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Contribution of dairy goat farming to household dietary diversity among smallholder farmers in the Central Highlands of Kenya

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Abstract

In Kenya, dairy goat farming has highly been practiced for food provision and as an income-generating enterprise. However, there is scanty information on the contribution of dairy goat farming to the quality of diets consumed at household level especially among rural smallholder farmers. This study therefore analysed the contribution of dairy goat farming to household dietary diversity of the smallholder farmers. Data was collected at the end of the wet season (April-May) from a sample of 385 households in Kirinyaga County, using structured questionnaires programmed in the KoboToolbox. Household dietary diversity scores (HDDS) was used as a measure for food security, where 12 food groups commonly consumed in the area were considered. Propensity to score matching (PSM) with a probit regression framework was used to minimize the selection bias while determining the effect that dairy goat farming (treatment) had on dietary diversity. The nearest neighbour matching (NNM) estimated the average treatment effect on the treated (ATT). Results revealed that vegetables, cereals, beverages, fats and oils were consumed more compared to meat, fish and eggs. Age, gender, title deed ownership, and monthly household income significantly influenced the likelihood of practicing dairy goat farming. The ATT showed that dairy goat farmers had higher HDDS by 1.014, an implication of diversified diets. The results suggest that dairy goat farming should be encouraged and improved among smallholder farmers in an effort to minimize malnutrition. Besides, there is need to conduct training on the optimal intake of the different food groups.

Keywords: Food security, nearest neighbour matching, optimal diets, propensity score matching

1 Introduction

Food security is the right to safe and nutritious food that is available at all times and that meets people's dietary preferences and needs in order to lead an active and healthy life (Berry *et al*., 2015; Lang & Barling, 2012). Dietary diversity is related to the act of consuming different food groups which directly influence the nutritional outcomes of a person (Sambo *et al*., 2022). Globally, about 690 million people suffer from nutritional inadequacy as a result of consuming too little or the wrong foods (FAO, 2020), and 20 % of that population lives in Africa (Kihiu & Amuakwa-Mensah, 2021). Besides, Africa reported an increased number of food insecure people by 26 % between 2000 and 2019 (FAO, 2020).

Food security discussions became popular in Kenya after the passage of the Constitution of Kenya in 2010, which explicitly acknowledged the right for every individual to be free from hunger and have enough food of good quality (Republic of Kenya, 2012). Among the developing countries with severe levels of hunger, Kenya is at position 86 out of 117 (Ngotho, 2020). Additionally, about 14.5 million people in Kenya are categorised as food insecure; where 29 % cannot access the bare minimum of dietary diversity to maintain a healthy and improved lifestyle (Ngotho, 2020).

Several measurements have been used to determine dietary diversity. Woldu *et al*. (2016) used the household dietary diversity score (HDDS) to optimize the contribution of dairy goat farming to food security in various production systems in Ethiopia. Similarly, HDDS together with a seven day calorie intake were employed to assess the effect of horticultural export on food security of the smallholder famers in Kenya (Wambui, 2014). On the contrary, Adeoluwa & Dinbabo (2018) used the food consumption scores (FCS) in terms of dietary diversity, nutrient intake and frequency of

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consumption to determine the food secure smallholder farmers in North-Western Nigeria.

Literature shows that livestock production plays an essential role in ensuring food security among smallholder farmers (WFP, 2016). However, few studies have assessed the nutritional significance of dairy goat farming among smallholder farmers (Nyambok, 2015; Woldu *et al*., 2016; Richard, 2017; Stone, 2020; Wodajo, 2020). Much of the recent literature pertaining dairy goats have mainly addressed the constraints affecting production, market participation, and economic contribution of dairy goats (Mataveia *et al*, 2018; Mbindyo *et al*., 2018; Kagucia *et al*., 2020).

In Kenya, goats are a major sub-sector in the agriculture sector and account for about 58 % of the total 46 million small ruminants reared in the country (Mbae *et al*., 2020). According to literature, the primary reasons of keeping goats include milk and meat production for sale and household consumption, sale of replacement stock, and manure production (Ogola & Kosgey, 2019; Kagucia *et al*., 2020). The common production system in Kenya is extensive, where the dairy goats graze or browse on the naturally occurring pastures (Mbae *et al*., 2020). The dominant exotic breeds are German Alpine, Kenya Alpine, Saanen, Anglo Nubian, Toggenburg, and the crosses between them (Kagucia *et al*., 2020). The key challenges that affect dairy goat production are poor access to livestock markets, credit facilities, extension services, specialised support from veterinarians, and inadequate technical skills (Mataveia *et al*., 2018; Kagucia *et al*., 2020).

Previous studies done in Kenya have revealed that majority (approximately 80 %) of the dairy goats are reared in the central highlands (Mburu *et al*., 2014; Richard, 2017; Njagi, 2018). Nonetheless, in a food security classification done in these highlands, households (49 %) recorded poor nutritional status, and a high vulnerability to acute food insecurity (IPC, 2021). Furthermore, the human diets observed by the World Food Programme (WFP) were relatively unstable, with the report showing about 15 % and below FCS (WFP, 2016). However, there is little information on whether inadequate nutrition is due to low dietary diversity. Furthermore, previous studies on food security in Kirinyaga County (central highlands) have paid little attention to the contribution of dairy goats to dietary diversity among smallholder farmers (Wambui, 2014; Mugambi, 2017). The aforementioned studies have rather focused on the micronutrient intake among the mothers and how horticultural export impacts food security in the household. This study conceptualized that dairy goat farming positively influence dietary diversity of smallholder farmers in Kirinyaga County, following the already defined contribution of dairy goats towards households' dietary intake (Nyambok, 2015; Wodajo *et al*., 2020). Against this background, we investigated the contribution of dairy goat farming to dietary diversity in smallholder households and assessed the most commonly consumed food groups.

2 Materials and methods

2.1 Study area

The study was conducted in Kirinyaga County, in the Central highlands of Kenya. The County lies between 1,158 m a.s.l. in the South and 5,380 m a.s.l. at the peak of Mt. Kenya; at a latitude of 0° - 400 S, and longitude of 37° - 38° E and covers about 1,487 km^2. The total population of the County is estimated at 610,400 (KNBS, 2019). There are five sub-Counties in this region (Kirinyaga Central, Kirinyaga East, Kirinyaga West, Mwea East and Mwea West). The County receives bimodal rainfall with a short rainy season from March to May and a long rainy season from October to November. Agriculture is the most important economic sector in the County and, due to the small farm sizes and the high population density, it is mainly practised by smallholder farmers who practise both arable farming and livestock keeping (Wambui, 2014). The County has also seen unprecedented growth in dairy goat farming (Njagi, 2018).

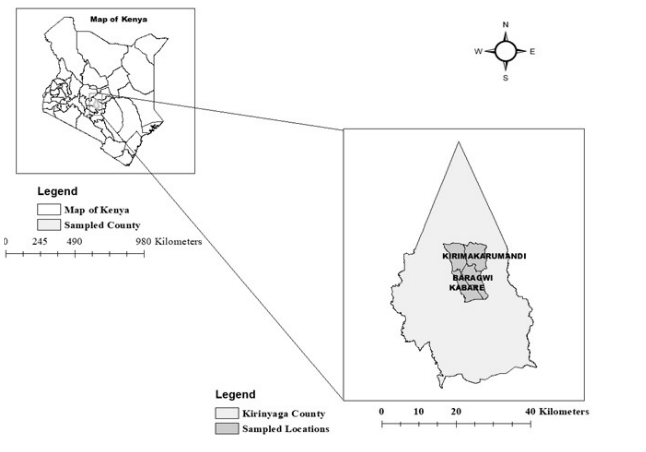

Fig. 1: *A map showing the sampled locations in Kirinyaga East Sub-County (Karumandi, Kirima, Baragwi, Kabare, and Njukiini) (Source: ArcMap version 10.8).*

2.2 Sampling

The study adopted a combination of purposive and multi-stage random sampling techniques to select the sub-county, wards, locations, sub-locations and villages for household surveys of smallholder farmers with dairy goats and without dairy goats. In the first stage, Kirinyaga East Sub-County was purposively selected owing to the high number of smallholder farmers keeping dairy goats (2900), at an estimated population of 1,300 dairy goats (Kirinyaga County Annual Reports, 2021). The second stage also involved purposive selection of five wards namely; Karumandi, Njukiini, Kabare, Baragwi, and Kirima, due to high concentration of dairy goat farmers. The choice of the wards was aided by the register maintained by the Ministry of Agriculture and Livestock in Kirinyaga County (KNBS, 2019). In the third stage, a location was selected from each ward. The fourth stage entailed randomly selecting one sub-location from each location. The fifth stage narrowed down to villages; Kangai, Mirichi, Kiangombe, Raimu, and Kathoge that were randomly selected from each sub-location. Lastly, proportion to size formula was used to derive a total of 385 households to be interviewed from the five villages, comprising of 271 dairy goat farmers (DGF) and 114 non-dairy goat farmers (NDGF).

2.3 Data collection

Data was collected late April 2022 to May 2022. A questionnaire was developed and programmed in the KoboToolbox; the technique that facilitate data collection in the field (Ghazali, 2021). The questionnaire aimed at assembling details on household demographics and socio-economic characteristics of the smallholder DGF and NDGF including; age, gender, education level, farm size, title deed ownership, household income, and main occupation. Information on household food consumption in the last seven days was further collected to observe the diets. The seven-day recall period was considered to avoid biases that may occur because of shorter reference periods (24 hours), thus, not revealing the correct habitual diets, or longer recall periods, which are prone to errors (Kafle, 2014). Farmers were asked to indicate the foods consumed out of different food categories as recommended by FAO (2014). The food categories considered were tubers, cereals, fish, milk, meat, eggs, oils and fats, fruits, legumes, vegetables, sugars, and beverages.

2.4 Data analysis

The data collected was coded in Statistical Package for Social Sciences (SPSS) version 25. Afterwards, STATA version 15 together with SPSS version 25 software were used to conduct the analysis. Before carrying out the analysis, Kolmogorov-Smirnov test was used to check for normality, where variables with a p-value of less than 0.05 were dropped. The continuous variables (age and household size) were evaluated in means and standard deviation, and a two tailed t-test was done to compare any difference in the average age values and household members between DGF and NDGF. Percentage and standard deviation were on the other hand generated to examine the categorical variables (gender, farm size, education, title deed ownership, land ownership status, main occupation and household monthly income) for both DGF and NDGF. Chi square test was used to test any significance difference in the categorical variables between the two groups.

2.4.1 Household dietary diversity score

The HDDS was used to examine dietary diversity, given that it has successfully been applied previously to show access to food and dietary diversity at the household level (Sibhatu & Qaim, 2017; Woldu *et al.*, 2016). Besides, HDDS is one of the techniques recommended by FAO to help determine the individual or household economic access to food (FAO, 2011).The HDDS assessed household dietary intake by constructing a basic count of food groups consumed in the household for the last seven days. The definition of the different consumers was done as follows; in the case a household had consumed a certain food group in the last seven days, the specific category was assigned the value of one (1) and zero (0) if otherwise (Kennedy *et al.*, 2010). To calculate the score, the values for all food groups consumed were summed. The scores were then divided into quartiles where the high HDDS quartile comprised of households that consumed more than eight food groups. The two medium quartiles were combined to represent households that consumed five to seven food groups, while the low HDDS quartile entailed all the households that consumed four food groups and below.

2.4.2 Propensity Score Matching

In an effort to measure the impact of the treatment (dairy goat farming) on the outcome (dietary diversity), selection bias might arise due to the non-random assignment between the treated (DGF) and the control (NDGF) groups (Gebrehiwot & Veen, 2015). The propensity to score matching (PSM) was used to minimize this estimation bias from the observable variables (Gitonga *et al.*, 2013). The PSM comprised of two stages following Akuffo & Quagrainie (2019). The first stage involved estimation of demographic and socio economic variables that may affect the likelihood of practicing dairy goat farming. The second stage further determined the treatment effect by comparing the outcome between the treated and the control observations. To estimate the impact on deciding to adopt dairy goat farming on the outcome variable, the net impact of adoption on the household dietary diversity was calculated (Nazifi *et al.*, 2021). The respective probit equations are;

$$\gamma_1 = \beta_1\chi + \varepsilon_1 \quad (1)$$

$$\gamma_0 = \beta_0\chi + \varepsilon_0 \quad (2)$$

Where: γ_1 is the outcome variable for the treated group and γ_0 is the outcome variable for the control group;χ are the observable households' characteristics for both groups; β_0 and β_1 represent the effect that χ has on the outcome; while ε_1 and ε_0 are the error terms. The difference between treated (DGF) and the control (NDGF) showed the net impact as a result of dairy goat farming.

$$net\ impact = \gamma_1 - \gamma_0 \quad (3)$$

2.4.3 *Nearest neighbour matching*

The nearest neighbour matching (NNM) algorithm was used to estimate the average treated effect on treated (ATT) (Nazifi *et al.*, 2021). The NNM creates a causal effect by using the propensity score of similar individuals (with matching observable characteristics) in both the treated and the control group. The matching assumption adopted is that for each treated observation, there is a nearest match in the

Table 1: *Descriptive statistics of dairy goat farmers (DGF) and non-dairy goat farmers (NDGF)*

	DGF (N=271)		*NDGF (N=114)*		*Difference test*
Continuous variables	*Mean*	*SD*	*Mean*	*SD*	*T-test**
Age of HH head (years)	48.58	9.82	42.34	9.09	0.000***
HH size	5.27	0.582	5.24	0.886	0.425
Categorical variables	*%*	*SD*	*%*	*SD*	$\chi^{2\dagger}$
Gender		0.90		0.78	0.686
Male	58.3		60.5		
Female	41.7		39.5		
Education		0.77		0.73	0.588
Primary	28.8		27.2		
Secondary	48.0		54.4		
College	21.0		15.8		
University	2.2		2.6		
Farm size (ha)		0.56		0.51	0.079**
<1	52.0		63.2		
1-2	44.6		36.0		
>2	3.3		0.9		
Land ownership		0.59		0.58	0.961
Inheritance	91.5		92.1		
Private	7.7		7.0		
Communal	7.0		0.9		
Title deed		0.37		0.47	0.000***
Yes	83.4		66.7		
No	16.6		33.3		
Main occupation		0.77		0.87	0.208
Agriculture	67.9		57.0		
Self-employed	18.8		23.7		
Casual labourer	11.4		15.8		
Formally employed	1.8		3.5		
HH monthly income		0.97		0.98	0.135
<50 $	21.8		27.2		
60 – 120 $	63.5		64.9		
120 $ and above	14.8		7.9		

*** =1 % significance level,**=5 % significance level; N= number of respondents; DFG=dairy goat farmers; NDGF= non-dairy goat farmers; SD= standard deviation; HH=household $ = US Dollar; * p-value; † Chi-square p-value control observation with similar characteristics (Akuffo & Quagrainie, 2019).

Similarly, according to Wang & Cheng (2020), cross-sectional surveys are subject to confounding, when a variable directly influence the outcome and is also associated with the treatment. In the current study, the variables used to predict the dietary diversity scores were also associated with the likelihood of being a dairy goat farmer. Rosenbaum & Rubin (1983) propose matching the propensity scores between the treated and the control to reduce the bias. Therefore the use of NNM served the purpose of controlling the confounding and calculating the ATT.

3 Results

3.1 Demographic and socio-economic characteristic of smallholder farmers

The average age of the households in the two groups was significantly different (p = 0.000) as shown in Table 1. The average household size for both DGF and NDGF was 5 members. Male-headed households dominated in the study in both groups. Highest level of education attained by both DGF and NDGF was secondary school (Table 1). Farm size significantly varied between the two groups (p = 0.027), where a great number of the households (52 %) DGF and (63 %) NDGF occupied less than one hectare of land. Title deed ownership among the DGF and NDGF was uneven (p = 0.000), where a larger portion (83 %) of DGF held a title deed for the land they occupied compared to NDGF (67 %). The main occupation embraced by most of the respondents (68 %) DGF and (57 %) NDGF was agriculture. Besides, although the difference was not significant more of the NDGF engaged in casual labour or self-employment in contrast to DGF. Finally, more than half of the respondents (65 %) NDGF and (64 %) DGF indicated \$ 60–\$ 120 as their monthly income.

3.1.1 Descriptive information of dairy goat farming in the study area

The main purposes for keeping dairy goats according to most respondents were milk consumption at the domestic level, sale of milk and manure. Very few respondents agreed to have kept dairy goats due to small farm sizes, sale of live goats and for meat consumption. Most of the farmers kept 1-3 dairy goats. The prominent breeds were Kenya Alpine and Toggenburg, and the goats were mainly reared in zero-grazing systems as opposed to tethering. Farmers regularly used natural pastures and crop residues as feed. Manure generated was utilised on the farms to enhance crop productivity while a great number opted to sell it and earn some income. Most of the respondents (63 %) reported \$ 5–\$ 30 as the monthly income generated from keeping dairy goats.

Table 2: *Information on dairy goat farming in the study area (N=271).*

Variable	*Percentage*
Reasons for keeping goats	
Domestic milk consumption	30.9
Milk for sale	28.2
Sale of manure	18.0
Small farm sizes	10.8
Sale of live goats	10.7
Meat production	1.3
Number of dairy goats kept	
1-3	90.2
4-6	8.1
7-9	1.7
Milk output in litres/day	
1-2	42.8
3-5	57.2
Type of breeds kept	
Kenyan Alpine	43.0
Toggenburg	32.5
Saanen	16.1
East African	8.1
Production system	
Zero-grazing	92.3
Tethering	7.7
Type of feed commonly used	
Natural pastures	48.9
Crop residues	37.7
Planted pastures	13.4
Use of manure	
On cultivated land	56.7
Selling	43.3
Total monthly income from dairy goats	
< 4 \$	24.7
5 – 30 \$	63.1
40 – 90\$	8.1
> 100 \$	4.1

\$ = US Dollar.

3.2 Household dietary diversity status of DGF and NDGF

Both DGF and NDGF households fell under the medium and high HDDS quartiles, and none of the households interviewed recorded low HDDS (Table 3). However, DGF had higher dietary diversity scores at an average of 10.6 compared to an average of 9.6 for NDGF (p = 0.000).

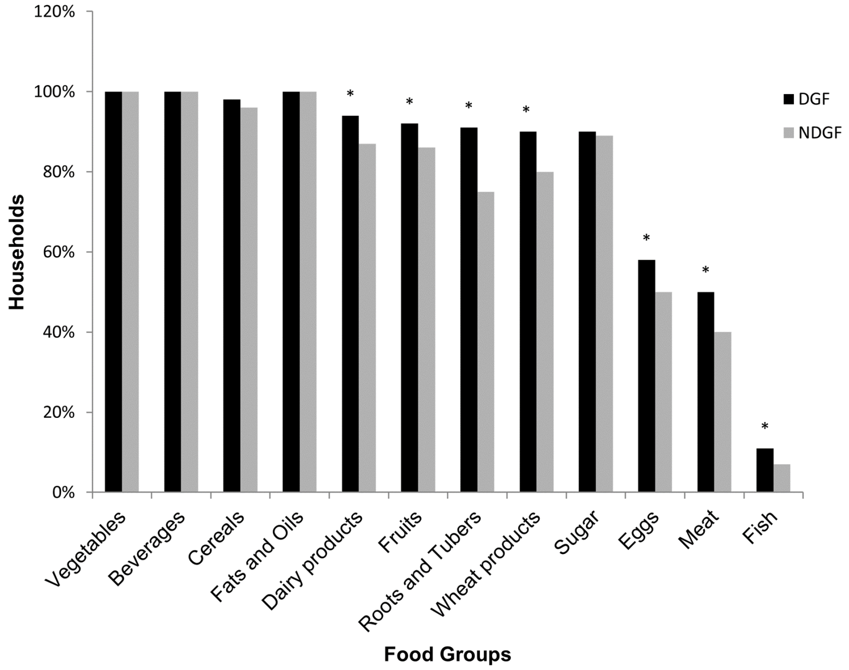

Fig. 2: *Food groups consumed by the sampled DGF (dairy goat farmers) and NDGF (non-dairy goat farmers) households in the last seven days. (*denotes p < 0.05 for comparison between DGF and NDGF in consumption of specific food groups).*

3.3 Consumption of different food categories

Fig. 2 shows that, all of the sampled households consumed vegetables, beverages, fats and oils in the last seven days. Consumption of sugar and cereals was also high in both groups. DGF were prominent ($p > 0.05$) in the consumption of dairy products, fruits, wheat products, root and tubers. The consumption of meat, eggs, and fish was low in both DGF and NDGF households. However, consumption of these food items in the DGF households was higher ($p < 0.05$).

Table 3: *Household dietary diversity status of dairy goat farmers (DGF) and non-dairy goat farmers (NDGF)*

	DGF (N=271)	*NDGF (N=114)*
Parameters	*Percentage*	*Percentage*
Medium HDDS *(5-7)*	3.7	27.2
High HDDS *(>8)*	96.3	72.8
Mean HDDS	10.6	9.6
Standard deviation	1.08	1.47
Maximum	12	12
Minimum	7	6
Pearson Chi-square	χ^2=46.5840	*p*-value = 0.000***

DGF=dairy goat farmers, NDGF=non-dairy goat farmers, HDDS=household dietary diversity, N=number of respondents,***=1 % significance level.

3.4 Factors influencing participation in dairy goat farming

The PSM matching held a conditional assumption that the outcome was completely independent on the treatment. The results of the estimated coefficients from the probit model are presented in Table 4. The R^2 values show that 15 % variation in the dependent variable was explained following inclusion of the independent variables in the model. The goodness of fit measures in the model was indicated by the 1 % level of significance in the likelihood ration Chi square value. From the explanatory variables included, age, gender, education, title deed ownership, and household income significantly impacted participation in dairy goat farming. Increase in the farmer's age and gender of the household head increased the likelihood to practice dairy goat farming at 1 % level of significance. The level of education attained by the household head also positively determined the adoption of dairy goat farming at 10 % significant level. Additionally, title deed ownership and household income positively affected the possibility of keeping dairy goats among the smallholder farmers in the region at 1 % significance level.

Table 5 shows the NNM results on the average effect of dairy goat farming on the dietary diversity of the smallholder farmers, that was estimated after the propensity score estimates. The results revealed that DGF had higher HDDS by 1.044, which was significant at ($p < 0.01$). The ATT implies that farmers who practiced dairy goat farming increased their dietary diversity scores by 1.044 compared to non-dairy goat

Table 4: *Probit regression to determine the factors affecting participation in dairy goat farming.*

Variables[§]	*Coefficient*	*Std. err.*	*z*	*P>z*
Age	0.0527***	0.0083	6.32	0.000
Gender	0.5486***	0.1656	3.31	0.001
Household size	0.0582	0.1061	0.55	0.583
Education	0.1870*	0.1108	1.69	0.091
Farm size	0.1905	0.1418	1.34	0.179
Land ownership status	-0.0125	0.1183	-0.11	0.916
Title deed	0.4807***	0.1757	2.74	0.006
Household Income	0.2276***	0.0825	2.76	0.006
-cons	-4.1408	0.9231	-4.49	0.000
Number of observations	385			
LR Chi^2 (9)	67.98			
Pseudo R^2	0.1453			
Pro > Chi^2	0.000			
Log likelihood	-199.908			

*** =1 % significance level, *=10 % significance level, Std. err=standard error
§see also table 1.

Table 5: *Average impact of dairy goat farming on household food security.*

Outcome	*ATT*	*St.Err.*	*t-value*	*p-value*	*Interval*	*Sig*
HDDS	1.044	0.196	5.33	0.000	1.428	***
Mean = 10.335	SD = 1.291					

ATT= average effect on the treated, St.Err= standard error, Sig= significance level, HDDS= household dietary diversity, SD= standard deviation, ***= 1 % significance level.

farming households. In estimation of ATT for a given treatment, the t-value obtained should be greater than 2 to conclude whether a satisfying match between the treated and the control observation was made (Isaboke *et al.*, 2016). This study found a t-value of 5.33, which indicates that a suitable match between the DGF and NDGF was achieved.

4 Discussion

In Kenya, dairy goats farming has been adopted as an income generating activity, besides, accounting for the household's food consumption in terms of meat and milk (Mbindyo *et al.*, 2018; Kagucia *et al.*, 2020). This study was conducted to help determine the influence that dairy goat farming has on household dietary diversity, and further provided a reference to whether farmers had diversified diets which translates to an optimal state of health, and also limits various forms of malnutrition (Fanzo, 2019). The theoretical basis of the study was that, dairy goat smallholder farmers will record higher dietary diversity scores, indicating safe and healthy diets, as compared to NDGF.

DGF households showed in average a higher HDDS (10.6) than NDGF households (9.6). This result is consistent with the concept of the study and also in line with Nyambok (2015) who observed that farmers regularly consumed a greater variety of food groups after adopting dairy goat farming. The mean HDDS observed for DGF households was, however, higher than the average score of 5.7 reported by Woldu *et al.* (2016) in the highlands of Ethiopia. This difference might result from the fact that more households in this Kenyan region consumed milk, fruits and wheat products in proportionally higher amounts than the dairy goat farmers in the Ethiopian highlands.

More diversified diets from DGF households as compared to NDGF households were realised through an increased intake of fruits, wheat products, roots and tubers. These findings agree with Workicho *et al.* (2016) who reported that, the frequently consumed food items among the high HDDS households were tubers and fruits. Besides, the overall number of consumed food groups was above five which is an indication that this region has met the minimum dietary intake as recommended by FAO, with five being the cut-off point in any dietary diversity assessment (FAO, 2014).

The absolute consumption of vegetables, cereals, and beverages by both groups in the last seven days is a direct result of agriculture being the dominant occupation. This confirms the findings of Rozy *et al.* (2016), which were also made in Kirinyaga County, that most farmers consumed vegetables, especially African leafy vegetables like pumpkin, cowpea, amaranth, and nightshade leaves. Farmers. Additionally, the region is prevalent in rice production (Evan *et al.*, 2018), and tea production (Leshamta, 2017) attributing to the high consumption of cereals and beverages (tea), respectively. The findings further agree with Woldu et al. (2016) and Kalavathi *et al.* (2010) who found that the food categories consumed by most dairy goat farming households were vegetables and cereals.

A large number of the surveyed households consumed sugar, fats and oils. This is probably due to the fact that their monthly household income enabled them to buy cooking oil and sugar. Moreover, the consumption of tea is mainly accompanied by the use of sugar as a sweetener. However, a high proportion of (saturated) cooking oil and sugar in the household diet is in contradiction with the dietary guidelines for humans (Herforth *et al.*, 2019). The WHO fact sheet advocates higher intake of unsaturated fats, for example, from fish, nuts and avocado to promote a balanced diet (WHO, 2018). Also, FAO's national dietary guidelines for Kenya shows that fish, meat and eggs are under the category of the protein-rich food to be consumed at least twice a week to assure a balanced diet (FAO, 2014; Herforth *et al.*, 2019). But in the research area, consumption of these food items was very low. The reduced consumption of fish, meat and eggs can be explained by the continual increase in the cost of fish and meat over the last few years in Kenya (Korir *et al.*, 2020), thus, limiting access to these food items. Additionally, practically all goat-raising farmers stated that producing meat was not their primary purpose. These results are in line with the findings of Woldu *et al.* (2016) among dairy goat farmers in Ethiopia, where eggs, fish and meat were also consumed in lower quantities.

The observed difference in dairy products (milk) consumption among DGF and NDGF is mainly attributable to the fact that most DGF initially decided to keep goats to ensure domestic milk production and consumption. Keeping dairy goats to specifically consume milk at the household level was reported to improve dairy products consumption among smallholder farmers in Thika Region, Kenya (Kagucia *et al.*, 2020). But, although goat keeping improved the dietary situation at household level, the decision to participate in dairy goat farming was determined by gender, age and formal education. This is consistent with the study by Maitho & Kinyua (2015) in Laikipia district, Kenya who also found that most of the dairy goat famers were male, older, and had attained at least secondary education. Income is also an important consideration for the decision to practice dairy goat farming as sufficient financial resources are required to cover the costs of purchasing goats, as well as veterinary, breeding, and feeding expenses (Mbindyo *et al.*, 2018). The probit regression underpinned these findings where overall household income increased the probability to rear goats.

Most DGF farmers had secure land tenure as they possessed a title deed. The assured land tenure could be a prerequisite for taking up goat farming and establishing a zero-grazing system with a small stable. This is consistent with Aravindakshan *et al.* (2020) who found that secure land tenure was associated with increased agricultural productivity and land improvement among famers in Bangladesh.

Overall, this study shows that dairy goat farming is positively associated with dietary diversity at the household level considering the positive and significant ATT value. This is in agreement with Stone *et al.* (2020) who also found that keeping dairy goats promoted improved household nutrition in Zanzibar. Development of techniques to enhance and sustain dairy goat farming among smallholder farmers and to entice more farmers to keep dairy goats is thus necessary. Further, the high consumption of starchy foods and low consumption of protein-rich foods in the study area is noteworthy, which is the leading cause of unbalanced diet. In view of this, programmes need to be planned and jointly conducted by nutritionists and health researchers, to sensitise farmers on optimal nutrition, and educate on the use of alternative and easily accessible foods for protein supply. In addition, further research is needed to assess some of the factors that lead to the low consumption of fish, meat, and eggs among the smallholder farmers in the study area.

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Conflict of interest

The authors declared that they have no conflict of interest.

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