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Potential for Commercialisation of Value-Added Products: A Case Study of Banana Value Addition in Embu, Tharaka-Nithi and Meru Counties in Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Despite being Kenya's leading fruit crop, contributing 35.6% of total fruit production, the minimal value addition in bananas significantly limits their potential as a vital source of income for many

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growers. This study assessed the extent to which value addition is done for bananas in Kenya, as well as explored the potential for commercialization of banana-value-added products. It was done in Embu, Tharaka-Nithi, and Meru, which are banana-rich counties in Kenya. A structured questionnaire was administered to 509 respondents to collect data, which was subjected to $\chi 2$ and logistic regression analyses. Results revealed that majority (63.3% and 79.1%) of the farmers were female and over 40-years-old, respectively. A proportion of 27.1% had not completed primary education, 38.1% had completed primary education, and 24.2% had completed secondary education. The length of time spent on banana farming varied significantly by county ($\chi 2 = 40.9$, $P<.001$), with Tharaka-Nithi having the highest proportion (63.0%) with over 30 years. Similarly, contribution of bananas to household income differed significantly by county ($\chi 2 = 48.6$, $P<.001$), with 54.6% of Meru farmers reporting 76-100% contribution. The uptake of value addition was significantly ($P<.001$) low (2.4%). Value addition was only reported in Tharaka-Nithi (5.9%), where products included crisps (0.6%), flour (0.8%), ripened (0.8%), and roasted (0.4%) bananas. The dry products have long shelf-life, earn farmers more income than fresh produce, and are commercialisable through direct marketing, shops, supermarkets, and niche institutions. Age ($P=.772$), education level ($P=.536$), and gender ($P=.335$) did not significantly influence uptake of value addition. Nonetheless, males were 2.09 times more likely to add value, as compared to females. Farmers who had acquired secondary and tertiary education were 1.76 and 1.67 times more likely to add value, as compared to those who had no formal education. A significant association was found between counties and responses on whether processing facilities and quality control training were incentives for increased value addition ($\chi 2 = 21.7$, $P=.006$), with Embu showing the strongest agreement (77.6%). These results highlight the need for targeted interventions such as establishment of processing facilities, training on banana processing and quality control, addressing infrastructural challenges, and creating better market access, to promote value addition in the banana value chain.

Keywords: Banana farming; production incentives; shelf-life; small-scale farmers.

1. INTRODUCTION

Banana is grown in over 130 countries in tropical and subtropical regions by small-scale and large-scale farmers. It is the second most highly produced fruit after citrus, contributing to 16% of world fruit production, as well as the sixth most important food crop after rice, wheat, barley, soybean, and corn (Gulati et al., 2022). It plays an important role in food security and is a source of export revenue in some economies. Banana is a convenient fruit across the world as it is affordable, nutritious, and available everywhere throughout the year. It is predominantly produced in Asia, Latin America, and Africa. The biggest producers are India, accounting for 26.8% of total world production in 2017, followed by China (9.8%) and Indonesia (6.3%). Other important banana-producing countries are Brazil (59%), Ecuador (5.5%), Philippines (5.3), Angola (3.8%), Guatemala (3.4%), and Tanzania (3.1%) (Siddiq et al., 2020). According to the Food and Agriculture Organization (FAO) in 2017, approximately 5.6 million hectares of land were dedicated to banana production globally (Ayiera, 2020).

Banana is the leading fruit crop in Kenya, making up 35.6% of the total fruit production, and a primary source of income (Kirimi et al., 2023; Nyang'au et al., 2021). Production of bananas in Kenya is mostly concentrated in the western, central and coastal regions, whose warm and humid climate provides ideal conditions for banana growth (Nyang'au et al., 2021). Banana is an important crop for small-scale farmers and contributes significantly to the economy of the country (Muthee et al., 2019; Nyang'au et al., 2021). Most of the bananas produced in Kenya are consumed locally, either fresh or cooked, and are important sources of food for the populace (Mwendia et al., 2021). Additionally, bananas are exported to neighbouring countries such as Tanzania, Uganda, and Rwanda.

Postharvest loss of bananas in Kenya remains a major challenge despite the significant contribution of bananas to the economy. The high perishability of bananas coupled with inadequate storage and transportation facilities result in considerable postharvest losses (Kamore et al., 2024; Wahome et al., 2021). According to a FAO (2014) study, dessert banana recorded over 11% postharvest loss before factoring in losses on the farm, while losses during ripening of dessert banana from Meru, Kirinyaga, and Murang'a was about 20%. Factors contributing to postharvest losses

include poor handling during harvesting and transportation, inadequate storage facilities, market access and value addition (Kamore et al., 2024; Saha et al., 2021). Use of traditional farming methods, with limited application of technology, unstable market prices, absence of subsidized inputs, limited access to improved materials, scarcity of extension experts, and insufficient demonstrations also contribute to the losses (Kirimi et al., 2023). A study by Muigai et al. (2021) revealed that a mere 31.9% of farmers engage in banana value addition, and no specific banana value addition technologies were identified in Chuka, Tharaka-Nithi, Kenya. Of those who engaged in value addition, 35.6% opted for banana ripening before sale, while 64.4% engaged in bulk packaging.

Interventions such as improved postharvest handling practices, storage facilities, and market access are necessary to reduce postharvest loss of bananas. Promotion of value addition activities such as banana processing into products could help reduce postharvest losses and open up new markets. This study aimed at filling the information gap regarding the state of value-added banana products in Meru, Embu, and Tharaka-Nithi counties in Kenya. It also explored the influence of socioeconomic factors in the production of value-added products at the farm level and along the value chain. It further examined the level of involvement and impact of cottage industries in enhancing the value of banana products.

2. MATERIALS AND METHODS

2.1 Study Site and Design

A cross sectional study was conducted in Tharaka-Nithi, Meru and Embu Counties in Kenya between May and August 2020, utilising interviews, expert opinions, focus group discussions and personal observations targeting banana farmers. The counties are located in the upper Eastern Kenya and boarder the eastern slopes of Mount Kenya.

2.2 Determination of the Sample Size

Since the number of farmers in the targeted counties was unknown, the sample size was calculated using the formula n = (z^2 p(1-p))/d^2 described by Kothari (2004), where n is the sample size, z is the z statistic at 95% confidence level (z = 1.96), p is the estimated population proportion, taken as p is 0.5 (maximum variability), and d is the desired precision level of ±5% at 95% confidence level. This formula gave a minimum sample size of 384 banana farmers for this study. Thus, from each county, a minimum of 128 banana farmers were sought for inclusion in this study. Around 15 key informants were purposively sampled to participate in the focus group discussions. Ultimately, the survey captured 509 farmers, which were 32.5% above the minimum expected sample size. The 509 banana farmers, comprising 205 (40.3% from Tharaka-Nithi), 161 (31.6% from Meru), and 143 (28.1% from Embu), gave informed consent to take part in this study.

2.3. Questionnaire Design

A structured questionnaire was used to collect data on value addition in bananas produced in Tharaka-Nithi, Meru and Embu Counties. The structured questionnaire sought information on socio-demographic characteristics of banana farmers, banana handling practices preharvest on the farm and postharvest off the farm, banana value added products, incentives needed for value addition, as well as storage and preservation practices. The questionnaire was pre-tested using 23 farmers in Kirinyaga County.

2.4 Data Collection and Analysis

For each of the banana farmers, the questionnaire was administered as an interview. Trained interviewers were used to administer the questionnaire. Farmers' responses were recorded and submitted for analysis. The data obtained from the structured questionnaires was analysed using Statistical Package for Social Sciences (SPSS) software version 25. For categorical data, frequencies of occurrence of response were calculated. For numerical variables, data was summarized as means. Chi-square test was used to test independence of the nominal variables at P=0.05 level of significance. Chi-square goodness of fit test was done with an assumption of equal proportions of respondents who gave a yes or no response regarding whether or not they undertook value addition in bananas. Logistic regression analysis was used to determine the influence of gender, age and education level on the farmers' willingness to add value in bananas.

3. RESULTS AND DISCUSSION

3.1. Demographic Characteristics of Farmers

Table 1 shows the demographic characteristics of banana farmers in Tharaka-Nithi, Meru and

Embu. Results showed significant differences (*P*=.05) in demographic characteristics (gender, age, education level, experience, and contribution to household income by banana farming). Majority of the respondent farmers were female (63.3%). This was because in the study area, there were more females who had joined banana farmers' groups and hence were available to participate in the interviews as compared to men. The results agreed with those of Ntabo et al. (2024) and Kirimi et al. (2023) who reported a higher percentage of 63% and 67% of farmers being female in Kisii and Meru, respectively.

Inquiry about the household head revealed that majority (69.94%) of households were headed by males as shown in Fig. 1. The county did not significantly (*P*=.527) influence the gender of the household head. This result contrasted with a previous study carried out by Mwendia (2019), who investigated drivers of diversification of banana farming among households in Meru and reported that majority (67%) of the banana farmers were male, who in turn were directly responsible for household farming choices. Also in Uganda, males (65%) were most involved in banana farming compared to females (Mpiira et al., 2023).

Age distribution revealed that the majority of farmers were aged over 40-years-old (79.1%). Only 4.7% of the farmers were aged 21 to 30-years-old (Table 1). In comparison with other similar studies in Kisii County of Kenya where banana farming is also popular, the mean age of banana farmers was 45 years (Ntabo et al., 2024). Another study in Meru County had earlier reported an average of 40 years for banana farmers (Mwendia, 2019). The age reported is closer to that of banana farmers in Uganda at 44 years (Mpiira et al., 2023). This may mean that banana farming is a source of livelihood for the elderly and that the young aged below 30 years were not interested in farming, but instead were preoccupied in other activities.

The majority of farmers (27.1%) had either no formal education or not completed primary education. About 38.1% of the farmers had completed primary education, while only 24.2% of the farmers had completed secondary education. Those who had attained tertiary education were only 10.6%, with only 1.6% being university level graduates. This means that most of the respondents interviewed had no formal employment and therefore solely relied on informal sources of income such as banana farming. There was also a significant difference in level of education among the three counties (*P*<.001). This may also explain why majority of the respondents (68.9%) had been engaging in banana farming for over 10 years. For most of the farmers (60.9%), banana farming contributed over 50% of their family monthly income. For 26.3% of the farmers, banana farming contributed between 76% and 100% of the family income. This highlights the importance of banana farming as a source of income in this region. The results are similar to those of Murigi et al. (2024), who demonstrated that smallholder contract banana farmers depended largely on the enterprise as a source of household food and income generation.

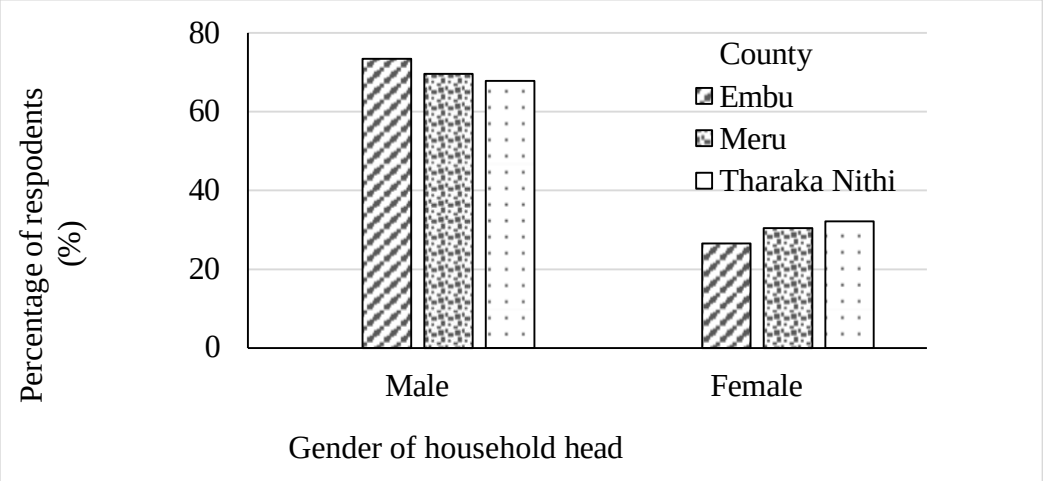

Fig. 1. The gender of household heads in Tharaka-Nithi, Embu and Meru Counties (Chi-square test of independence, χ^2=1.3, *P*=.527)

Table 1. Characteristics of banana farmers in Embu, Tharaka-Nithi and Meru Counties in Kenya

Characteristic	Sub-characteristic	N	Overall percentage (%)	Embu County (%)	Tharaka-Nithi County (%)	Meru County (%)	*X^2, *P*-value
Gender	Male	187	36.7	37.4	36.9	25.7	13.3, .01
	Female	322	63.3	22.7	42.2	35.1	
Age (years)	Below 20	1	0.2	100.0	0	0	43.6, <.001
	21-30	24	4.7	20.8	33.3	45.8	
	31-40	81	15.9	8.6	40.7	50.6	
	41-50	108	21.2	25.0	36.1	38.9	
	51-60	131	25.7	32.8	38.9	28.2	
	Above 60	164	32.2	36.6	45.1	18.3	
Education	No formal education	34	6.7	29.4	26.5	44.1	35.5, <.001
	Primary (In-complete)	104	20.4	25.0	44.2	30.8	
	Primary (Complete)	129	25.3	23.3	31.0	45.7	
	Secondary (In-complete)	65	12.8	23.1	43.1	33.8	
	Secondary (Complete)	123	24.2	32.5	45.5	22.0	
	College/ Vocational	46	9.0	37.0	50.0	13.0	
	University Education	8	1.6	62.5	37.5	0.0	
Length of time in banana farming (years)	Below 10	158	31.0	29.7	38.0	32.3	40.9, <.001
	10- 20	171	33.6	24.6	31.6	43.9	
	21 - 30	80	15.7	35.0	35.0	30.0	
	Above 30	100	19.6	26.0	63.0	11.0	
Contribution of bananas to household income	0 - 25%	54	10.6	24.1	57.4	18.5	48.6, <.001
	26 - 50%	145	28.5	31.0	46.2	22.8	
	51 - 75%	176	34.6	32.4	42.0	25.6	
	76 - 100%	134	26.3	20.9	24.6	54.6	
	Total	509	100				

**Chi-square test of independence between the categorical variables for characteristics (rows) and counties (columns).*

The results further showed that the length of time in banana farming varied significantly across counties (χ2 = 40.9, *P*<.001). In Embu, 38.0% of farmers had been farming bananas for less than 10 years, while in Meru, 43.9% had been farming for 10-20 years. Tharaka-Nithi had the highest proportion of farmers (63.0%) with over 30 years of experience in banana farming.

Similarly, the contribution of bananas to household income also varied significantly by county (χ2 = 48.6, *P*<.001). In Tharaka-Nithi, 57.4% of farmers reported that bananas contributed 0-25% of their household income, while in Meru, 54.6% of farmers stated that bananas contributed 76-100% of their household income. This shows that banana farming is a significant economic activity and a source of income for many people in the three counties. This underlines the importance of the banana value chain in advancing the economic prowess of the three counties.

3.2 Value Addition in Bananas

Value addition was only reported in Tharaka-Nithi (Table 2). The other two counties (Embu and Meru) did not report any value-addition practices by banana farmers and this could be due to the ready market of the bananas due to proximity of the farmers to the urban areas. Embu and Meru Counties are more urbanized compared to Tharaka-Nithi County. Since value addition is intended to extend the shelf-life and increase the market price, farmers in Tharaka-Nithi might not have been able at all times to make immediate sale to the small town (Chuka) and hence benefited more from value-added products. A study by Evans et al. (2020) showed that proximity to the market is a factor that highly contributes to uptake of value addition of agricultural produce. According to this study, more farmers in Tharaka-Nithi participated in banana farming compared to the other two counties (Table 2). The surplus in the banana output could have contributed to the uptake of value addition in Tharaka-Nithi. This result is similar to that of Osondu et al. (2023) that most farmers involved in agri-value-added products in Nigeria had a surplus of produce.

It is evident that the uptake of value addition by farmers was overall significantly (*P*<.001) low (2.4%) (Fig. 2). This could be due to a lack of proper infrastructure, technology, or a ready market for the value-added products. Value-added products are also highly priced compared to freshly harvested produce. The high price could be one of the reasons why the uptake of value-addition technology is low among farmers. Value addition is predominantly carried out by skilled chain actors who have access to compatible markets for value-added products and possess the necessary technology. Other studies have listed similar challenges to uptake of value addition (Evans et al., 2020; Mohapatra et al., 2011; Ntabo et al., 2024).

The value-added products in this study were mainly flour (36%), ripened bananas (29%), crisps (21%), and roasted bananas (14%) (Fig. 3). Comparing the four value-added products, banana flour has the lowest moisture content and hence a longer shelf life. Banana flour can easily be incorporated into other starchy foods such as porridge, functional foods, mashed potatoes, and mashed bananas, among others.

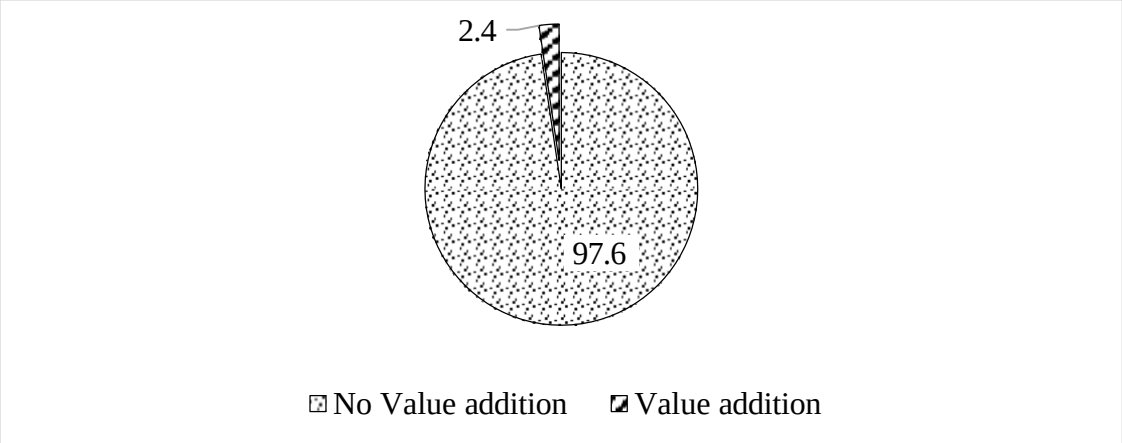

Fig. 2. Graph showing percentage of farmers engaged in banana value addition in Tharaka-Nithi, Meru and Embu Counties in Kenya (χ^2 = 159.8, *P*<.001)

Table 2. Banana value addition by farmers in Tharaka-Nithi, Meru and Embu Counties

County	Response	Frequency	Percentage (%)	χ^2, *P*-value*
Embu	No	143	100	462.1, <.001
Tharaka-Nithi	No	193	94.1	
	Yes	12	5.9	
Meru	No	161	100	
Total		509		

**Chi-square goodness of fit test was done with an assumption of equal proportions of respondents who gave a yes or no response regarding whether or not they undertook value addition in bananas*

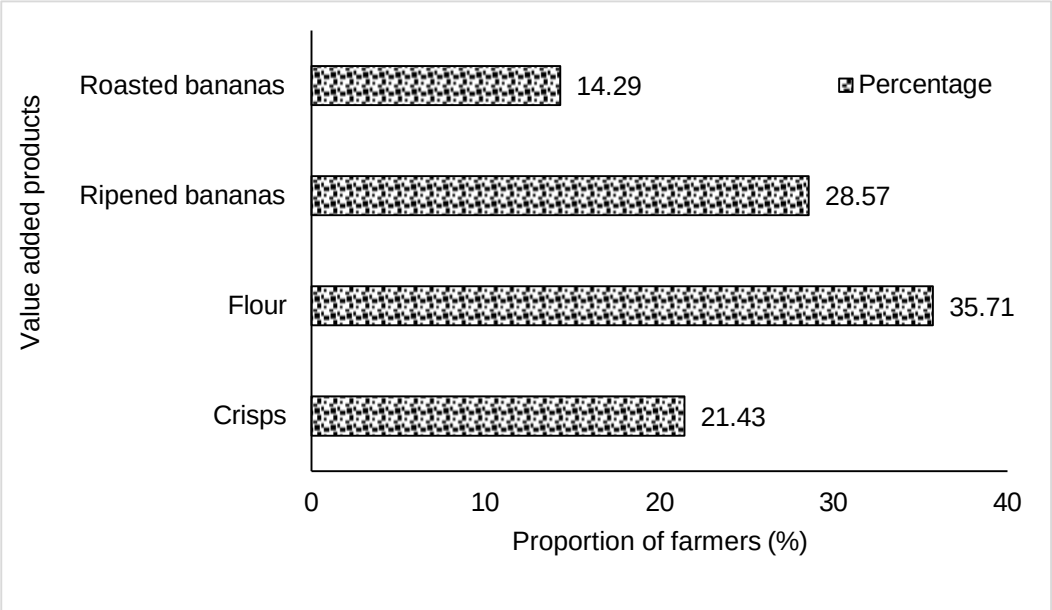

Fig. 3. Comparison of value-added products among banana farmers in Tharaka-Nithi

Several researchers have highlighted a preference for dried banana flour as a value-added product due to its ease of incorporation into various foods (Mohd Dom et al., 2021; Yu et al., 2020). Bananas are typically dried using sun-drying methods, which are cost-effective and accessible to many farmers. These factors have made banana flour to be one of the most preferred value-added products alongside ripened bananas. Ripened bananas, known for their sweet taste, are versatile and can be consumed as a meal, fruit, or snack. Additionally, the ripening process requires minimal technological input, making it an easier and more practical value-addition option for farmers (Cho and Koseki, 2021). Roasting of bananas is mainly done in open-air markets and the product is consumed immediately when still hot due to the effect of banana starch stalling. Only farmers close to the market can roast bananas directly at the markets. Banana crisps require oil and heat. The cost incurred to prepare the crisps makes most farmers shy away from the crisps product.

3.3. Effect of Gender, Age and Level of Education on Uptake of Value Addition

Logistic regression analysis revealed that gender, age and education level of the banana farmers did not significantly influence their decision to add value to bananas (Table 3). Nonetheless, male farmers were 2.09 times more likely to add value to bananas as compared to females. Furthermore, those who had acquired secondary and tertiary education were 1.76 and 1.67 times more likely to add value to bananas as compared to those who had no formal education. Chi-square analysis results also revealed that gender, age and education level of the banana farmers were independent of the farmers' decision to add value to bananas (Table 4). Nonetheless, a higher proportion of male-led households (3.2%) engaged in value addition compared to female-led households (1.9%) (Table 4). In a study by Osondu et al. (2023) in Nigeria, female agri-prenuers were more likely to

take up value addition compared to male agri-prenuers, which contrasted with the present findings, which can be explained by the relatively higher education among men compared to women (Al Hinai et al., 2022).

Respondents above 60-years-old carried out more value addition compared to any other age group (Table 4). This is similar to a study by Ngenoh et al. (2020) which reported that majority of value-addition individuals were older than those not willing to take it up. This could be as a result of retirement and pursuit of other sources of income compared to younger individuals who may have other income streams. In contrast, Ntabo et al. (2024) in Kenya and Kyomugisha et al. (2018) in Uganda reported that young agri-prenuers (45 years and below) were more likely to take up agri-innovations than the older agri-prenuers.

The highest level of education of farmers who performed value addition was college graduation (4.3%), followed by those who finished secondary school (4.1%) (Table 4). This shows that education has a positive impact on value addition. There were no banana farmers who were university graduates. This meant that university graduates prefer other methods of income generation apart from banana farming. Level of education has been shown to affect uptake of value addition due to exposure to value added products; the education could either be formal or informal (Nalunga et al., 2015).

3.4 Knowledge of Incentives Likely to Improve Value-Addition Uptake

Majority (over 60%) of farmers strongly agreed that provision of processing facilities and instruction on quality control could increase banana production in the three counties (Fig. 4). There was a significant (χ^2 = 21.7, *P*=.006) association between the counties and the responses regarding provision of processing facilities and instruction on quality control as shown in Fig. 4. Farmers from Embu showed the strongest agreement (77.6%) on the need for the aforementioned incentives, followed by Meru (75.8%) and Tharaka-Nithi (67.8%). Availability of incentives such as provision of value addition processing units have been proven to stimulate farmers into production of more agricultural products (Ntabo et al., 2024).

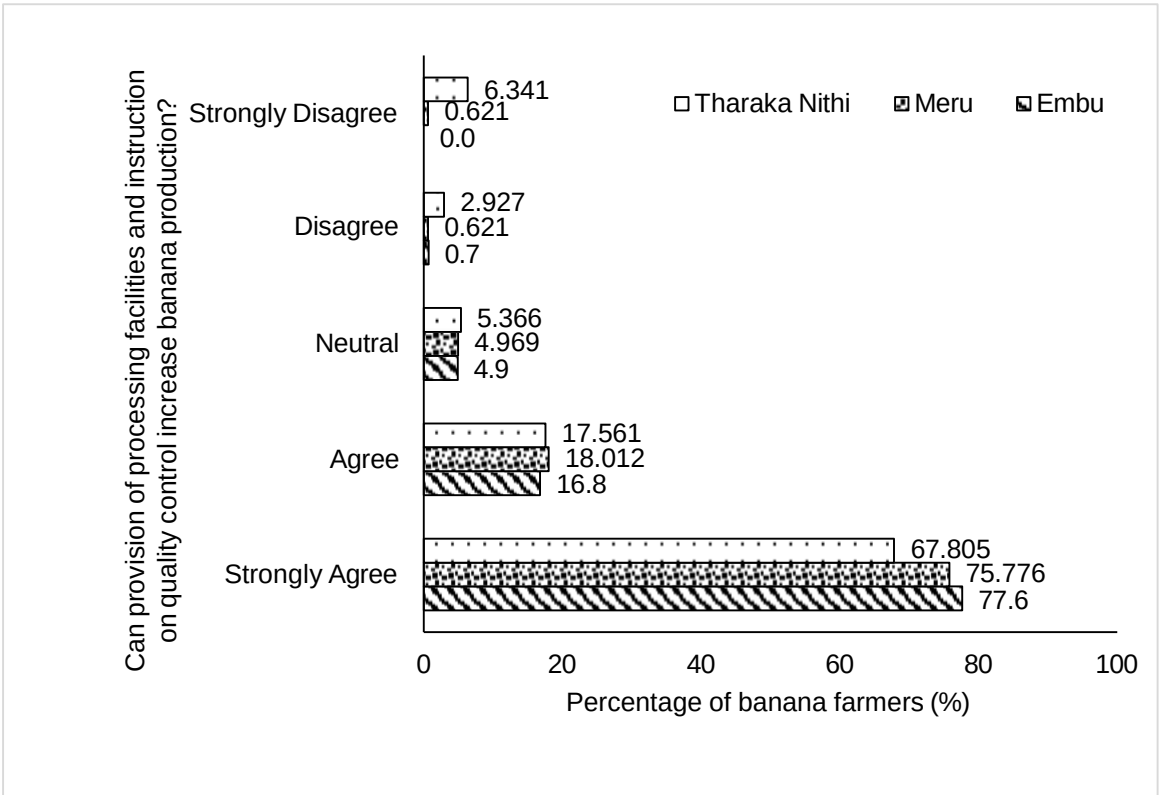

Fig. 4. Response of farmers in counties on incentives requirement to improve banana production (Chi-square χ^2 = 21.7, *P*=.006)

Table 3. Logistic regression analysis predicting uptake of value addition as affected by gender, age and level of education of the respondents

Characteristic of respondents	Terms	Coeffi-cients	SE of Coefficients	Z-value	*P*-value	Odds ratio	95% CI for odds ratio
	Constant	-2.77	0.64	-4.33	0.00		
Gender (reference is "female")	Male	0.74	0.63	1.17	0.24	2.09	(0.61, 7.14)
Age (reference is "≥60 years")	21-30 years	-0.07	1.24	-0.06	0.96	0.94	(0.08, 10.58)
	31-40 years	-1.04	1.13	-0.91	0.36	0.36	(0.04, 3.27)
	41-50 years	-0.56	0.89	-0.63	0.53	0.57	(0.10, 3.27)
	51 -60 years	-1.03	0.87	-1.18	0.24	0.36	(0.06, 1.98)
Education level (reference is "no formal education")	Primary Edu	-0.51	0.98	-0.52	0.60	0.60	(0.09, 4.07)
	Secondary Edu	0.56	0.83	0.68	0.49	1.76	(0.35, 8.86)
	Tertiary Edu	0.51	1.04	0.49	0.62	1.67	(0.22, 12.89)

Table 4. Effect of gender, age and education on value addition uptake in Tharaka-Nithi

Characteristic of respondent	Sub-characteristic	Response		Total	χ^2, *P*-value*
		No	Yes		
Gender	Male	181	6	187	0.930, .335
		96.8%	3.2%	100%	
	Female	316	6	322	
		98.1%	1.9%	100%	
Age (years)	Below 20	1	0	1	2.528, .772
		100%	0.0%	100%	
	21-30	23	1	24	
		95.8%	4.2%	100%	
	31-40	80	1	81	
		98.8%	1.2%	100%	
	41-50	106	2	108	
		98.1%	1.9%	100%	
	51-60	129	2	131	
		98.5%	1.5%	100%	
	Above 60	158	6	164	
		96.3%	3.7%	100%	
Level of education	No formal education	34	0	34	5.423, .491
		100%	0.0%	100%	
	Primary (In-complete)	101	3	104	
		97.1%	2.9%	100%	
	Primary (Complete)	127	2	129	
		98.4%	1.6%	100%	
	Secondary (In-complete)	65	0	65	
		100%	0.0%	100%	
	Secondary (Complete)	118	5	123	
		95.9%	4.1%	100%	
	College/ Vocational	44	2	46	
		95.7%	4.3%	100%	
	University Education	8	0	8	
		100%	0.0%	100%	
Total		497	12	509	
		97.6%	2.4%	100%	

Table 5. Effect of age on agreement with introduction of post-harvest incentives to increase profitability of banana farming

County	Age of respondent	N	Can provision of processing facilities and instruction on quality control increase banana production?					χ^2, *P*-value
			Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
Embu	Below 20 years	1	100.00%					9.14, .870
	21-30 years	5	60.00%	20.00%	20.00%			
	31-40 years	7	100.00%					
	41-50 years	27	85.20%	11.10%	3.70%			
	51 -60 years	43	74.40%	23.30%	2.30%			
	Above 60 years	60	75.00%	16.70%	6.70%	1.70%		
Total		143	77.60%	16.80%	4.90%	0.70%		
Meru	21-30 years	11	90.90%	9.10%				14.63, .552
	31-40 years	41	73.20%	17.10%	7.30%	2.40%		
	41-50 years	42	81.00%	16.70%	2.40%			
	51 -60 years	37	67.60%	21.60%	10.80%			
	Above 60 years	30	76.70%	20.00%			3.30%	
Total		161	75.80%	18.00%	5.00%	0.60%	0.60%	
Tharaka-Nithi	21-30 years	8	62.50%	12.50%	12.50%	12.50%		12.97, .675
	31-40 years	33	57.60%	24.20%	6.10%	3.00%	9.10%	
	41-50 years	39	71.80%	12.80%	7.70%	2.60%	5.10%	
	51 -60 years	51	78.40%	11.80%		2.00%	7.80%	
	Above 60 years	74	63.50%	21.60%	6.80%	2.70%	5.40%	
Total		205	67.80%	17.60%	5.40%	2.90%	6.30%	

Table 6. Effect of gender on implementation of banana processing industries

County	Gender	N	Can provision of processing facilities and instruction on quality control increase banana production?					χ^2, *P*-value
			Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
Embu	Male	70	82.90%	12.90%	4.30%			2.81, .422
	Female	73	72.60%	20.50%	5.50%	1.40%		
Total		143	77.60%	16.80%	4.90%	0.70%		
Meru	Male	48	70.80%	20.80%	8.30%			2.93, .570
	Female	113	77.90%	16.80%	3.50%	0.90%	0.90%	
Total		161	75.80%	18.00%	5.00%	0.60%	0.60%	
Tharaka-Nithi	Male	69	59.40%	20.30%	5.80%	1.40%	13.00%	9.70, .046
	Female	136	72.10%	16.20%	5.10%	3.70%	2.90%	
Total		205	67.80%	17.60%	5.40%	2.90%	6.30%	

Table 7. Effect of level of education on the incentives to be rendered to increase banana production and profitability

County	Level of education of respondents	N	Can provision of processing facilities and instruction on quality control increase banana production?					χ^2, *P*-value
			Strongly Agree	Agree	Neutral	Disagree	Strongly disagree	
Embu	No formal education	10	80.00%	20.00%				10.85, .901
	Primary school (In-complete)	26	84.60%	15.40%				
	Primary school (Complete)	30	80.00%	16.70%	3.30%			
	Secondary school (In-complete)	15	86.70%	13.30%				
	Secondary school (Complete)	40	67.50%	20.00%	10.00%	2.50%		
	College Education/ Vocational training	17	76.50%	11.80%	11.80%			
	University Education	5	80.00%	20.00%				
Total		143	77.60%	16.80%	4.90%	0.70%		
Meru	No formal education	15	93.30%	6.70%				22.83, .297
	Primary school (In-complete)	32	71.90%	18.80%	6.30%		3.10%	
	Primary school (Complete)	59	69.50%	23.70%	5.10%	1.70%		
	Secondary school (In-complete)	22	90.90%	9.10%				
	Secondary school (Complete)	27	77.80%	18.50%	3.70%			
	College Education/ Vocational training	6	50.00%	16.70%	33.30%			
Total		161	75.80%	18.00%	5.00%	0.60%	0.60%	
Tharaka-Nithi	No formal education	9	77.80%	11.10%			11.10%	18.55, .776
	Primary school (In-complete)	46	60.90%	23.90%	4.30%	6.50%	4.30%	
	Primary school (Complete)	40	62.50%	25.00%	7.50%		5.00%	
	Secondary school (In-complete)	28	67.90%	14.30%	3.60%	7.10%	7.10%	
	Secondary school (Complete)	56	69.60%	12.50%	7.10%		10.70%	
	College Education/ Vocational training	23	78.30%	13.00%	4.30%	4.30%		
	University Education	3	100.00%					
Total		205	67.80%	17.60%	5.40%	2.90%	6.30%	

During the interview, an observation was made that there was minimal support of incentives by the county administration, as evidenced by respondents in Embu. This agreed with Murigi et al. (2024) findings that the major constraints of banana production in Embu County include lack of support from the county government. Tharaka-Nithi County envisioned addition of value to its agricultural produce (Tharaka-Nithi County Government, 2013), although it has not really actualised it to significant levels that could benefit the local banana farmers. The farmers in all the counties understood the benefits they would reap from the harvest in case post-harvest incentives were promoted in their counties. The benefits included reduction in post-harvest losses, increased sales, market assurance, controlled pricing of the banana harvest, and product diversification. This would subsequently encourage more farmers to participate in banana production (Naik et al., 2024; Singh et al., 2024).

3.5 Effect of Age, Gender and Education on Post-Harvest Incentives Uptake

Farmers' age and the need for ground-breaking services to increase banana production in the three counties is shown in Table 5. There was no significant association (*P*=.05) of age of the respondent and responses about the implementation of incentives.

Nonetheless, the respondents below 20 years highly and strongly agreed (100%), whereas the age group of 31-40 years was the least to strongly agree (69.1%) on the uptake of post-harvest incentives in their counties. This could be as a result of this age bracket (31-40) being involved in other income-generating activities other than banana farming. The implementation of processing, cottage industries, and quality control activities can benefit everyone irrespective of age. This is in agreement with Olumba and Onunka (2020) who reported that banana production enterprises had great prospects in alleviating poverty and promoting industrial growth and rural development.

There was no significant association of gender with response to the question of implementation of incentives in Embu ($\chi^{2,}$ = 2.81, *P*=.422) and Meru ($\chi^{2,}$ = 2.93, *P*=.570) (Table 6). Nevertheless, in Tharaka-Nithi, gender significantly ($\chi^{2,}$ = 9.698, *P*=.046) influenced the response of banana farmers to implementation of banana processing facilities as an incentive to increase production and value addition uptake (Table 6). More females (72.1%) strongly agreed as compared to males (59.40%). Irrespective of different gender roles in crop production, both genders agreed with the need and potential benefits of banana processing facilities. This contrasts with the findings of Iradukunda et al. (2019), which reported that post-harvest crop utilization preferences vary across genders.

Education level did not significantly influence farmer's response (Embu *P*=.901, Meru *P*=.297, Tharaka-Nithi *P*=.776) with regard to the implementation of the banana cottage and processing industries (Table 7). However, the respondents who had attained university education strongly agreed (87.5%) with the implementation of the value addition services in their counties. The highly educated respondents in this study (university level) were not involved in value addition. This was attributed to involvement in other off-farm activities to supplement their economic income. At the same time those of mid-level education (secondary school) were involved in post-harvest value addition since they were fully committed to banana farming and hence had more time dedicated to the agri-enterprise. This result is similar to the findings of Ntabo et al. (2024), which showed that farmers involved in value addition were not participating in other off-farm economic activities.

4. CONCLUSION AND RECOMMENDATIONS

Despite the importance of banana farming as a livelihood source, value-addition practices were only reported in Tharaka-Nithi, where 5.9% of farmers engaged in processing bananas into products such as flour, crisps, roasted and ripened bananas. Also banana farmers could produce a wide range of value-added products such as juice, snacks, flour for gluten-free baking, bread, and baby food for commercialisation.

Besides processing of banana fruits into food for human consumption, other technologies for dealing with the waste stream in the banana value chain and its value addition process should be encouraged in Kenya. Parts like leaves, stem fibres, and fruit peels could be utilised to produce anti-toxoplasma antibody, biofuels, bioplastics, laboratory media, bio-enzymes and animal feeds.

The uptake of value addition was overall low (2.4%), with factors such as lack of infrastructure,

technology, and market access hindering wide adoption on a commercial scale. Results further showed that male farmers and those with secondary or tertiary education were more likely to adopt value-addition practices. The majority of banana farmers in the region strongly supported the provision of processing facilities and training on quality control as key incentives to enhance banana production and value addition.

While banana farming was shown to be an essential economic activity in these counties, strategies to enhance the adoption of value addition are necessary. These strategies include addressing infrastructural challenges, providing training on value-addition techniques, and creating better market access, particularly for farmers in less urbanized areas. Expanding value-addition practices should be promoted to contribute significantly to commercialisation, sustainability and profitability of banana farming in Kenya.

CONSENT

During the survey, participants were notified of the objective of the study and that the information they were going to provide would be held confidential and used only for research and development. They were further notified that participation was entirely voluntary and that they could opt-out of the survey at any time during the interview. They then gave their consent.

ETHICAL CONSIDERATIONS

Permission to carry out this study was obtained from the National Commission for Science and Technology and from the respective county Commissioners for the three counties of Meru, Tharaka-Nithi and Embu in Kenya.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that no generative AI technologies such as large language models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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