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Influence of knowledge, attitude and practices of consumers on the consumption of hydroponically grown fruits and vegetables in Kiambu County, Kenya

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Abstract

Fruits and vegetables are culturally accepted foods consumed by a majority of people worldwide. Knowledge, attitude and practices of consumers have been found to influence the choice and consumption of foods in many populations. However, little is known on their impact on consumption of foods that are produced using novel farming methods such as hydroponic farming, in Kenya. For this reason, this study assessed the influence of knowledge, attitude and practices (KAP) on the frequency of consumption of hydroponically grown fruits and vegetables (FAVs) in Kiambu County, Kenya. A cross-sectional design, involving a consumer survey of 310 randomly selected participants, was used. A pretested structured questionnaire was used to conduct face-to-face interviews. Data was analyzed using SPSS where descriptive statistics and binary logistic regression were applied. The results showed that a majority of the participants (89%) had good knowledge about the quality and safety of hydroponically grown FAVs. They also used good practices in handling the FAVs (69%). However, the overall attitude towards hydroponic foods was negative (2.54±1.204). With regard to the influence of KAP on the frequency consumption of FAVs, knowledge was the only predictor of the frequency of consumption of fruits ($p=0.002$, $\beta=1.639$) and vegetables ($p=0.044$, $\beta=1.232$). Based on sociodemographic factors, age and the level of education significantly influenced the frequency of consumption of FAVs. In conclusion, the frequency of consumption of hydroponic FAVs is influenced by the level of knowledge of consumers on the quality and safety of foods grown in this system. Nutrition education on the quality and safety of hydroponically grown foods should be conducted so that consumers are informed about the hydroponically grown nutritious foods and also gain a positive attitude towards this new sustainable farming system.

Keywords: *Knowledge, attitude, practices, hydroponic farming, soil-based system*

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Introduction

Consumption of fruits and vegetables (FAVs) is considered a good health behavior because of the numerous benefits associated with these foods (Ramos *et al.*, 2013). In effort to reduce progression and severity of non-communicable diseases (NCDs), nutritionists and medical practitioners are redirecting their key messages in the nutrition counselling sessions towards increased intake of FAVs. Similarly, the World Health Organization (WHO) recommends intake

of 400g/d of FAVs (equivalent to 5 servings per day) to prevent NCDs (Frank *et al.*, 2019). However, the frequency of consumption of these foods has remained low among most consumers in several countries for quite some time. This has been attributed to unavailability, low affordability, inaccessibility and misinformation about the importance of FAVs in the diet (Frank *et al*., 2019; Okop *et al*., 2019). To address some of these challenges, researchers and innovators in the agricultural sector have tailored their efforts towards increasing the availability and accessibility of these foods by using farming methods such as hydroponic system that produce high yields within a short period throughout the year (Haddad, 2021; S.N and V.L, 2020). The benefits of this system are witnessed in most of the developed countries such as United States, Australia and Japan where tons of nutritious foods are being sold on the international market in and out of season (Gumisiriza *et al*., 2020). As a matter of fact, the adoption rate of this system has risen among both the subsistence and commercial farmers since it is considered sustainable and cost-friendly in food production after the initial set-up. On the other hand, the system is new in most of the developing countries with only countable farmers installing it. This implies that the crop production method in these countries is still reliant on the soil-based system that is subject to the shortcomings of climate change, low yields and less nutritious foods. In Kenya, hydroponic farming has been introduced to a number of farmers in Kiambu County which is a rich agricultural area for several food crops. There is optimism that more farmers will follow suit to adopt hydroponic farming system with more training on how to set up and manage crops in this system (Binge, 2019). In the long-run, soil-based system might be replaced considering the continual deprivation of natural resources and the need to get enough produce to feed the whole nation (Jagtap *et al*., 2022).

Nonetheless, the preference and consumption of foods produced in different farming methods is a consumer-based decision even if farmers and the stakeholders approve the role that hydroponic system plays in relation to food production. Of keen interest in this study is impact of knowledge, attitude and practices (KAP) of consumers on the frequency of consumption of hydroponically grown FAVs. It has been established that high level of knowledge about the foods presented to the consumer influences the decision to take the food. Many researchers have also suggested that awareness, and adequacy of knowledge about the existence of food and its attributes helps consumers to make informed choices before consumption of the respective foods (Spronk *et al*., 2014). Consumers get information from various sources ranging from education programs, social media, advertisements, food experts and informal interactions in the community (Ergönül, 2013). As a result, those who are empowered with the nutritional information have a higher likelihood to consume healthy and nutritious foods compared to others. However, there is paucity of information on the influence of knowledge on frequency of consumption of foods produced in new farming techniques such as hydroponic system. With reference to attitude, a positive consumer attitude might lead to consumption of the food. Attitude is a way of thinking or feeling about something, and it is usually based on the experiences that one has on different aspects of the food which leads to aversion or liking of the food (Patch *et al*., 2005). In the event consumers do not have prior experiences with the food such as those produced in a new farming technique, the attitude is shaped by comparison to the foods produced in the methods that are already in existence. However, consumer attitudes can be altered by modifying the food attributes that are negatively rated; thus, the purpose of this study is to evaluate consumer attitudes toward various aspects of hydroponically grown FAVs. In relation to the practices used in handling foods, some consumers are key on the preservation of the quality and safety of their foods hence consume foods that are properly handled (Gkana and Nychas, 2018). This implies that poor food handling practices might be a reason for some consumers to keep away from consumption of foods that are prepared in or away from the family. It is against this background that this study was tailored to assess the KAP of consumers on the quality and safety of hydroponic FAVs, and their influence on the frequency of consumption of hydroponically grown FAVs in Kiambu County, Kenya.

Materials and methods

Study area

The study was conducted in Kiambu County in August 2021. Kiambu County is located in the central region in Kenya. It borders Nairobi and Kajiado counties to the south, Machakos to the East, Murang'a to the North and North East, Nyandarua to the North West, and Nakuru to the West. It has 12 sub-counties; Gatundu North, Gatundu South, Kiambu, Kikuyu, Githunguri, Limuru, Lari, Kiambaa, Kabete, Juja, Ruiru and Thika East and Thika West sub counties (Kiambu, 2022). Kiambu county was purposively selected because the major economic activity practiced is agriculture. The two sub-counties, Kikuyu and Kiambu, were purposively selected because they had more hydroponic farms compared to other sub-counties. The map of Kiambu county is presented in Figure 1.

Figure 1: The map of Kiambu county, Kenya (Courtesy of Kiambi et al., 2021)

Study design

A cross-sectional study design involving face-to face interviews was used to assess KAP of consumers on the frequency of consumption of hydroponically grown FAVs.

Study Population

The study population comprised of randomly selected consumers of FAVs in Kiambu and Kikuyu sub-counties. The residents of these sub-counties were the ideal sample to assess the KAP towards the quality and safety of hydroponically grown FAVs since hydroponic farming system is mostly practiced in these areas.

Inclusion criterion

The eligible participants were persons in the household above the age of 18 who normally purchased and/or prepared FAVs for consumption in the family.

Exclusion criterion

Consumers aged above 70 years were excluded from the study even if they were involved in the

preparation and /or purchase of FAVs. This was based on the understanding that old age is mostly associated with reduction in the memory capacity of an individual (Zhen, 2016) hence a high likelihood of misinformation on the questions in this study on consumer practices which relied mainly on recall. Consumers who were sick or had covid-19 (evidenced by fever) were also excluded from the study.

Sampling

Sampling Frame

The sampling unit was the households in Kiambu and Kikuyu sub-counties that obtained FAVs from farmers and/or vendors. The participants in these households were persons aged between 18 to 70 years, whose roles were either purchasing and/or preparing FAVs for the family. The households were selected using a simple random technique.

Sample size determination

The sample size was 310 participants. It was determined using Cochran's formula ($n_o=Z^2pq/e^2$) (Cochran, 2003) as illustrated below;

Sample size $n_o=Z^2pq/e^2$ …… Equation 1

n_o= (1.96*1.96*0.21*0.79)/ (0.05*0.05) =255

Assuming 18% attrition rate;

255/0.82=310 n=310

where n is the sample size being determined, Z is the level of significance at 5%, P is the proportion (21%) of households consuming FAVs in Kiambu County according to Lans *et al*., (2019) and e is the estimated level precision of 5%. Assuming non-responsiveness from participants, the calculated sample size was adjusted by 18% giving a total of 310 people.

Data Collection

Data was collected by a team of six research assistants who had experience in using online data collection tools and conducting nutritional surveys. The research assistants were well versed with Kikuyu language which most of the participants spoke and understood in these sub-counties. A one-day virtual training was conducted for the enumerators to familiarize with the research questions. Training on the standard operating procedures to prevent infection and spread of covid-19 was also done.

Data collection tool

A structured questionnaire was designed and uploaded on Open Data Kit (ODK) app to facilitate face to face interviews. The questionnaire had four sections where section one captured data on the sociodemographic characteristics of consumers while section two, three and four captured data on the knowledge, attitude and practices of consumers on the quality and safety of hydroponically grown FAVs, respectively. The questionnaire was pretested on five people in Ndumbuini area, Kiambu County. Misinterpreted and ununderstood questions were noted and corrected, and the number of questions was adjusted to reduce the length of the questionnaire. Pretesting also helped to check the reliability and validity of the questionnaire as well as the feasibility of the study. The time-taken to interview each participant was approximately 15 minutes. The participants were excluded from the actual data collection process.

Assessment of knowledge, attitude and practices of consumers on the quality and safety of hydroponically grown fruits and vegetables

To measure the knowledge of consumers on the quality and safety of hydroponic FAVs, six absolute statements were read to the participants who responded by choosing the appropriate options that were categorized as 'true', 'false' and 'I don't know' and coded as 1, 2 and 3, respectively. Since all the statements were positively phrased, the interpretation of these responses was that the respondents who chose 'true' had good knowledge while those who chose 'false' or 'I don't know' had poor knowledge on the aspects of hydroponic FAVs that were being assessed. The overall knowledge of each participant was obtained by creating a new variable where the mean of the six statements were calculated. A mean of one represented good knowledge while a mean of 2

and 3 represented poor knowledge on the quality and safety of hydroponically grown FAVs.

The attitude of consumers towards the quality and safety of hydroponic FAVs was measured using 15 statements which the participants responded on a five-point likert scale where 1=strongly disagree to 5=strongly agree as used by Kokthi *et al.*, (2015). To obtain the overall attitude, two statements that were negatively phrased were reversed and a new variable was created where the means of the 15 statements were obtained per participant. Attitude was then categorized into two where a mean ranging from 1 to 3.49 represented negative attitude while a mean above 3.50 represented a positive attitude (Balschweid and Thompson, 2002).

To assess the consumer practices that that impact the quality and safety of hydroponically grown FAVs, seven close-ended questions were used. The participants responded by picking only one option from the range of responses that were provided per question. The responses entailed the established good and poor practices in handling FAVs. Therefore, new variables from each question were created with only two responses where code 1 represented good practices while code 2 represented poor practices. The overall nature of practices was then obtained by calculating the means of the seven new variables where a mean of 1 indicated good practices while a mean of 2 indicated poor practices.

Data analysis

Data were exported from ODK database to Statistical Package for the Social Sciences software (SPSS) version 25 for analysis. The sociodemographic characteristics of consumers were analyzed as frequencies and percentages.

Level of knowledge, attitude and practices of consumers on the quality and safety of hydroponically grown fruits and vegetables

The overall level of knowledge was analyzed as means where a mean of one represented good knowledge which was coded as 1, and a mean of two and three represented poor knowledge that was coded as 0. The frequencies and percentages of participants with good and poor knowledge were then obtained. The attitude of participants was analyzed as means and standard deviations. A mean ranging from 1 to 3.49 represented negative attitude while a mean above 3.5 represented a positive attitude (Balschweid and Thompson, 2002). The practices of participants in handling FAVs were analyzed as means where a mean of one indicated good practices while a mean of two indicated poor practices. The frequencies and percentages of participants segregated by the nature of practices in handling FAVs were then obtained.

The predictors of the frequency of consumption of hydroponically grown fruits and vegetables in Kiambu County

A binary logistic regression model was used to determine the predictors of consumption of hydroponic FAVs. These entailed the sociodemographic characteristics, level of knowledge, attitude and practices of participants. The binary dependent variables were the frequency of consumption of fruits and the frequency of consumption of vegetables. In this study, the frequency was categorized into two where a weekly consumption of fruits or vegetables of less than three times indicated low consumption hence coded 0 while the frequency above four times (Lim and Kim, 2019) indicated high consumption hence coded 1. A Pearson correlation was run to test the association of independent variables before running the regression model. Gender was found to highly correlate with age (0.796) and the level of education of participants (0.935) at a cut off of 0.70 according to Dorman and Fraser, (2009). As a result, gender was excluded from the model and hence the independent variables were age, level of education, level of knowledge and nature of practices which were categorical variables, and attitude of participants which was an ordinal variable. The model was run at 5% level of significance following the equation outlined below;

$$\mathbf{Y_i}=\boldsymbol{\alpha}+\boldsymbol{\beta 1 X1}+\boldsymbol{\beta 2 X2}+\boldsymbol{\beta 3 X3}\ldots.\boldsymbol{\beta 5 X5}+\mu\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Equation 2

Where $\mathbf{Y_i}$ is the binary dependent variable depicting the frequency of consumption of fruits and the frequency of consumption of vegetables,

X_1 **to** X_5 are the independent variables, **α** is the regression constant, **β** is the regression coefficient and μ is the error term.

Ethical consideration

Respondents signed a consent form to show their willingness to participate in the study. Their confidentiality was protected by use of codes. Respondents were not discriminated on any grounds. Participation was free of charge and no one was coerced to take part in the study. Standard operating procedures were followed so as to prevent infection of research assistants and participants with Covid-19.

Results

Distribution of the sociodemographic characteristics of consumers

The distribution of the sociodemographic characteristics of FAVs consumers is presented in Table 1. The results show that the majority (56%) of the study participants were male. More than a half of the participants (54%) were middle-aged adults between 31-50 years, and had attained a secondary school level of education (51%). It was interesting to note that 50% of the participants who were involved in the preparation of FAVs in the family were male. However, a considerable proportion of female participants (44%) highlighted to be involved in both the preparation and purchase of FAVs for family consumption. With regard to consumption of fruits and consumption of vegetables, the overall frequencies were above average where one was the minimum level and seven the maximum in this study. Nonetheless, the study participants consumed vegetables at a slightly higher frequency than fruits.

Table 1: Distribution of the sociodemographic characteristics of fruits and vegetables' consumers in Kiambu Counties

Characteristics N=310	**Category**	**N**	**%**
Gender	Male	173	56
	female	137	44
Age (years)	15-30	128	42
	31-50	172	54
	51-70	10	4
Education level	Primary	46	15
	Secondary	158	51
	Tertiary	106	34
Role played in the household	Preparation of FAVs	155	50
	Purchase of FAVs	19	6
	Preparation and purchase of FAVs	136	44
Frequency of consumption of fruits in a week	Mean	4.64±1.930	
Frequency of consumption of vegetables in a week	Mean	5.35±1.675	

Influence of knowledge, attitude and practices of consumers on the frequency of consumption of hydroponic fruits and vegetables

Knowledge of consumers on the quality and safety of hydroponic fruits and vegetables in Kiambu County

The proportions of consumers segregated by the level of knowledge on the quality and safety of hydroponic FAVs are presented in Figure 2. Majority of the participants (89%) had good knowledge on the quality and safety of hydroponically grown FAVs.

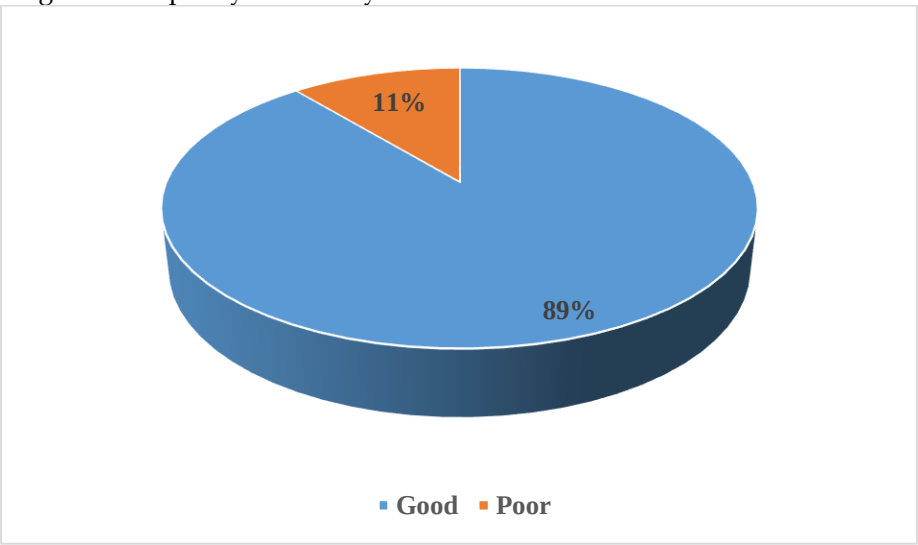

Figure 2: The level of knowledge of consumers in Kiambu County on the quality and safety of hydroponic fruits and vegetables

Table 3 presents results on the level of knowledge of consumers on each statement on quality and safety of hydroponically grown FAVs. Most consumers seemed to be more enlightened about the safety of FAVs hence contributing to the overall high level of knowledge as shown in Figure 2. On the other hand, their knowledge on the nutritional quality of hydroponic FAVs was quite low where only 36% had good knowledge that hydroponic FAVs had higher nutritional content compared to those grown in other farming techniques (Jan *et al.*, 2020; Majid *et al.*, 2020).

Table 2: The level of knowledge of consumers on statements on quality and safety of hydroponically grown fruits and vegetables

	Statements	Level of knowledge				comments
		Good		Poor		
		n	%	n	%	
1	Hydroponic FAVs have good visible qualities	99	32	211	68	I have never seen any them. This farming technique makes FAVs to be unusually big.

2	Hydroponic FAVs have better invisible qualities	111	36	199	64	I don't know about the nutrients that are there in fruits and vegetables. All fruits and vegetables have similar nutrient content.
3	Pesticides and fungicides make hydroponic FAVs unsafe	260	84	50	16	I agree, and it makes us predisposed to negative health outcomes.
4	Farming practices make FAVs unsafe	302	97	8	3	The operations determine safety since the farmer is in charge of supplying nutrients in the water.
5	Proper washing and cooking reduce chemicals from FAVs	294	95	16	5	Yes, it removes pesticides, toxins and germs. It's absolutely true, washing and cooking removes residues from fruits and vegetables
6	Storage and handling techniques affect quality of FAVs	295	95	15	5	Poor handling during storage causes contamination

Attitude of consumers towards quality and safety of hydroponically grown fruits and vegetables in Kiambu County

The results on the attitude of consumers on the quality and safety of hydroponically grown FAVs are presented in Table 3. Overall, the consumers had a negative attitude (2.54±1.204) about hydroponically grown FAVs. This was mostly contributed by the aspect of the safety of hydroponic FAVs. Consumers were skeptical about hydroponic food crops being grown for a short period of time (2.32 ± 1.488), they disagreed that hydroponic farming was the safest system for production of FAVs (2.23 ± 1.307) and therefore they were not willing to look for hydroponically produced FAVs in the market for family consumption. Intriguingly, despite a few consumers having good knowledge in the quality of hydroponically FAVs, most of them had a slightly positive attitude about the visible and invisible qualities of hydroponic FAVs (statement 1 and 3) hence rated them higher compared to other aspects.

Table 3: The attitude of consumers in Kiambu County on the quality and safety of hydroponically grown fruits and vegetables

	Statement	**Mean±SD**
1	Hydroponic FAVs have the best visible qualities	3.27 ± 1.339
2	I'd look for only hydroponic FAVs in the market	2.25 ± 1.323
3	Hydroponic FAVs have the best nutritional qualities	3.55 ± 1.279
4	I am not concerned about the quality of FAVs	3.05 ± 1.486
5	Hydroponic FAVs should be produced everywhere	1.63 ± 0.777
6	The quality of hydroponic FAVs is not satisfactory ^{R}	4.37 ± 0.777

7	It's good to produce FAVs in a short period	2.32 ± 1.488
9	I care about the safety of hydroponic FAVs	4.01 ± 1.211
10	Hydroponic system is safe for growing FAVs	2.23 ± 1.307
11	I'd look for hydroponic FAVs because they are safe	1.95 ± 1.262
12	Hydroponically grown fruits and vegetables are naturally grown	2.72 ± 1.786
13	I'd recommend my family to eat hydroponic FAVs	2.16 ± 1.249
14	Hydroponics should be the only production method	2.00 ± 1.211
15	Hydroponics is the solution to poor quality and unsafe FAVs	2.31 ± 1.564
	Overall	**2.45 ± 1.204**

Attitude was measured as mean ± SD on a five-point scale where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree. Statements with superscripted letter R show that they were reverse coded.

Practices of consumers that impact the quality and safety of hydroponic fruits and vegetables in Kiambu County

The results on the practices that consumers in Kiambu County employ in handling FAVs are presented in Table 4. The practices of consumers were generally good in relation to handling FAVs before purchase and consumption. Most consumers (68%) washed their FAVs under running water before cutting them. They noted that they stored FAVs for at most one day before preparation and consumption (79%). However, majority (72%) had poor means of storage of FAVs which could negatively impact the quality and safety of FAVs. In addition, 63% used poor food preparation methods other than steaming vegetables.

Table 4: Practices of consumers in Kiambu County that impact the quality and safety of fruits and vegetables

	Questions	**Practice**	**n**	**%**
1	Where do you source your FAVs?	1-Farmer	31	10
		0-Others	279	90
2	Which factors do you consider before purchasing FAVs?	1-Nutrients	67	22
		0-Visible qualities	243	78
3	Where do you keep/store FAVs after purchase?	1-fridge/cooking utensils/shopping bags	86	28
		0-others	224	72
4	How long do you store FAVs after purchase?	1-never store, eat straightaway/one day	244	79
		0-more than two days	66	21
5	Do you remove peels from fruits before consumption?	1-Yes	306	99
		0-No	4	1
6	How do you wash FAVs?	1-under running water	211	68
		0-others	99	32
7	How do you prepare your FAVs?	1-eat them raw/steaming	113	37
		0-others	197	63
Overall		**1-good**	**213**	**69**
		0-poor	**97**	**31**

Predictors of the frequency of consumption of hydroponic fruits and vegetables in Kiambu county

Predictors of the frequency of consumption of fruits in Kiambu County

Table 5 presents results on the predictors of consumption of hydroponic fruits by consumers in Kiambu County. The significant predictors of the frequency of consumption entailed age, level of education and knowledge about the quality and safety of hydroponically grown fruits ($p<0.05$). All the predictors had a positive influence on the frequency of consumption of fruits. An increase in the age and the level education of consumers would increase the frequency of consumption of fruits by 0.479 and 0.552 units, respectively. On the other hand, an increase in the knowledge about quality and safety of hydroponic fruits would increase the frequency of consumption of fruits with more than one unit.

Table 5: Predictors of the frequency of consumption of fruits in Kiambu County

Factor	β	S.E.	Sig
Age	0.479	0.154	**0.002**
Level of education	0.551	0.185	**0.003**
Knowledge	1.639	0.523	**0.002**
Attitude	0.301	0.274	0.273
practices	0.153	0.268	0.569
constant	-4.814	1.293	0.000

Predictors of the frequency of consumption of hydroponic vegetables in Kiambu County

The predictors of the frequency of consumption of hydroponically grown vegetables are presented in Table 6. Similarly, age, level of education, and knowledge about the quality and safety of hydroponic vegetables significantly predicted the frequency of consumption of vegetables among consumers in Kiambu County ($p<0.05$). All the predictors had a positive influence on the consumption of vegetables with an increase in the level of knowledge increasing the frequency of consumption by more than a unit.

Table 6: Predictors of the frequency of consumption of hydroponic vegetables in Kiambu County

Factor	β	S.E.	Sig
Age	0.395	0.200	**0.048**
Level of education	0.645	0.228	**0.005**
Knowledge	1.232	0.656	**0.044**
Attitude	-0.618	0.338	0.068
Practices	0.367	0.350	0.300
Constant	-1.024	1.539	0.506

Discussion

Knowledge of consumers on the quality and safety of hydroponically grown fruits and vegetables.

Knowledge about different aspects of food has been found to shape the frequency, and pattern of consumption of the foods by consumers because of rational thinking before interacting with the foods (Liu *et al.*, 2020; Testa *et al.*, 2019). The findings of this study have revealed that the consumers in Kiambu County have an overall good knowledge about hydroponically grown FAVs which influenced the relatively high frequency of consumption of FAVs as shown in Table 1. The findings are similar to the results

from the studies by Blas *et al*., (2019) in Spain where consumers had high knowledge on food quality and safety and hence demanded production and processing techniques that would improve the quality and safety of the foods so that they consume more. Rahman *et al*., (2021) highlights that in the near future, the assurance of quality and safety of foods from producers will be paramount before production and marketing of food products. This is because the modern consumers are determined in searching for information about foods with the help of internet and communication channels such as TV programs, smartphones and radio programs (Jallinoja *et al*., 2018).

Notably, the consumers in this study were well versed about the safety issues of FAVs ranging from the farm operations to consumption of the foods. It was encouraging that the consumers understood that the safety of FAVs was not only their role to play when preparing and consuming FAVs, but equally originated from the activities that farmers carry out in the field and in handling of food. Specifically, the majority agreed that excessive use of pesticides and fungicides truly makes FAVs unsafe for consumption. This could be due to enlightenment about the food related diseases especially non-communicable diseases that result from consumption of chemical contaminated foods. The evidence of this assertion is drawn from the study by Adeyeye *et al*., (2022) who puts forth that health-conscious consumers who are aware of the inherent and foreign composition of their foods are likely to shun contaminated foods because of the fear of food-borne illnesses. However, the level of knowledge of consumers in this study was limited compared to that of consumers in the study by Chen *et al*., (2020) in Alabama, USA where consumers were aware of the safety of hydroponically grown microgreens as well as the nutritional quality. The skewness in the knowledge of consumers in our study could be attributed to the fact that there is a paucity of information on the nutritional content of hydroponically grown foods in Kenya since it is a new farming system. Unlike the physical food contaminants such as soils and biological agents such as pests that can be determined from the outward appearance of foods, the invisible nutritional quality relies on an in-depth analysis of the food matrix to establish the level of nutrients. This implies that the knowledge of consumers in Kenya about the nutritional aspects of FAVs is likely to increase with availability of information about hydroponically grown foods. The dissemination of information to consumers could be effected through different media of communication so as to enlighten them about the benefits of hydroponic farming system (Estell *et al*., 2021).

4.2 Attitude of consumers on hydroponically grown fruits and vegetables

It was quite surprising to note that the overall attitude of consumers in this study was negative towards the quality and safety of hydroponically grown FAVs. This is because their attitude did not synchronize with the frequency of consumption of the FAVs which was relatively above average as shown in Table 1. The negative attitude could be because the consumers are still learning about the production system hence are yet to understand and accept the foods grown in it. On the other hand, the high frequency of consumption despite the negative attitude could be because FAVs are limitations in the labelling of food products in the market place according to the production system.

The negative attitude was majorly coined around the safety of the hydroponically grown FAVs which the consumers had high level of knowledge on (Table 2). This suggested that consumers in this study did not find the safety of hydroponically grown FAVs satisfactory. Nonetheless, these results were comparable to those obtained by Chen *et al*., (2020) where consumers expressed to value the locally produced FAVs compared to other methods of production especially hydroponic farming system. They associated the local production, soil-based farming, of FAVs with healthiness, good taste, cultural value and environmental friendliness. Second to soil-farming was the organic farming method that was associated with limited use of synthetic fertilizers and pesticides, livestock antibiotics and use of genetically modified organisms (GMOs) (Haghiri *et al*., 2009; Nandi *et al*., 2016).

In a general view, the preference of food production methods is likely to be influenced by familiarity and experiences that consumers have

with farming techniques. This is to imply that consumers can hold on the customary soil-production method since it has been used from antiquity hence approval of the sensory attributes and safety levels (Gashgari *et al.*, 2018). As a result, the acceptance of new farming techniques such as greenhouse farming and hydroponic systems that use high-technology controlled environment could be low because of a slight difference in the level of quality and safety (Karanisa *et al.*, 2022). This postulation is supported by the study by Broad *et al.*, (2022) where local food consumers were reluctant to accept the foods produced by high-technology environment agriculture because of the question of naturalness and environmental conservation as in the local soil-based farming methods. With the prediction of Food and Agriculture Organization (FAO, 2018) that hydroponic farming system will be the top food production method by 2050 because of sustainability and high yields, the frequency of consumption of hydroponic food crops can be improved by educating consumers about the benefits of hydroponic farming system and the explaining the scientific considerations of its safety level so as to change the attitude of consumers towards acceptance of these foods.

On the other hand, the consumers were slightly more positive about the quality of hydroponic FAVs even though they had a relatively low level of knowledge about it. This could have been because of the desirable visible qualities that are conspicuous with hydroponically produced FAVs such as tenderness, broad leaves of vegetables and big sizes of fruits, unspotted FAVs and dark colored foods. In most instances, consumers value the quality of foods using the outward appearance not only because of lack of knowledge of the intrinsic nutrients but also unavailability of verification methods of the level of specific nutrients in the food. This is not different even on the international market as evidenced by the study by Yang *et al.*, (2021) in Japan, Taiwan and Indonesia. Consumers and retailers utilized the best-worst method to select foods despite the provision of other quality certification methods. As a consequence, the good-looking FAVs were purchased while the rest were rejected because of the 'low quality' in the outward appearance. An implication of a such consumer behavior is that as the demand for food quality and safety is going high, most food producers will put in efforts to modify the appearance of foods rather than the intrinsic components hence reduction in the nutritional status and health outcomes of consumers. Fortunately, consumer education by nutritionists on the importance of inherent nutritional quality of foods has been positively associated with a change in consumer attitude towards new foods hence make informed food choices that impact positively on their health (Yao *et al.*, 2013).

4.3 Practices of consumers in handling hydroponically grown fruits and vegetables

Whereas some routine ways of handling foods lower the level of quality and safety, other practices are recommended since they maintain or even increase the suitability of the food (Frank *et al.*, 2019). In this study, consumers generally employed good practices in handling FAVs. Among these included washing FAVs under running water before preparation and consumption. This was remarkable since there is sufficient evidence that most consumers in the low-and-middle income countries usually use soaking and rinsing method, because of insufficiency in water supply, which increases the contamination of the food unless more than three exchanges of water are used (Zander and Bunning, 2014). In the study by Kilonzo-Nthenge *et al.*, (2006) it was established that washing-under-running-water method significantly reduced the microbial load from the surfaces of FAVs more than other methods. This method is also recommended by the United Nations Children's Fund (UNICEF) especially in areas with a low level of hygiene so as to reduce the accumulation of microbial contaminants on the foods (De Faria Coelho-Ravagnani *et al.*, 2021).

Secondly, consumers in this study had a good practice of storing FAVs for only a day before consumption, in the event they did not take them on the day of purchase. This is encouraged as a good practice since the time of food storage is critical for the multiplication of infectious microorganisms besides deterioration of nutrients especially vitamin A and C that are sensitive to light and temperature (Lee *et al.*, 2018). This finding was comparable to the results of a review by Makule *et al.*, (2022) in Sub-

Saharan Africa where consumers were reported to consume FAVs the same day they obtained them from farmers or vendors due to unavailability of appropriate storage mechanisms such as fridges that reduce the chances of food contamination and spoilage. This is evidenced in this study by the poor practice of consumers who were not able to consume FAVs within the day of purchase. Most of them indicated that they stored the FAVs in an open place such as shelves or left them in the shopping bags rather than storing them in the fridges. The absence of cold chain systems in most households in the developing countries is among the topmost reasons of food wastage besides other post-harvest losses at the farm level (Holsteijn and Kemna, 2018).

The other poor practice in handling FAVs was noted in the preparation of vegetables for consumption. Most consumers indicated that they boiled or fried vegetables rather than steaming. While these methods could be the normalized ones in the preparation of vegetables in most households across the developing world, they have been associated with the destruction of the nutritional quality of foods. The magnitude of loss is even greater when the water is drained from the vegetables since the nutrients leach from the leaves into the water. This is supported by the study by Barrett, (2007) who stated that the major nutrient losses are counted when the vegetables are subjected to excessive thermal treatment for a long time. Steaming method, on the other hand, has been illustrated to be a safer method of vegetable preparation which retains the bioactive compounds in food (Lee *et al*., 2018). It is also important to note that consumption of some vegetables when they are raw is commendable in delivering nutrients in the body since there is very minimal rate of destruction. Even though consumers in Kenya do not consume raw vegetables unless they are presented as salad and/or *kachumbari*, it is necessary to enlighten them on the importance of this practice with the aim of attaining nutrients from vegetables in the recommended amounts. Anyhow, it is usually unintentional to alter the quality and safety of FAVs with the practices employed in handling foods. This is because some practices are used from the point of preference and conveniency while others are used because of lack of knowledge of the alternative methods. This points out the vital role of sensitization of the community about proper food handling techniques so that the consumers use the best methods that maintain or improve the quality and safety of the foods available to them (De Faria Coelho-Ravagnani *et al.*, 2021).

4.4 Predictors of the frequency of consumption of fruits and vegetables

Basically, several factors influence the food choices of consumers in a specific geographic location. While some of these factors might be unique to a population, others are shared across countries. Notably, the influence of these factors can be either positive or negative. Specific to this study, an increase in age, level of education and the knowledge of consumers on the quality and safety of FAVs could significantly increase the frequency of consumption of hydroponic FAVs. Firstly, categorization of consumers based on age is necessary in this era because of the difference in the food exposures and experiences that are facilitated with global interactions through internet access. As many young consumers are attracted to the processed and packaged foods, older consumers are more conscious about their health outcomes hence consumption of healthy and nutritious foods such as FAVs. The current results are congruent with the study by Sanlier *et al.*, (2018) in Turkey where most young consumers preferred processed animal-based street foods to plant-based products as opposed to the older consumers. The results were also similar among the Ugandan consumers (Kityo and Park, 2022). Another reason about this observation could be because of the high prevalence of food-related health conditions among the older consumers. There is adequate evidence that show that most of the health conditions such as heart diseases, cancer, osteoporosis develop or aggravate with progression in age (O'Brien *et al*., 2020; Shchepinov, 2020). As a result, health experts counsel consumers to use plant-based foods such as FAVs which have adequate antioxidants, bioactive compounds and phytochemicals that delay the development of progression of the prevailing diseases. Therefore, consumers who are advancing in age tend to follow this recommendation for an increased lifespan and

reduction in the burden of health care costs (Schiano and Drake, 2021).

Secondly, it was reasonable that an increase in the level of education of consumers could increase the frequency of intake of FAVs in this study. The current results were similar to the studies by Assari & Lankarani, (2018); Frank *et al*., (2019); Stea *et al*., (2020). This could be because a higher education level enlightens consumers to make informed food choices from the knowledge obtained in the learning areas. Highly educated consumers are therefore more aware and alert on the food and health related matters hence rationally weigh the benefits and risks of the foods available to them before making their choices unlike their low level educated counterparts. In the study by Van Loo *et al*., (2020) educated consumers were reported to prefer plant-based food alternatives to farm and lab-grown animal foods citing nutrition and health benefits as the motivational factors. This outlines the importance of community nutrition education of consumers with a low education level to increase their knowledge on the importance of consumption of healthy, safe and nutritious foods such as hydroponically grown FAVs. This is because an increased level of knowledge was positively associated with an increase in the frequency of consumption of both fruits and vegetables by consumers in this study as shown Table 5 and 6, respectively. The findings were similar to the studies by Hirvonen *et al*., (2017); Spronk *et al*., (2014) especially in the western countries. It is beyond doubt that consumption of nutritious foods is highly dependent on the awareness of the composition of nutrients in the foods within the reach of consumers. Nutritional knowledge can easily be transmitted through different media platforms to both consumers who have specialized in the nutrition matters and others. However, the uptake of this information is solely individual-based implying that there is a need for consistency in transmission, and use of different channels to put emphasis on this critical matter so as to improve the uptake of information. In addition, nutrition knowledge can be shared among children in schools so as to nurture citizens who are versed with nutritious and healthy foods for a good nutritional and health outcomes (Asakura *et al*., 2017; Barbosa *et al*., 2016) .

On the other hand, the attitude and practices of consumers could not have influenced the frequency of consumption of hydroponically grown FAVs significantly because of the role that these foods play in the diet of most consumers in Kenya. It is worth mentioning that Kenyan consumers utilize vegetables as part of the main meal in a higher frequency compared to animal-based foods for reasons ranging from low socio-economic status to customary food consumption patterns. In this regard, even if the consumers have a negative attitude about quality and safety of vegetables, they might find it difficult to exclude them from the diet especially the families that use them as the only sauce for consumption of staple foods such as 'Ugali', rice and sweet potatoes. In another perspective, consumers access and afford FAVs from the wet markets where the quality and safety level are reliant on the social relationship with the farmers and vendors. The supermarkets that often label FAVs i.e., in terms of the farming system are inaccessible to most consumers. In addition, the supermarkets tag high prices that are often a hindrance to purchase foods as compared that on the local market. For these reasons, most consumers do not have a variety of options that can allow them to factor in their attitude before buying FAVs despite the production system. The insignificant influence of consumer practices on the frequency of consumption of hydroponic FAVs could be because each household has different acceptable ways of handling foods hence a less important consideration in consuming foods. Therefore, even if the practices are applied without knowledge of the quality and safety of foods, the consumers identify with them and maintain their frequency of consumption as long as the family members do not succumb to illnesses (Paltrinieri, 2017).

Conclusion

Acceptance, and consumption of food crops produced in new farming techniques is facilitated by a range of factors. This includes possession of proper information about the food production systems, knowledge on the benefits of the foods and the socio-demographic characteristics of the

consumer. This was well demonstrated in this study as a high level of knowledge of consumers about the quality and safety of hydroponic foods significantly increased the consumption of FAVs. In relation to the socio-demographic characteristics of consumers, this study revealed that age and the level of education were the predictors of the frequency of consumption of FAVs. It was also interesting to note that the frequency of consumption of FAVs remained relatively high despite the negative attitude of consumers towards this new farming technique that consumers are still familiarizing with. Lastly, the study results showed that consumers in Kiambu County employed good practices in handling FAVs hence preservation of the quality and safety of the foods.

Recommendations

Based on the findings of this study, the following recommendations, towards (i) promotion of hydroponically grown foods and (ii) further research, can be made.

6.1 Recommendations for promotion of hydroponically grown fruits and vegetables

i. This study suggests that nutritionists should conduct community nutrition education programs among consumers who are unaware of the quality and safety aspects of hydroponically grown foods so that they make informed choices in purchasing and consuming foods for a good nutritional and health outcome.
ii. Nutritionists and food safety experts should enlighten consumers about the general proper handling practices that maintain the quality and safety of foods. This can be facilitated through local radio programs, TV channels and smartphones so as to reach a larger number of people.
iii. The extension officers should sensitize, and train farmers countrywide so as to scale up the production of hydroponic food crop in a sustainable farming system so as to meet the nutritional needs of consumers hence alleviate malnutrition in Kenya.

6.2 Recommendation for further research

Most of the consumer concerns that contributed to an overall negative attitude towards hydroponic FAVs were centered around safety of hydroponically grown foods. To ascertain the safety of hydroponic foods, a study should be conducted to establish the safety of hydroponically grown foods from microbial and chemical contaminants at farm level, market and consumer levels.

Data availability

Data used to support the findings of this study are available from the corresponding author upon request.

Conflict of interest

Authors declare no conflict of interest upon publication of this paper.

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