributed to the popularity of the African nightshade in many parts of Kenya as also reported by Abukutsa *et al*. [8].

The median energy unit value[1] of IVs ranged from KSh 41-94/1000 kcal, with the average estimated to be KSh 56/1000 kcal. It was noted that the cost of nutrients was less in rural areas than in peri-urban areas, as shown in Figure 1. The difference in cost of the nutrients is attributed to transport and higher production costs in the peri-urban areas due to the semi intensive production style.

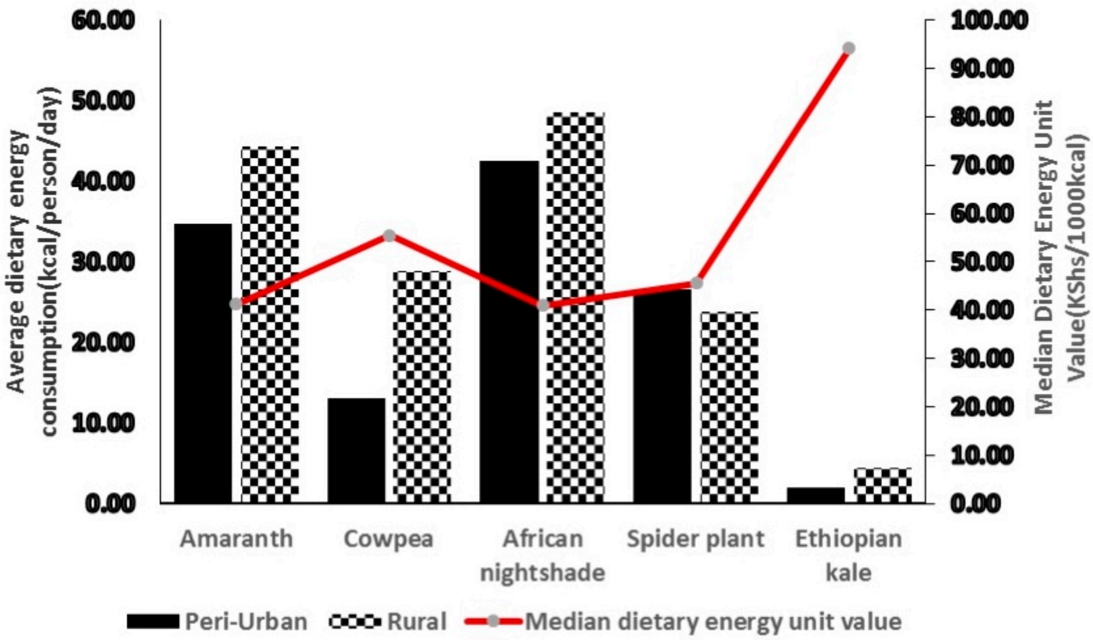

Figure 1: Dietary energy consumption from IVs and their respective median dietary energy unit values

Contribution of IVs to dietary protein consumption and median dietary protein unit value

Consistent with previous report by The National Academic Press (14), it is shown here that IVs do not fully meet the daily protein requirement but can complement the nutrient sources. Indigenous vegetables (IVs) contributed 12% of the total dietary protein consumption. The dietary protein contribution was found to be higher in rural areas (10%) than in peri-urban areas (Figure 2). These findings are in range with those reported by Gockowki *et al*. [8], who estimated that IVs provided 11% of daily protein nutritional requirement of surveyed households in Yaoundé, Cameroon. The dietary protein intake from amaranth was the highest among the IVs at 4.6 g/100 g, potentially meeting 8% of the recommended daily dietary adult requirement of 56 g of protein per day. These results showed that IVs provided a cumulative of 12 g protein/person/day. This is linked to the relatively high protein content of IVs as was also reported by other researchers [10,13,15,30].

[1] One US dollar = 103.69 Kenyan shillings (KShs) as of November 15, 2017

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Economic access to food through markets is an integral aspect in achieving nutrition security [1]. Therefore, lower income households may largely depend on the cheaper but nutrient inadequate staples for diets [31]. However, the results indicate that IVs are a cheaper source of protein. For instance, the cost of unit protein from IVs ranged from KSh 37-146 per 100 g of the edible part. Amaranth was the cheapest source of protein among the IVs. In other selected food groups, cereals, dairy products and meat had a mean dietary protein unit value ranging between KSh 25.8-185.2, 21-238.1 and 43-142 per 100 g, respectively. The average median dietary protein unit value of exotic vegetables was 245.7 g/person/day. The IVs are, therefore, relatively cheaper and more available source of protein on a per unit basis making them an accessible alternative for the low income rural and Peri urban households.

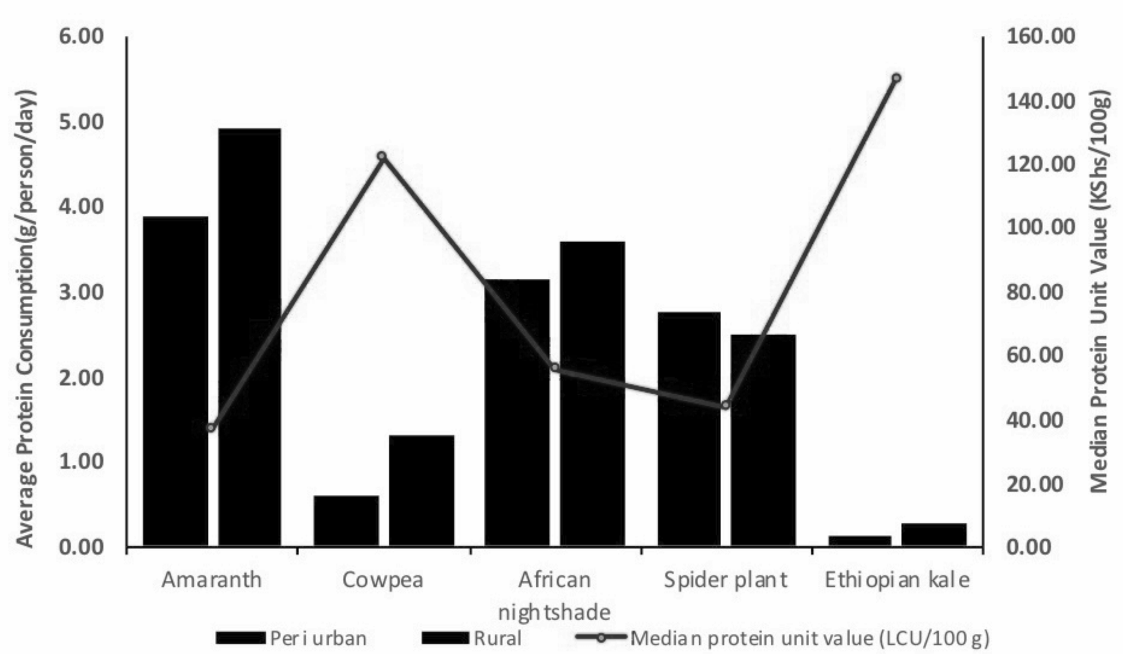

Figure 2: The contribution of IVs to dietary protein consumption and the corresponding median unit values

Source of food commodity

Physical accessibility to food is a component of nutrition security. Households generally access food through own production or purchases. This may be hampered by low agricultural yields, poverty and infrastructural challenges [32]. From the analysis, using the source of average energy dietary consumption as a representative source of food, the main sources of food included purchases (66.2%), own production (26.9%), food consumed away from home (4.3%) and other sources such as gifts (2.5%). In contrast, the main source of IVs consumed was from own production, representing 85% of the share of total consumption of this food commodity group. Similarly, 10.4% were purchased, 1.2% consumed away from home and 3.4% came from other sources, as depicted in Figure 3.

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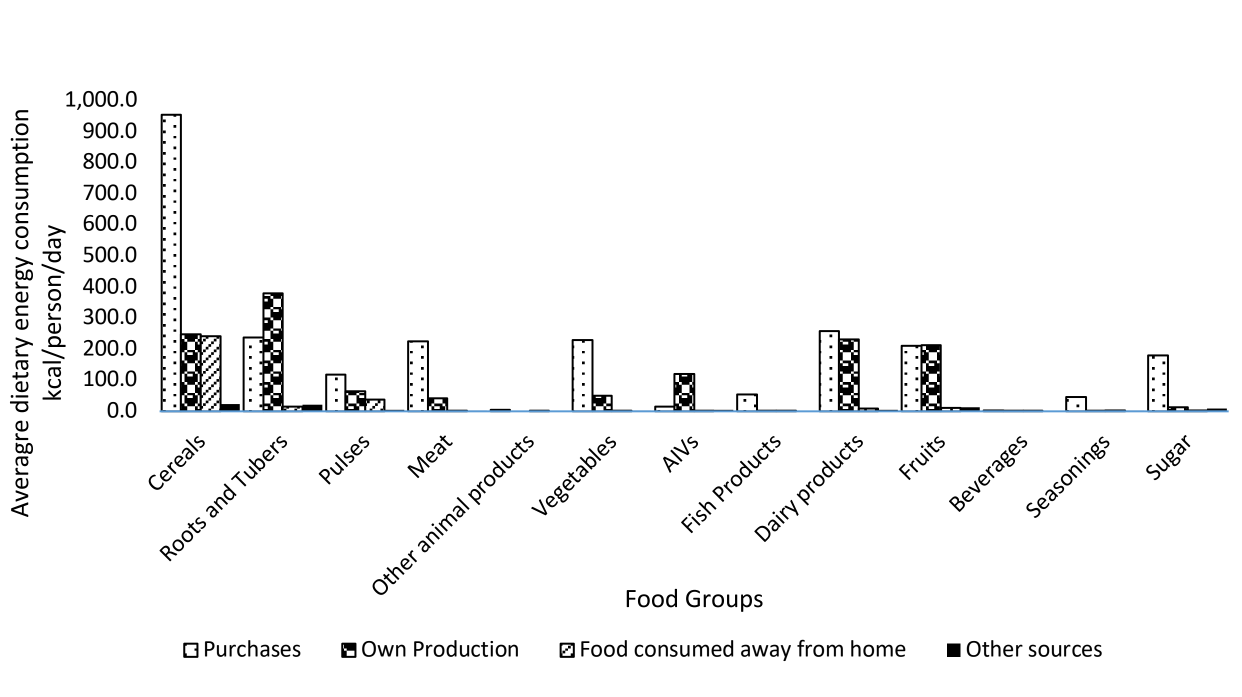

Figure 3: Sources of food in terms of average dietary energy consumption per capita per food class item

Rural and peri-urban dietary consumption trend

Peri-urban dwellers mainly relied on purchased food, constituting 71.5% of their dietary energy from all food items, while only 20.2% was from own production. The remainder, 8.3% was from other sources. Comparatively, the percentage of purchased food was lower in rural areas at 52.1% and own production at 37.7%, and the rest 10.2% from gifts and food consumed away from home. Additionally, analysis of the results showed that African nightshade was the most consumed vegetable among the IVs at 97.9 g/person/day and 111.9 g/person/day in peri-urban and rural areas, respectively. The total average edible quantity of IVs consumed in the peri-urban area was 57.5 g/person/day while in rural areas it was slightly higher than peri-urban at 73.2 g/person/day. In retrospect, though there is growing interest in peri-urban gardening, the high number of peri-urban households that are still compelled to purchase their food items could be attributed to insecure land tenures and prohibitive urban planning policies in line with Ambrose Oji [33].

Dietary diversity

Diversity of diets is synonymous with increased nutritional quality and incorporating IVs have additional health benefits [34,35] . The household diets is largely made of cereals, roots and tubers signifying low quality diets[36]. The result of this study shows that the main source of dietary energy consumption was cereals and roots and tubers at 34% and 15% ,respectively (Figure 4, panel A).Indeed, household diets in Kenya predominantly consist of maize flour, popularly called `*Ugali*` as also reported by Kamau and Elmadfa [37] hence, it is the main source of energy. Indigenous vegetables contributed 3.3% to the total consumption. Other exotic vegetables were still more popular than IVs and contributed 6.5%. Although, IVs do not provide all the required dietary energy, they offer

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great relief as a side dish of starchy staples, especially for low income households who would otherwise depend only on the usual staples or have gone without any food at all. The WHO recommends a population intake of 400 g/person/day of vegetables and fruits to prevent an estimated 2.7 million deaths through chronic diseases [7]. This study found the total average consumption of IVs to be 57.5 g/person/day and 73.2 g/person /day in peri-urban and rural areas. Hence, IVs made a considerable contribution to meeting the recommended levels.

Additional data analysis indicated that the IVs' contribute 12% to the total dietary protein consumption while the share of exotic vegetables was much lower than IVs at just 4% (Figure 4, panel B). This shows that IVs are better and cheaper sources of protein as compared to exotic vegetables in keeping with Nyadanu and Lowor [30]. Given that high value-macronutrient foods such as meat, dairy and poultry products are expensive and hence inaccessible to many, IVs could serve as a close and cheaper substitute. Additionally, in the current wake of high food prices that limits quantity of food consumed, diversity of meals available and quality of food purchased, IVs provide a solution both in terms of energy and protein contribution as well as low unit costs.

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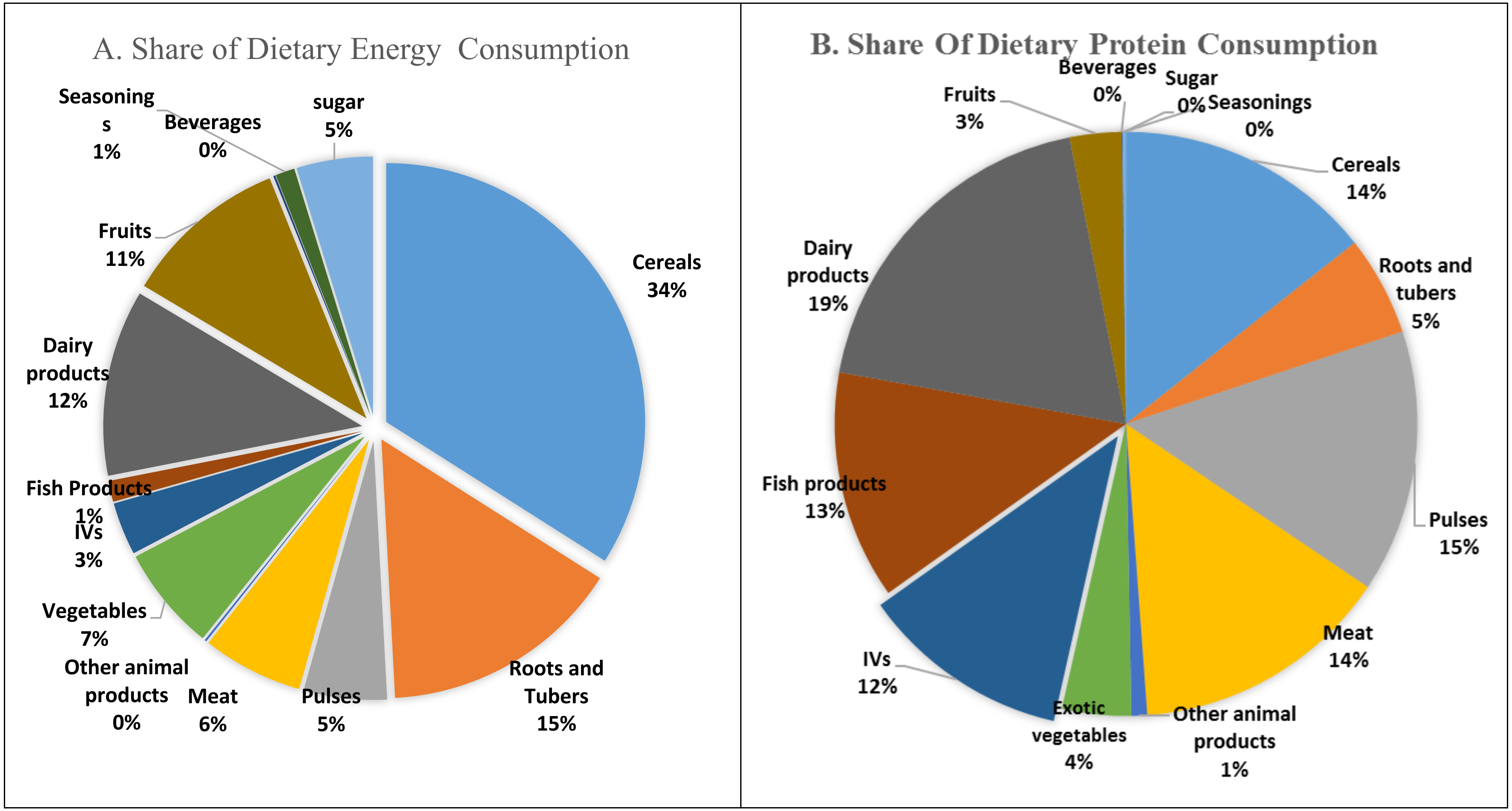

Figure 4: Dietary diversity in terms of energy consumption (%)

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Limitations of the study
In the HORTINLEA household survey, the food consumption questionnaire required weekly (seven-day) recall. Incidentally, the seven-day recall method results in overestimation of consumption, which is attributed to, among other factors, food wastage over seven days. Though 24-hour recall is deemed more accurate, it could not be used due to its prohibitive costs. In addition, the research used FCTs from several countries due to a lack of data for Kenya. In cases where the exact match of the food commodity was absent, the closest match was taken. Therefore, there were sources of errors in approximating the nutritional content of some food items.

The bioavailability of nutrients in IVs and their modification through various processing techniques in terms of preservation and cooking methods were not taken into consideration in the analysis of their nutrient contents. It should also be noted that the HORTINLEA household survey is not representative at a national level. However, relatively large samples were taken within each county, which makes the data to offer a comprehensive overview of indigenous vegetable producers in rural and peri-urban areas. Hence, the results of the analysis of the survey data could be generalised to indigenous vegetable producers in rural and peri-urban areas.

CONCLUSION

African nightshade is identified as the most consumed IVs in the sampled households in Kenya. It provides the largest share of dietary energy consumption, with an average of 43 kcal/person/day. In terms of dietary protein consumption, amaranth is found to provide the highest share and is cheapest source of proteins. It provides an average of 4.9 g/person/day, which meets 8% of the protein requirement of adults. Evidently, IVs can be used as supplement to fill the protein gap. Given that most of the IVs consumed are from own production, they could provide a much-needed macronutrients namely protein and energy. This is especially true in rural areas where the average consumption of IVs is higher than in peri-urban areas.

It is perceivable that the inclusion of IVs in diets has the potential to increase the nutrient content and improve the palatability of meals. This research recommends that policy makers consider employing the sustained use of IVs as an agricultural strategy to combat food insecurity, especially in rural and peri-urban households. The results of this investigation can be used to upscale and promote indigenous vegetables and mark them as being beneficial in terms of policy interventions. Finally, it is recognised that IVs can also make an extensive contribution to diets in terms of macronutrient contribution. In this respect, further research is needed on the micronutrient contribution of IVs and on their medicinal values at a micro-level using household survey data.

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Table 1: Socio-demographic characteristics of Households surveyed in selected rural and peri-urban counties in Kenya

Characteristics	Sample (n)	%
Total number of individuals	6,919	
Total number of households	1232	
Mean age household member	25.9	-
Mean household size	5.6	-
Average land ownership	1.58 acres	-
Education of household head (n=1234)		
No education	84	6.8
Primary education	477	38.6
Secondary education	503	40.8
Tertiary education	170	13.8
Gender of household head (n=1234)		
Male	978	79.3
Female	236	20.8
Area of residence of household		
Peri-urban	424	34.4
Rural	808	65.6
Occupation of household head		
Managers and professionals	222	18.2
Technicians and clerical support	36	3.0
Services and sales workers	114	9.3
Agriculture, forest fishery workers	771	62.5
Without occupation	87	7.1

Source: Author's calculation based on HORTINLEA Survey, 2014

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