

Food Security and Nutritional Outcomes of Households Producing Selected Fruits and Vegetables in Kenya

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Abstract

Fruits and vegetables play very important roles in the livelihoods of both producers and consumers. However, commercialization of these horticultural value chains could result in farmers selling all their produce and using their economic benefits on other things other than nutrition of their households. This study investigated the food security and nutritional impacts of producers of select horticultural value chains of mango, tomato, and vegetable cowpeas. The study was conducted through household survey using a pretested questionnaire. The study areas were purposively selected based on predominance of the selected value chains. For mangoes, Makueni and Kilifi counties were selected. For tomatoes, Kajiado and Homabay counties were selected; while for cowpeas, Makueni and Kisumu counties were selected. The key nutritional indicator variables were analyzed including food expenditure, food security using Household Food Insecurity Access Scale tool and dietary quality using Dietary Quality Questionnaire for Kenya. The overall results showed that about 53.3% of all surveyed households were food secure, while 24.7% of the households were either moderately or severely food insecure. The dietary quality was quite similar across the various value chains except in Kilifi County where lower scores for the dietary quality indicators were realized. The multiple regression analysis indicated that the factors which significantly resulted to food insecurity and diet quality include the number of years spent in school by the household head, size of agricultural land, age of the household head and number of household members. Even though mango, tomatoes, and cowpeas, which are all commercial crops, presents a great advantage of nutrition and economic power to the farmers, the nutrition status of these farmers is still of concern. Factors, such as income, seasonal variation, limited nutrition knowledge, gender inequities, and environmental constraints, could be hindering the ability of farming households to achieve diverse and balanced diets. This points to a great need for interventions that enhance household food security among farming households such as promotion of nutrition sensitive agriculture, nutrition education and gender equity in household decision making.

Categories: Food security and sustainability, Field & Horticultural crops sustainable production, Food nutrition

Keywords: value chain, food insecurity, dietary quality, indicator, nutrition

Introduction

The horticultural sector in Kenya is indicated as one of sub-Saharan Africa's principal success stories. The sector is one of the key drivers of Kenya economy due to it booming trade relationship with European Union and its significant contribution to food security and household incomes to a large number of households involved in the value chain [1-4].

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About 95% of total Fresh Fruits and Vegetables (FFV) production is marketed locally indicating an overwhelming dominance of the domestic market vis-a-vis the exports market in terms of utilization of the total FFV production volumes. FFVs are essential for well-balanced diets, as they provide essential nutrients, phytonutrients, and fiber, and are strongly associated with overall good health and reduced risk of lifestyle diseases [5]. Hence, just like in other parts of the world, consumption of FFVs as part of a healthy diet is a craze that has taken Kenyans by storm in the past decade. Kenya is a large producer of tropical fruits like mango. However, the exports of these fruits are of less significance since most of these fruits are consumed domestically with low outward orientation of these products [6].

Production and consumption of vegetables and fruits have been reported to be on the rise in Kenya, with an annual growth rate of vegetable production placed at 5.46% [7]. This is due to recent research which has shown that they are rich in vitamins, minerals and bioactive compounds and could provide cheaper and more sustainable solution to food insecurity and malnutrition [8-10]. However, the problem of malnutrition still persists, with reports that consumption of vegetables is still much lower than the recommended amounts by the World Health Organization (WHO) [11]. Most parts of Africa still experiences the triple burden of malnutrition encompassing undernutrition, overnutrition and micronutrient deficiencies [12,13].

Horticultural products contribute to food security and improved nutrition in Kenya, comprising fruits like mango, exotic vegetables like tomato, and indigenous vegetables like cowpea, playing a major role in the livelihoods and food systems of smallholder communities. The cultivation of these fruits and vegetables provide a diverse range of nutritious food options, making them highly relevant for addressing the persistent challenges of malnutrition, micronutrient deficiencies, and low dietary diversity in rural households. While people are more aware of the health benefits of vegetables and fruits, their desirability is still low and even associated with the rural settings [14]. Despite the nutritional potential of these crops, malnutrition continues to affect many farming regions in Kenya. Studies suggest that access to nutritious food does not always translate into improved nutrition outcomes due to factors such as poor dietary habits, gender inequalities, market pressures, and environmental constraints. Most farming households, in some cases, commercialize their farming, leading the households to prioritize selling nutrient-rich foods rather than consuming them. This commercialization dynamic creates a paradox where producers of nutritious crops do not necessarily exhibit better nutrition outcomes. Other factors that could determine nutrition in the households include food consumption patterns, seasonality of the crops, nutrition knowledge, environmental challenges that affect production and even loss of nutrients along the value chain, such as with poor handling and poor cooking methods, which have negative effects on the nutrients. Reports also indicate that the diets of most farming households have also been evolving from the traditional foods to more refined foods, a transition that is being experienced globally [15].

In Kenya, about 30% of the total population is under nourished, with food insecurity and undernutrition being most prevalent in rural areas [16]. Production of fruits and vegetables provides opportunities to promote nutrition and plays a key role in achieving better community food systems by determining availability, affordability quality, and acceptability of different products [17,18]. Achieving these requires strategies that increase productivity to provide enough food, but will also require that markets function efficiently to provide producers with stable incomes to sustain a decent standard of living and consumers with safe, affordable, and nutritious food. Most interventions that have been put in the horticultural value chains have historically been mainly on increased income for stakeholders along the value chain, and have not put nutritional aspects into consideration, either in terms of improving the nutrition of producers or of consumers. Despite strategies employed along the value chains, win-win outcomes may still not be possible in terms of nutrition and economic values for horticultural products.

The directions and magnitudes of the relationships between factors that affect food security and household nutrition have been shown to vary across studies [16]. There is, however limited knowledge on how these factors vary across certain horticultural value chains, and nutritional-related vulnerabilities of horticultural farming households. Such information would be very crucial in informing value chain-based interventions and strategies [16].

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This research aims to determine the food and nutritional security impacts of selected horticultural products in households in Kenya. The study focused on specific horticultural value chains which have been selected based on high production and economic importance nationally, and include vegetables cowpea, mango, and tomatoes [3].

Therefore, this research seeks to: (1) assess the state of food and nutrition security among producers of cowpeas, tomato, and mango across different counties in Kenya, (2) explore the factors that determine the food and nutrition security of these farming households. The comparison of food and nutrition security status and determinants among the fruit and vegetables farming household seeks to explain whether participation in selected crops is in any way related to the producer's food and nutrition security situations.

Conceptual framework

Food and nutrition security among agricultural households is influenced by the interaction between production systems, livelihood resources, and household-level food utilization practices [19]. This study was guided by the Sustainable Livelihoods Theory, the Food and Nutrition Security Framework, and the Agriculture-to-Nutrition Pathways Framework, which together explain how horticultural crop production contributes to improved household food and nutrition outcomes [20-22].

The Sustainable Livelihoods Theory provides the basis for understanding horticultural crop production as a livelihood strategy through which households utilize available resources to improve their well-being [23]. Farmers depend on livelihood assets such as land, water, labor, financial resources, farming knowledge, technology, and institutional support to engage in horticultural production. Access to these resources influences production levels, crop diversity, and productivity, which subsequently determine household food availability and income-generating capacity [24]. The Food and Nutrition Security Framework explains that food security is achieved when households have adequate access to sufficient, safe, and nutritious foods [21]. The framework explains that production of fruits and vegetables increases the availability of nutrient-rich foods at household level, while the sale of surplus produce generates income that improves access to a wider range of foods. Subsequently, increased consumption of horticultural crops enhances dietary diversity and improves micronutrient intake, contributing to better nutrition outcomes [22]. The Agriculture-to-Nutrition Pathways Framework further explains the mechanisms through which agricultural activities influence nutrition [20,22]. Horticultural production affects nutrition through three major pathways. The production pathway improves household access to fruits and vegetables, the income pathway increases purchasing power for diverse foods, and the empowerment pathway influences household decisions regarding food allocation, consumption, and resource use [22].

Based on these theories, the conceptual framework proposes that horticultural crop production is the independent variable influencing food and nutrition security outcomes through three intermediate pathways: food availability, economic access, and dietary diversity. Horticultural production is determined by factors such as crop diversity, land allocation, availability of inputs, irrigation, production technologies, farmer knowledge, and extension support [25-27]. These factors influence the quantity and quality of horticultural produce available to households. The ultimate outcome is improved food and nutrition security, reflected through increased household food availability, improved dietary diversity, better food consumption patterns, reduced seasonal food shortages, improved micronutrient intake, and reduced risk of malnutrition. However, the relationship between horticultural production and nutrition outcomes could face tradeoffs, which can directly affect the livelihoods of the households [28].

Materials And Methods

Study areas and design

The study utilized the dataset from a household survey conducted in 2024 under the Feed the Future Horticulture Innovations Lab project titled "Determining the Trade-Offs Between Short and Long Horticulture Value Chains in Kenya." The household survey covered five counties in Kenya for the three selected value chains, including Makueni and Kisumu

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for cowpea, Makueni and Kilifi for mango, and Kajiado and Homabay for tomato. These were purposively selected based on production volumes as documented by Horticultural Crops Directorate (HCD) in Kenya [3]. Two sub-counties were then selected purposively from the counties on the basis of their production of the horticultural products.

Makueni, Kajiado, Kilifi, Homa Bay, and Kisumu counties have diverse climatic conditions and soil characteristics that influence agricultural activities. Makueni and Kajiado counties experiences a semi-arid climate characterized by high temperatures, low rainfall, and frequent droughts. Their soils are mainly sandy loams, clay loams, and shallow soils, while Kajiado has places with volcanic soils. Kilifi County has a warm and humid coastal climate influenced by the Indian Ocean, with moderate bimodal rainfall. Its soils are largely sandy coastal soils, sandy loams, and clay soils. Homa Bay and Kisumu counties experiences a tropical sub-humid climate with moderate rainfall and warm temperatures due to their proximity to Lake Victoria. The soils are mainly clay loams, sandy loams, and fertile alluvial soils, though erosion can occur in upland areas.

The study employed household surveys to identify pathways through which the selected value chains impacts on nutrition of households. The study focused on specific horticultural value chains which were selected based on high production and economic importance nationally, including traditional/indigenous vegetable (cowpea), tropical fruit (mango), and exotic vegetable (tomatoes).

Sampling procedures and participants

This study developed a sampling frame for each of the targeted respondents in the selected value chains. Systematic random sampling technique was employed to identify the households. The survey was conducted with household heads or a representative of each sample household. A mixed sampling technique, which involves the use of purposive sampling together with stratified and probability sampling techniques was employed while taking into account their appropriateness in responding to the objective of the study for each value chain. Selection of participants for the survey took into account gender, age, and location and was done with the help of local agricultural officers and leaders of existing farmer groups. The total samples size for all the three value chains was 908. The sample size was determined by the formula as follows [29]:

$$x = \frac{Z^2 pq}{e^2}$$

Where x = sample size, Z = value of Z -score at 95% confidence level (1.96), e = sampling error at 5%, p = maximum population variability at 50%, i.e. (0.5), and $q = 1 - p$ (0.5).

Data collection and management

A survey tool targeting horticultural producing households was developed into an elaborate digitized questionnaire (CS-PRO). The tool targeted information on various themes including demographic and farm-level characteristics, household livelihoods, food security, and nutrition. Before the data collection, an enumerator training was conducted, followed by questionnaire pre-testing with real farmers in one of the counties to evaluate effectiveness in capturing the intended data. The enumerator training purpose was to assist the enumerators understand the questionnaire, get appropriate translation on questions into Kiswahili, understand data types, data quality, probing skills, and operation of the data collection software installed in tablets. The outputs from the pre-testing were used to modify the questionnaire into a final version. During fieldwork, each of the enumerator used a programmed tablet to collect data. At the end of each data collection day, the devices were synched with the server so that the data are transmitted automatically to the server. Quality checks were conducted on the data in the server to ensure consistency and accuracy.

Measurements of key variables

The key variables in this study included food expenditure, food security, and dietary quality. Food expenditure was measured as the total amount of money spent on food items in the household every month. Food security was measured using household food insecurity access scale (HFIAS) tool developed by the Food and Nutrition Technical Assistance

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(FANTA) project [30]. This tool presents nine questions which covers three food insecurity domains including (a) anxiety and uncertainty about household food supply, (b) insufficient quality of food in terms of variety, preference, and social acceptability, and (c) insufficient food intake and its physical consequences [15,30]. The indicator also categorizes the households into four: food secure, mildly food insecure, moderately food insecure and severely food insecure; depending on the responses to the nine questions.

Dietary quality was measured using Dietary Quality Questionnaire (DQQ) for Kenya developed by the Global Diet Quality Project, 2021 (<https://www.dietquality.org/countries/ken>). The DQQ-Kenya tool gathers data on food group consumption, required for calculating diet quality indicators, and comprises a set of 29 yes/no questions. This was used to determine dietary quality indicators including Minimum Dietary Quality for Women (MDD-W), Dietary Diversity Scores (DDS), Non-Communicable Disease (NCD)-protect and risk scores and adherence to dietary guidelines food groups consumption (All-5).

The household DDS was calculated by counting the food groups consumed across the following 10 food groups: (1) grains, white roots and tubers, and plantains, (2) pulses (beans, peas, and lentils), (3) nuts and seeds, (4) dairy, (5) meat, poultry and fish, (6) eggs, (7) dark green leafy vegetables, (8) vitamin A-rich fruits and vegetables, (9) other vegetables, and (10) other fruits. The MDD-W was defined as consumption of 5 or more of the 10 food groups by women respondents of reproductive age (15-49 years) [31]. The NCD-protect score reflects consumption of a variety of plant-based foods considered healthy and are associated with lower risk of NCDs. It is based on the consumption of nine healthy food groups including whole grains, pulses, nuts and seeds, vitamin A-rich orange vegetables, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, citrus, and other fruits. The NCD-protect score was calculated by counting the food groups consumed with a higher score indicating more health-promoting foods consumption [32].

The NCD-risk score evaluates the consumption of foods that should be avoided or limited in the diet due to their association with high risk of NCDs [33]. This indicator was calculated by counting the foods consumed from eight food groups, which should be limited or avoided, including soft drinks (sodas); baked/grain-based sweets; other sweets; processed meat (double count); unprocessed red meat; deep fried food; fast food and instant noodles; and packaged ultra-processed salty snacks. A higher score indicates higher consumption of foods and drinks to avoid or limit, and correlates negatively with meeting global dietary recommendations for the general population [32].

In addition, we calculated the “All-5” indicator of consuming five globally recommended food groups (starchy staples, vegetable, fruit, pulse, nut, or seed and animal-source food) [33].

Ethical considerations

Research permit was sought from the National Commission for Science, Technology and Innovation (NACOSTI), Kenya. Permission was sought from various local government authorities before undertaking the survey. Informed consent was sought from all the participants who took part in the study. They were assured of their data confidentiality and that the data was to be used solely for the study. Participation in the study was purely voluntary, and all respondents were at liberty to withdraw at any time without any consequences.

Data analysis

At the end of the data collection, all data were exported from the online platform to SPSS spreadsheets for further cleaning and checking of any errors and inconsistencies. The cleaned data were analyzed using IBM SPSS Statistic 27. Descriptive statistics such as frequencies and means were used to describe the food security status and dietary quality indicators. Multiple regression analysis was employed to assess the factors associated with the food security status of the households.

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Results And Discussion

Characteristics of study population

The characteristics of participants involved in this study are presented in Table 1. The selected characteristics are important in assessment of the determinants of household food and nutrition security. All the sampled households had crop farming as the primary source of income, with other sources including livestock farming and pensions.

Characteristic		Mango		Tomato		Cowpea		Overall
		Makueni	Kilifi	Kajiado	Homabay	Makueni	Kisumu	
HH Sample size		147	164	148	146	150	153	908
Household size (Av.)		5	7	5	6	5	6	6
Average age of HH head		56.6	56.5	41.5	41.7	49.2	45.7	48.5
Gender of respondents	Male	101 (68.7%)	117 (71.3%)	142 (95.9%)	128 (87.7%)	87 (58%)	82 (53.6%)	657 (72.4%)
	Female	46 (31.3%)	47 (28.7%)	6 (4.1%)	18 (12.3%)	63 (42%)	71 (46.4%)	251 (27.6%)
Sampled sub-counties		Makueni, Mbooni	Kilifi N., Malindi	Mashuru, Oloitoktok	Suba North, Rachuonyo	Makueni, Kibwezi	Nyando, Kisumu E.	11 Sub-counties
Poverty rates* (%)		44.7	53.0	37.3	28.2	44.7	39.0	41.15
Level of education		3.8	3.1	3.4	3.8	2.9	2.7	3.3
Average annual expenditure (Ksh.)		404,339	392,486	434,446	458,340	357,034	341,404	397,369
Total expenditure on food items Ksh.		267,083	288,535	293,243	305,757	253,674	250,061	276,357
Average % of expenditure on food		68.5	75.0	71.1	68.5	73.5	75.9	72.2

TABLE 1: General characteristics of surveyed household.

*Source: The Kenya Poverty Report: Based on the 2022 Kenya Continuous Household Survey [34].

Mango farmers were generally older compared to tomato and cowpea farmers, while tomato farming households were generally younger. This could indicate that the mango farmers are more established in practice. All the farming households had an average of six members which was similar for all the counties. The study also reports that more men are involved in horticultural farming, with tomatoes farming in Kajiado involving the lowest number of women (4.1%). The farmers generally had basic education, with an average level of some secondary education (Level 3). The expenditure

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levels of all the households were generally high, with the percentages of expenditure on food being higher than those reported for the various counties in the Kenya poverty report 2022, which were 64.2% in Makueni, 60.9% in Kilifi, 60.0% in Homabay, 52.2% in Kajiado, and 55.6% in Kisumu [34]. According to this report, Kilifi County had the highest poverty rates which is an indication of economic vulnerability.

Food insecurity index of the households

To determine food insecurity status, four types of HFIAS indicators were calculated, which provided information on the Household Food Insecurity Access-related Conditions (HFIAC), Household Food Insecurity Access-related Domains (HFIAD), Household Food Insecurity Access Scale Score (HFIASS), Household Food Insecurity Access Prevalence (HFIAP).

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HFIAS Question	Yes (%)	No (%)	Frequency (%)		
			Rarely	Sometimes	Often
Q1. Worry about food	55.4	44.6 ^{FS}	31.3 ^{FS}	18.5 ^{MiFI}	5.6 ^{MiFI}
Q2. Unable to eat preferred food	65	35.0 ^{FS}	32.9 ^{MiFI}	25.1 ^{MiFI}	6.9 ^{MiFI}
Q3. Eat just a few kinds of food	61.9	38.1 ^{FS}	30.1 ^{MiFI}	24.0 ^{MoFI}	7.8 ^{MoFI}
Q4. Eat foods they really do not want to eat	62.1	37.9 ^{FS}	33.0 ^{MiFI}	23.2 ^{MoFI}	5.8 ^{MoFI}
Q5. Eat a smaller meal	52.4	47.6 ^{FS}	29.3 ^{MoFI}	18.1 ^{MoFI}	5.1 ^{SFI}
Q6. Eat fewer meals in a day	48.8	51.2 ^{FS}	29.2 ^{MoFI}	15.6 ^{MoFI}	4.0 ^{SFI}
Q7. No food of any kind in the household	24.2	75.8 ^{FS}	15.7 ^{SFI}	7.3 ^{SFI}	1.2 ^{SFI}
Q8. Go to sleep hungry	16.7	83.3 ^{FS}	11.5 ^{SFI}	4.5 ^{SFI}	0.8 ^{SFI}
Q9. Go a whole day and night without eating	12	88.0 ^{FS}	8.0 ^{SFI}	3.5 ^{SFI}	0.4 ^{SFI}
Average HFIAS					
53.3%	Food Secure (FS)				
21.7%	Mildly food insecure (MiFI)				
19.1%	Moderately food insecure (MoFI)				
5.6%	Severely food insecure (SFI)				

TABLE 2: General household food insecurity access-related conditions of the farming households.

* FS – Food secure; MiFI – Mildly Food Insecure; MoFI – Moderately Food Insecure; SFI – Severely Food Insecure

The HFIAC shows the percentage of household that gave an affirmative response to each of the nine questions, regardless of the frequency, hence showing the households experiencing food insecurity at any level. The indicator is further disaggregated to determine the frequency of the food insecurity condition across households. From the results of this study, the HFIAC existed, despite the varied frequencies (Table 2).

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	Cowpeas VC		Tomato VC		Mango VC		Overall
	Makueni	Kisumu	Kajiado	Homabay	Makueni	Kilifi	
Food Secure (%)	56.5	39.6	56.9	50.5	71.2	46.3	53.3
Mildly food insecure (%)	18.3	29.5	21.9	25.5	11.6	23.3	21.7
Moderately food insecure (%)	17.7	26.8	17.5	18.9	10.5	22.7	19.1
Severely food insecure (%)	6.6	6.9	3.8	5.9	2.6	8.3	5.6

TABLE 3: Household Food Insecurity Access Prevalence per value chain and counties.

The overall results for the Household Food Insecurity Access Prevalence (HFIAP) indicator showed that about 53.3% of all the household were food secure, indicating that these households did not experience any food insecurity or just experienced worry but rarely. Household with mild food insecurity are those that worried about not having enough food, unable to eat preferred food, ate more monotonous diet with some food considered undesirable, but these only happened rarely [30]. Almost a quarter of the surveyed households (24.7%) were either moderately or severely food insecure (Table 2). Household with moderate food insecurity are those that sacrificed quality more often, eating monotonous diet and undesirable food more frequently, cut back on food quantities and number of meals sometimes but did not experience severe conditions; while the severe food insecure households that reported to have cut back on meal size and number more often, and experiences any of the three most severe conditions including running out of food, going to bed hungry, and going a whole day and night without eating, even rarely [30].

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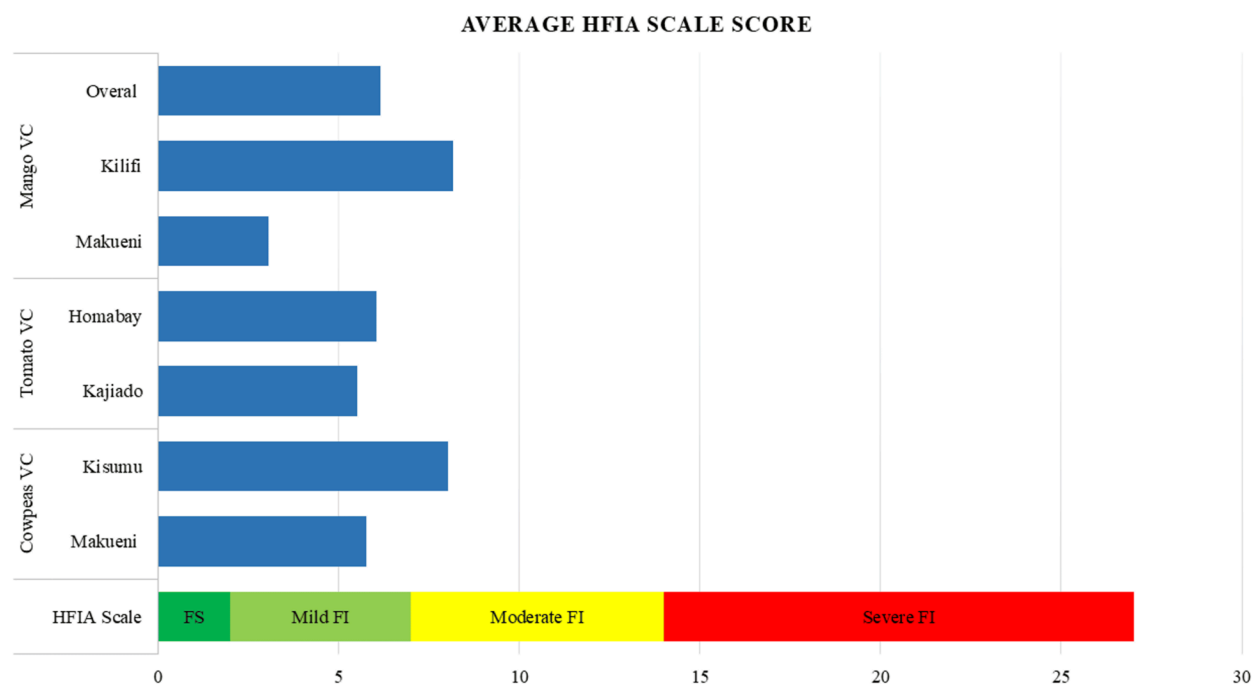


FIGURE 1: HFIA scale scores of the farming households.

HFIA, Household Food Insecurity Access; FS, Food Secure; FI, Food Insecure (Mild FI, Mildly Food Insecure, Moderate FI, Moderately Food Insecure, Severe FI, Severely Food Insecure)

Household Food Insecurity Access Scale score (HFIASS) measures the degree of food insecurity in the household and complements the HFIAP. The indicator measures the frequency of occurrence and only sums the codes for each frequency of occurrence question, hence the maximum score for a household is 27 if all the responses to the nine questions are code 3 [30]. The lower the HFIASS, the better the food security status. From the results of this study, Kilifi mango farming households and Kisumu cowpea farming household had the highest score, getting into the moderate food insecurity on the HFIA scale (Figure 1).

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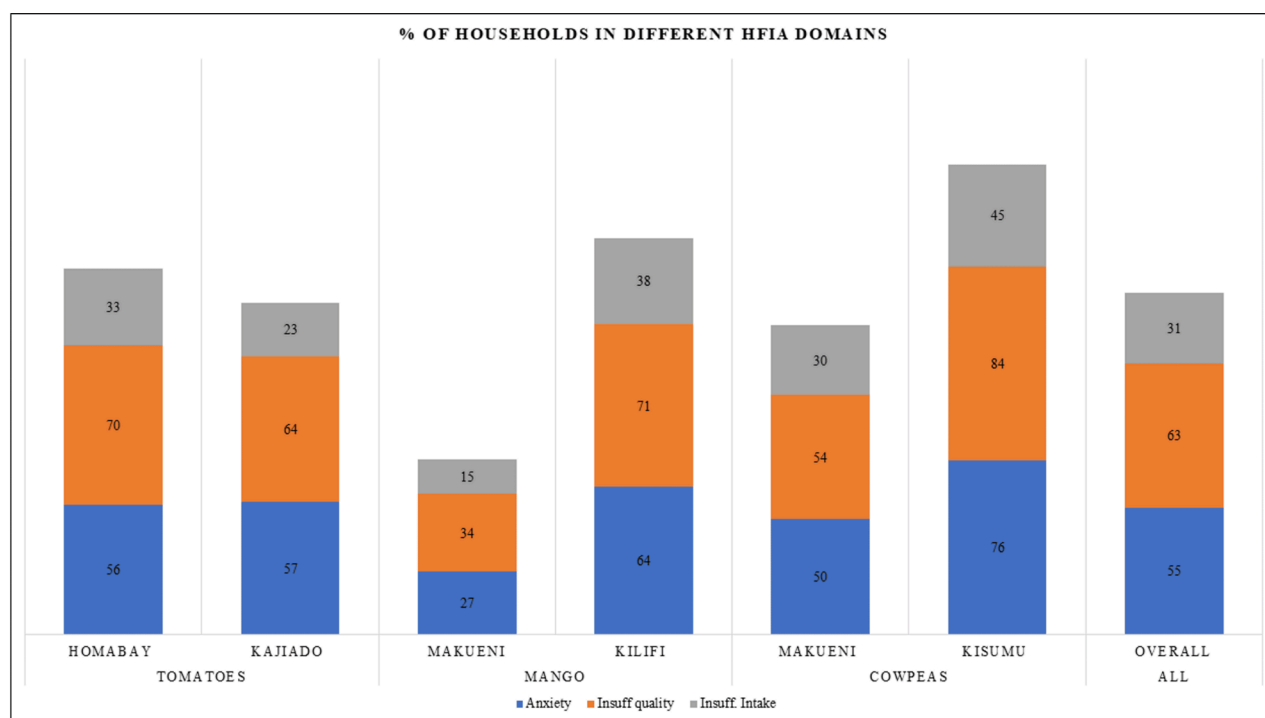


FIGURE 2: HFIA domains.

HFIA, Household Food Insecurity Access

The indicators of the HFIA-related Domains (HFIAD) provided information of households experiencing food insecurity under the domains of anxiety and uncertainty about the household food supply (Yes response to Q1), insufficient quality of food including variety and preferences of the type of food (Yes response to Q1, Q2, Q3); and insufficient food intake and its physical consequences (Yes response to Q5, Q6, Q7, Q8, Q9).

Farmers in Makueni county were leading in food security status, and this was both for mango and cowpea farmers. Cowpea farmers in Kisumu had the highest cases of food insecurity while mango farmers in Makueni had the lowest (Figure 2). The results also showed that producers of the same crop, but from different regions had different food insecurity prevalence, as in the case of mango farmers in Makueni being more food secure than mango farmers in Kilifi County. This clearly indicates that aside from crops, there could be other factors that determine household food security.

Diet quality indicators

Dietary quality is one of the major determinants of malnutrition. With the current evolution of the food system, the quality of diets becomes one of the main public health issues which needs more attention. This study employed the use of 29- item DQQ developed for Kenyan context. The questionnaire asks about the consumption of distinct food groups the previous day and night and can be used to derive indicators for nutrient adequacy and protection against NCDs, including both positive and negative risk factors [32]. The DQQ was used to collect data and determine the MDD-W indicator, DDS indicator, the global dietary recommendations score (GDR), and to capture dietary risk factors for NCDs.

In this study, the population that qualified for the MDD-W indicator, i.e. women aged between 15 and 49 years, was 138 of the total 908 samples (15.2%). The results show that a higher percentage of these women in most counties had a score of five or more, which indicates a likelihood of adequate micronutrient intake. However, 60% of the women in this bracket had lower likelihood of adequate intake in Kilifi County (Table 4).

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			Tomato VC		Mango VC		Cowpeas VC	
Indicator		All, <i>n</i> = 908	Homabay, <i>n</i> = 146	Kajiado, <i>n</i> = 148	Kilifi, <i>n</i> = 164	Makueni, <i>n</i> = 147	Kisumu, <i>n</i> = 153	Makueni, <i>n</i> = 150
MDD-W	Less 5	30 (21.7%)	3 (21.4%)	1 (25%)	9 (60%)	2 (10%)	9 (20.5%)	6 (14.6%)
	More or eq 5	108 (78.3)	11 (78.6)	3 (75%)	6 (40%)	18 (90%)	35 (79.5%)	35 (85.4%)
All-5 (% of <i>n</i>)		7.2	11.6	6.8	0.6	8.2	6.5	10
At least one vegetable (% of <i>n</i>)		96	96.6	97.3	89	97.3	99.3	97.3
At least one fruit (% of <i>n</i>)		48.5	56.2	45.3	28	65.3	47.7	51.3
At least one pulse, nut or seed (% of <i>n</i>)		17	17.8	24.3	12.2	14.3	13.7	20
At least one animal-source food (% of <i>n</i>)		80.5	88.4	68.2	74.4	82.3	86.9	83.3
At least one starchy staple (% of <i>n</i>)		81.4	82.2	87.8	70.7	88.4	71.2	89.3
Dietary Diversity Score (DDS)		4.5	5.1	4.4	3.8	4.4	5	4.6
Zero vegetable or fruit consumption (% of <i>n</i>)		3.3	2.7	1.4	9.1	2.7	0.7	2.7
At least one vegetable or fruit (% of <i>n</i>)		96.7	97.3	98.6	90.9	97.3	99.3	97.3
Pulse consumption (% of <i>n</i>)		17	17.8	24.3	12.2	14.3	13.7	20
Nuts or seeds consumption (% of <i>n</i>)		0.1	0.7	0	0	0	0	0
Whole grain consumption (% of <i>n</i>)		38.7	34.9	41.2	37.2	32	50.3	36
Processed meat consumption (% of <i>n</i>)		10.9	9.6	13.5	5.5	16.3	5.9	15.3
Salty or fried snack consumption (% of <i>n</i>)		82.6	82.9	81.8	65.9	91.8	83	92

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Deep fried food (% of <i>n</i>)	75.1	72.6	75	47.6	91.8	76.5	90
Sweet foods consumption (% of <i>n</i>)	12.2	13	6.8	6.1	25.9	9.8	12.7
Soft drinks (sodas, energy drinks, sports drinks) (% of <i>n</i>)	0.4	1.4	0.7	0.6	0	0	0
NCD-Protect	3.2	3.5	3.2	2.5	3.3	3.5	3.3
NCD-Risk	1.4	1.6	1.3	1.1	1.6	1.4	1.5
GDR Score	10.8	10.9	10.8	10.4	10.7	11.1	10.8

TABLE 4: Diet quality indicators.

*VC, value chain; MDD-W, Minimum Dietary Diversity for women; NCD protect, non-communicable disease protect; NCD risk, noncommunicable disease risk; GDR score, Global Dietary Recommendation score

ALL-5 is expressed as the percent of the population consuming all five recommended food groups the previous day or night [31]. These five food groups include one vegetable, fruit, pulse/nut/seed, animal-source food, and starchy staple. From this study, very low percentage of the household consumed foods from all the five food groups prior to the study. However, there were higher percentages on the consumption from the individual groups, with most households having consumed vegetables, animal source food, and starchy staples.

The DDS is the number of food groups consumed the previous day or night, of the 10 food groups captured in the DQQ indicator: (1) grains, white roots and tubers, and plantains, (2) pulses (beans, peas, and lentils), (3) nuts and seeds, (4) dairy, (5) meat, poultry, and fish, (6) eggs, (7) dark green leafy vegetables, (8) other vitamin A-rich fruits and vegetables, (9) other vegetables, and (10) other fruits [33]. The score is presented as the average number of food groups and ranges from 0 to 10 expressed as an average score for the population with a higher score indicating inclusion of more food groups in the diet. The higher the DDS score, the better the diet quality.

Even though the study involved farmers in the horticultural sector, the results still showed that an average of 3.3% of the surveyed population consumed zero fruit and vegetables the previous day. This could be a nutritional concern since during the survey period, some of these crops were in season. This could point to a clear food and nutritional choices among these households. Other negative nutritional indicators that were associated with high numbers are processed meat consumption (10.9%), salty or fried snack consumption (82.6%), deep fried foods (75.1%), and sweet food consumption (12.2%).

The GDR score ranges from 0 to 18 and indicates adherence to global dietary recommendations, which include dietary factors protective against NCDs. The higher the GDR score, the more recommendations are likely to be met. The GDR score in this study was averagely 10.8, which is greater than half of the highest possible value. This indicates that most farmers involved in mango, tomato, and cowpea value chains are likely to be meeting the recommended diets.

Association between household characteristics with HFIA and DDS

The results of the multiple regression analysis between household characteristics versus food insecurity and dietary quality indicators are presented in Table 5 and Table 6, respectively.

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In both cases, the household dietary diversity score and the food insecurity status significantly and negatively correlated to the HFIAS. This correlation which shows that the poor dietary diversity score associates with high prevalence of food insecurity has been reported in other studies in different areas [35,36].

Factor	Coefficients	Standard Error	t Stat	P-value
Intercept/ Constant	1.606	2.451	0.655	0.512
Dietary Diversity Score (DDS)	-0.448	0.100	-4.478	0.000*
Gender of HH Head	-0.152	0.561	-0.272	0.786
Marital status of HHH	0.227	0.332	0.684	0.494
Age of HH Head	-0.026	0.013	-2.018	0.044*
Education level of HH head	0.059	0.093	0.628	0.530
Years in school by HH Head	0.100	0.051	-1.949	0.055
No. of individuals in HH	0.321	0.068	4.696	0.000*
Size of agriculture land of HH	-0.245	0.049	-4.967	0.000*
Annual average food expenditure	0.000	0.000	-1.904	0.057
Total annual expenditure	0.000	0.000	0.865	0.387
% of expenditure on food	0.123	0.027	4.560	0.000*

TABLE 5: Multiple regression analysis of the factors affecting Household Food Insecurity Access Scale (HFIAS) of households.

*Significant.

The age of the household head was seen to significantly negatively correlate with food insecurity status. This shows that households with older heads had lower rates food insecurity, while those headed by younger individuals had higher food insecurity rates. This appears to be in agreement with the reports that households with older heads are more established economically compared to those with younger heads who could still be working hard on their financial stability [37]. The

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size of the agricultural land owned by the household was negatively associated with the food insecurity status, while the number of household members and the percentage of expenditure that goes to food were positively associated with food insecurity. From these findings, farmers with smaller pieces of land had higher food insecurity case, while those who spend a bigger percentage could be having lower expenditure (and earnings, which mostly just goes to food as the most important basic need).

Factor	Coefficients	Standard error	t Stat	P-value
Intercept/Constant	3.522	0.801	4.396	0.000*
HFIA	−0.049	0.011	−4.478	0.000*
Gender of HH Head	−0.167	0.185	−0.901	0.368
Marital status of HHH	−0.080	0.110	−0.728	0.467
Age of HH Head	0.004	0.004	0.845	0.398
Education level of HH head	−0.001	0.031	−0.038	0.969
Years in school by HH Head	0.086	0.017	5.151	0.000*
No. of individuals in HH	−0.038	0.023	−1.674	0.095
Size of agriculture land of HH	−0.042	0.016	−2.534	0.011*
Annual average food expenditure	0.000	0.000	0.153	0.878
Total annual expenditure	0.000	0.000	1.011	0.312
% of expenditure on food	0.016	0.009	1.722	0.085

TABLE 6: Multiple regression analysis of the factors affecting dietary diversity scores (DDS) of the households.

HFIA, Household Food Insecurity Access. *Significant.

From this study, the number of years spent in school by the household head, size of agricultural land, age of the household head, and number of household members were found to significantly correlate to the food insecurity status and dietary quality of the household (Table 6). Similar factors have previously been reported to associate to nutrition in other regions [38]. This can be explained by reports that better education contributes to increased household wealth [37],

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and that educated household heads may make better nutrition choices. The size of agricultural land was negatively associated with dietary diversity score. Farmers with small lands may be depending on buying of food, hence a diversified diet.

Discussion

Mangoes, tomatoes, and cowpeas are among the most significant cash crops in Kenya. According to the National Agriculture Production report 2025, mango is the second fruit after banana in terms of production, while tomato is the leading exotic vegetable and cowpeas is the leading indigenous vegetable in terms of production and value in Kenya [39]. Most farmers therefore often prioritize selling their produce to meet financial needs such as school fees, farm inputs, and healthcare. Consequently, households may consume less of the nutritious fruits and vegetables they grow, reducing potential dietary benefits.

The nutrition status of mango, tomato, and cowpea farming communities in various counties of Kenya reveals a complex interaction of several factors. Although these households grow nutrient-rich crops, several factors limit their ability to achieve optimal nutrition outcomes. This study reveals differences in the level of food security between the household involved in the different value chains. These variations were influenced by the different regions (counties), crop diversity, demographic factors such as gender and household sizes, income, and household expenditures. The variations in food insecurity among farming households have been previously reported by Mwangi et al. [16], who found out that pastoralists were more food insecure compared to small holder wheat and dairy farmers.

The poor dietary quality of some households could also be due to limited nutritional knowledge. Some households may not diversify diets despite access to multiple foods or prioritize starchy staples over fruits, vegetables, and legumes [20]. These behaviors contribute to nutrition gaps, especially for children under five and women of child bearing age. Low dietary diversities have been previously reported in households that produce their own food compared to those who buy [40]. This could mean that these farming households are sometimes limited to consuming only what they produce [24]. Availability of mangoes, tomatoes, and cowpea leaves fluctuates significantly throughout the year. Mangoes have two seasons in Kenya, with the main season spanning November to February, while the short season runs from May to July. This also usually differs as most places only have one season, while the long season could even be biennial in some cases. During rainy seasons, cowpea leaves are abundant; however, they are scarce in dry seasons due to low or no production, low adoption of drying and preservation methods. Similarly, tomato availability fluctuates mostly due to market-driven production cycles, pest pressure, and rainfall patterns.

Gender dynamics could also play a role in household nutrition [28]. Women play a critical role in food preparation and some farming activities but often have limited control over the income derived from these crops. Male dominance in marketing decisions can reduce household spending on nutritious foods. A previous study by Vo et al also indicated that households led by educated women are associated with higher household wealth, which would then translate to higher purchasing power and better nutrition [37]. External factors such as environmental and agronomic issues may also relate to household nutrition [41,42]. Frequent pest outbreaks, climate variability, droughts, and poor post-harvest handling reduce yields, incomes, and household food supplies [43-45]. These environmental pressures worsen household food security and lead to unstable diets.

Mango, tomato, and cowpea farming communities in Kenya have immense potential for improved nutrition due to the nutrient-rich nature of their crops. However, the benefits of production do not automatically translate into improved nutritional outcomes. Food security can be realized through production or purchasing at affordable prices from markets using household income [46]. Income prioritization, seasonal variation, limited nutrition knowledge, gender inequities, and environmental constraints hinder the ability of farming households to achieve diverse and balanced diets.

Addressing these challenges requires coordinated interventions that integrate agriculture, nutrition education, gender empowerment, climate resilience, and value-chain development. With stronger support systems and improved household practices, these communities can greatly enhance their nutritional wellbeing. While food groups consumption data can be used to indicate adherence to global dietary recommendations at population level, this indicator can also be used to track progress of populations towards meeting WHO guidance on healthy diets [47]. Food security and diet status

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of individuals from farming households may vary in different months. This is due to seasonal variations of food availability. This study was mainly based on consumption recall, which may vary with different seasons. The study, however, provides evidence of the food security situation among farming household of horticultural products, which may be useful for future research and development decisions.

Conclusions

This study sought to assess the status of the food and nutrition security of small holder fruits and vegetable farmers in selected areas of Kenya. The key findings indicate that there is considerably high prevalence of food insecurity, which could relate to malnutrition cases in the households. The HFIAS results showed that household farming cowpeas in Kisumu County of Kenya are most vulnerable to food insecurity. These findings could also point to the fact that most farmers prioritize income rather than household food and nutrition. The implications of these findings are profound. They underline the urgent need for interventions that enhance household food security in farming households.

From the results of this study, several recommendations are put forward that could improve the nutrition status of horticultural farming household. First, Nutrition-Sensitive Agriculture should be strengthened by promoting home consumption of produce before selling and also encouraging proper use of produce income for nutrition. Secondly, enhancing nutritional education and good dietary practices can be achieved through training on nutrient-preserving food preparation methods, and training both men and women on dietary diversity, nutrition, and household decision making. Thirdly, there is a need to promote gender equity and women's empowerment in horticultural farming by encouraging women participation in farmer groups, and agribusiness trainings. Finally, market systems should also be improved through supportive policies that strengthen market linkages and stabilizing farm-gate prices to protect farmer income. This can also be achieved by increasing the government and county-level support for nutrition-sensitive agriculture programs and integrating nutrition objectives into county development and agricultural planning.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Winnie Nyonje, Mervyn Muriungi, Geoffrey Otieno, Carilus Okoth, Willis Owino

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Supervision: Geoffrey Otieno, Carilus Okoth, Willis Owino

Disclosures

Plant subjects: All authors have confirmed that this study did not involve any herbarium specimen. **Human subjects:** Consent was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** This study was funded by the Feed the Future Innovation Lab for Horticulture through the United States Agency for International Development (USAID). **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

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