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Perception of Smallholder Chicken Farmers on Black Soldier Fly Larvae (BSFL) as a Super Alternative Protein Source for Chicken in Uasin Gishu County, Kenya

Gladys Jepchirchir Koech*, Priscilla Mkambe Nzaka, Edith Gathungu, George Owuor

Department of Agricultural Economics and Agribusiness Management, Egerton University, Njoro, Kenya

Email address:

gladyskoech29@yahoo.com (Gladys Jepchirchir Koech)

*Corresponding author

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Abstract: This study evaluates the perception of smallholder chicken farmers in the utilization of black soldier fly larvae (BSFL) as an alternative protein source, and its incorporation in livestock feed systems in Kenya, with a specific case of chicken farmers in Uasin Gishu, Kenya. The study employed a survey research design covering 245 smallholder chicken farmers interviewed through a semi-structured questionnaire. Results revealed that 72.5% of the chicken farmers were aware of the benefits of incorporating BSFL in chicken feed. Principal component analysis based on perception indices revealed that social acceptability, feed performance compared to conventional protein sources, and marketability of chicken products reared on BSFL were the key attributes guiding chicken farmers' buying decisions. Awareness of BSFL attributes, education level, access to agricultural extension services, group membership, and participation in off-farm activities significantly influenced chicken farmers' perceptions of BSFL. In conclusion, the study demonstrates that interventions such as training and farm demonstrations would increase chicken farmers' technical know-how on improving the productivity of chicken reared on BSFL. Accessing agricultural extension services is essential in reducing chicken farmers' uncertainties of accepting BSFL and encouraging the uptake of this rapidly growing and emerging technology. This work adds to the current understanding of BSFL-based feeds and creates opportunities for further linkages between chicken farmers, public-private partnerships, policymakers, feed manufacturers, and consumers of chicken products.

Keywords: Black Soldier Fly Larvae-Based Feed, Farmers' Perception, Linear Regression, Principal Component Analysis, Smallholder Chicken Farmers

1. Introduction

Agricultural development is considered one of the most impactful approaches to addressing extreme poverty, promoting shared prosperity, and supporting the projected population growth of 9 billion by 2050 [1]. When compared to other sectors, the agriculture industry has proven to be 2-5 times more effective in boosting incomes for individuals who have limited resources. The sector plays a significant role in driving economic growth. It contributes 4% to the global gross domestic product (GDP) and holds even more weight, accounting for over 25% of the GDP in certain least-developed countries [1].

The livestock sector in Africa accounts for one-third of the global livestock population [2] and approximately 40% of African agricultural GDP, ranging from 12% to 78% in individual countries [3]. The rapid growth in the global population has led to increased demand for foods rich in protein, especially animal-based proteins, thus increasing their production [4]. According to the report from FAO in 2017 [4], one approach to enhancing food production and alleviating poverty in Africa is through the implementation of intensive agricultural practices that aim to increase the competitiveness and profitability of livestock businesses. In Sub-Saharan Africa (SSA), poultry, fish, and pig farming have emerged as the most rapidly expanding agricultural sectors, offering significant income generation and employment prospects [4].

In Kenya, the livestock industry contributes to more than 30% of the total value of agricultural goods at the farm level. It also makes up over 10% of the country's Gross Domestic Product (GDP) and at least 50% of the agricultural GDP [5]. Additionally, this sector employs around half of the labor force involved in agriculture. Local needs for meat, milk, dairy products, and other livestock items like eggs are fulfilled by domestic livestock. This sector contributes around 30% of all agricultural products that are sold [6]. Pastoralism, ranch farming, and agro-pastoralism are common in arid and semi-arid regions. Under agro-pastoralism, farmers integrate crop and livestock production, and crop residues make up a significant portion of livestock feeds. Livestock comprises of dairy cattle, goats, camels, beef cattle, small ruminants, non-ruminants, and exotic and indigenous poultry.

In Kenya, more than 60% of households own at least one type of livestock, with more than 90% of rural households rearing poultry. Poultry keeping provides eggs, meat, and manure which make Kenya's poultry sub-sector have the potential of increasing household income and contributing to food security and nutrition security [7].

The poultry sector is practiced on a small to medium scale and is characterised as a fast-growing industry in Kenya, with increased demand for poultry products driving up production. Chicken products contribute to protein nutrition for many Kenyan households. The sub-sector is an important source of income as well as a means of fulfilling other social and cultural roles [8]. Chicken production systems are classified as commercial or subsistence based on their production goals [9]. It can also be classified according to different types of chicken production systems based on various husbandry practices as well as the input requirements and output levels involved [10].

In Uasin Gishu County, most farmers practice poultry farming on a small-scale capacity, more so, the county is boosting knowledge and reaching for poultry farming through projects such as Inua Mama na Kuku funded by the county and Kenya climate-smart agriculture project (KCSAP) funded by the World Bank which has increased the population of poultry posing a challenge to the farmers on how to feed them with a quality feed [11].

Despite the associated benefits, the sub-sector's potential is hindered by the high production cost, with feed alone accounting for more than 70% of total production costs. The commercial feed industry relies heavily on traditional protein sources like soybeans and fish meal for around 70% of their production expenses [12]. The conventional protein; soybean, and fish meal use' compete with human food. The food-feed competition has made it unsustainable [13]. The production of animal feed faces limitations due to the competition for resources such as land, fertilizers, energy, and water [14]. This imbalance between supply and demand has led to higher prices for both inputs and poultry products [15, 16]. This has necessitated the exploration of other protein sources.

There has been a growing interest in alternative protein sources such as BSFL, crickets and worms to replace the conventional sources [17, 18]. Insects have proved to have high crude protein and nutritional benefits, and unlike the production of plant-based and livestock-based protein sources, insects need less land and water to be produced and can feed on decaying market waste, thus contributing to environmental clean-up [13]. Given that waste disposal is still a challenge in many developing countries, insect farming will not only reduce waste disposal costs but also contribute to better health by adding value to low-value markets and kitchen waste [19, 20].

There has been a growing interest by public and private sectors in partnering with the International Centre of Insect Physiology and Ecology (*Icipe*) and Kenya Agriculture and Livestock Organization (KALRO) to explore the use of insects for poultry feed. Black soldier fly Larvae (BSFL) have been identified for mass rearing due to their ability to convert organic waste into high-quality crude protein (CP), fat, amino acids, fatty acids, vitamins, and minerals that are better than that of fishmeal and soybean [8, 21]. Despite the initiatives by public and private collaborations, the adoption of black soldier fly larvae-based feed is still low. Understanding farmers' perceptions will provide a clear reflection of their attitudes and their positive uptake of innovations to be introduced, which could have otherwise hindered the uptake of such innovations and technologies [22].

A recent trend of literature revealed that individuals who consume eggs from laying chickens fed on commercial BSLF meal had a favorable opinion and are willing to purchase such products [23]. However, there is still insufficient research on how farmers perceive feed incorporating BSF larvae. Traditionally, insects have been associated with disgust and dirt, resulting in them being regarded as pests [24]. This has led to the idea that they should be eradicated or kept out of the food supply chain [25]. This study is in line with those that seek to introduce insects more easily by incorporating them into animal feed [26]. Therefore, understanding farmers' perceptions and attitudes towards BSFL-based feeds is essential in the initiatives that seek to improve chicken welfare through consciously feeding chicken and proper animal management [27].

Based on research conducted by Okello et al., 2021 [28], this study aims to clarify the concept of perception among chicken farmers. Specifically, it refers to their familiarity and comprehension regarding the distinguishing attributes of BSFL-based feed as a protein source in chicken diets compared to traditional fishmeal and soybean protein. Recent literature has shown positive perception of eggs derived from chicken reared on commercial insect-based feed [23] with limited information on chicken farmers' perception of black soldier fly larvae-based feed.

Expanding on the research conducted by Okello et al., 2021 and Chia et al., 2020 [28, 29], this study focuses on exploring the perspectives and expertise of farmers in Kenya regarding the utilization of insects as an alternative source of feed. Hence, this research aimed to address the lack of information by examining how small-scale poultry farmers in Uasin Gishu County, Kenya perceive the use of BSFL-based feed as a substitute for protein.

2. Materials and Methods

2.1. Data Sources and Sampling Procedure

A survey of 245 smallholder chicken farmers was conducted between 5th March and 28th March 2023. The study employed a multi-stage sampling technique. Uasin Gishu county was purposively selected for its high population density, cosmopolitan population, and the high number of smallholder chicken farmers coupled with projects promoting the chicken value chain by the provision of inputs such as Inua mama na kuku project as well as Kenya climate-smart agriculture project. Soy, Kesses, and Ainabkoi sub-counties were purposely selected because of the higher number of smallholder chicken farmers. Kipsomba, Tulwet-Chuiyat, and Kapsoya wards were randomly selected for the study. Finally, a systematic sampling method was used to select households from the list provided by Sub-County Agricultural Officers. In the systematic sampling method, the first respondent was randomly selected from the list, and a sampling interval k was applied to obtain other respondents. k=N/n where k is the sampling interval, N is the total number of households in a given ward, and n is the sample size in each ward. The data for this study was obtained from a cross-sectional survey of farmers. Primary data was collected from the respondents using a semi-structured questionnaire; 105, 87, and 53 respondents were interviewed from Kipsomba, Tulwet-Chuiyat, and Kapsoya wards, respectively.

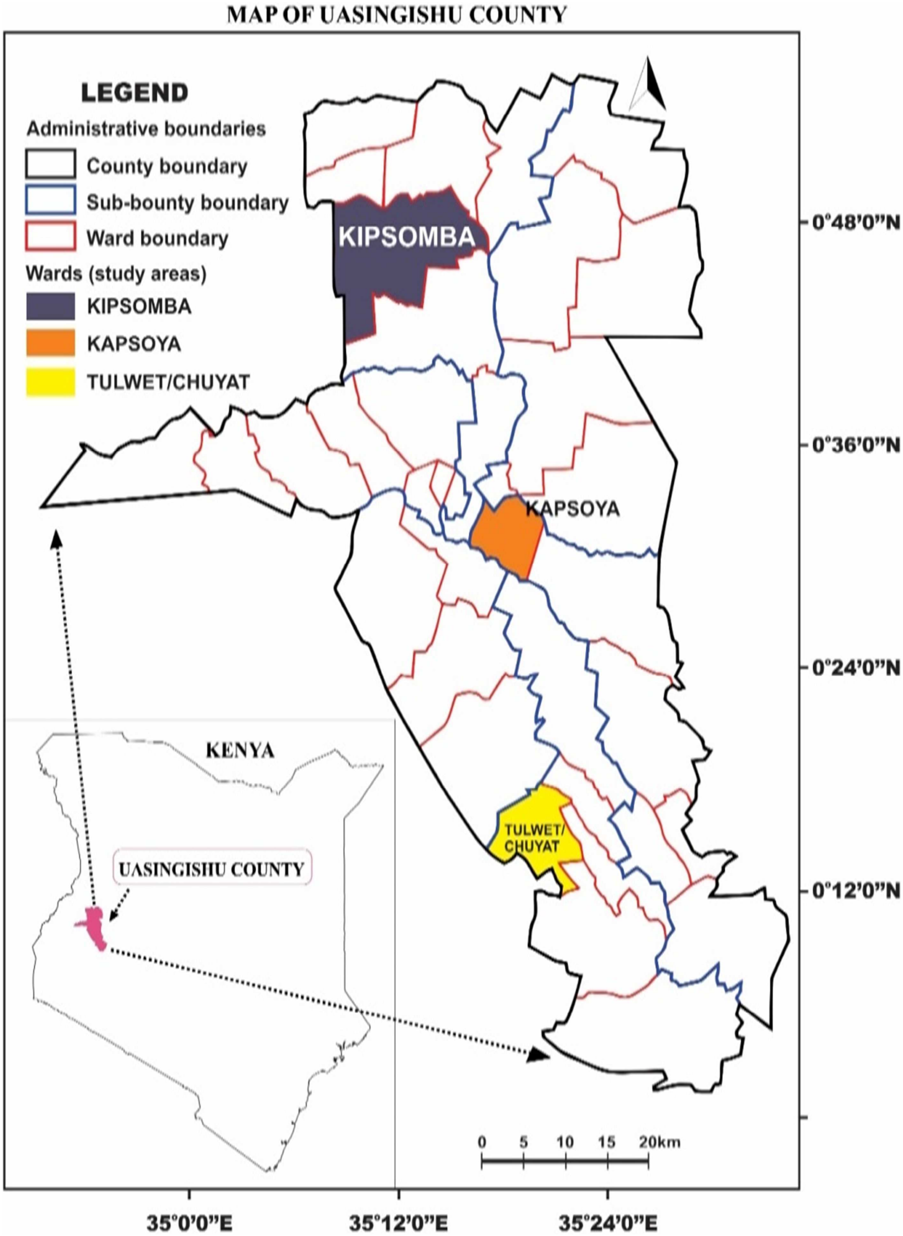

***Figure 1.** A map showing study sites of county wards within Uasin County. The areas are shown using solid colors.*

2.2. Study Area

The study was carried out in Uasin Gishu County (Figure 1). The county's headquarters is in Eldoret town. Uasin Gishu County spans from longitude 340 50' east to 350 37' east and from latitude 00 03' south to 00 55' north. It shares borders with Trans Nzoia County to the north, Elgeyo-Marakwet County to the east, Baringo County to the southeast, Kericho County to the south, Nandi County to the southwest, and Kakamega County northwest. The total area covered by this county is approximately 3,345.2 square kilometres [11]. The County experiences a high and reliable rainfall with an average annual rainfall ranging between 624.9mm-1560.4mm. It occurs between the months of March and September with two distinct peaks in May and August. The areas with relatively higher rainfall are found in Ainabkoi, Kapseret and Kesses whereas Turbo, Moiben and Soy receive relatively lower amounts of rainfall. The dry spells start in the month of November and end in February. Average temperatures range between 7°C and 29°C. The rainfall and temperatures in the County are conducive for both agriculture and livestock farming.

According to CIDP report, 2018 [11], the number of poultry farmers in Kipsomba ward, Soy sub-county is 2612, while poultry farmers in Tulwet-Chuiyat ward in Kesses sub-county are 1840, and 1129 chicken farmers in Kapsoya, Ainabkoi Sub-county. It is further pointed out in the GoK report, 2019 [6] that, high unemployment level, food insecurity due to dependency on rain-fed agriculture, and high poverty and income inequality levels are a challenge in Soy sub-county in Uasin Gishu County. CIDP, 2018 [11] proposed that diversification of food production and encouraging self-employment should be promoted to enhance food security and poverty alleviation.

Uasin Gishu County was chosen specifically because of its dense population, diverse residents, and large number of small-scale chicken farmers [11]. The area is also supported by initiatives like the Inua Mama na Kuku Project and the Kenya Climate Smart Agriculture Project, which provide resources to enhance the chicken value chain.

2.3. Definition and Measurement of Variables

Table 1. *Description of the Independent Variables used in the Linear Regression Model.*

Variable	Description	Unit	Measurement
AGE	Age of the respondent	Continuous	Years
GEN	Gender of the respondent	Dummy	1: Male 0: Female
EDUC	Education level of respondent	Categorical	1: No education, 2: Primary, 3: Secondary, 4: Tertiary
OCC	Occupation of the respondent	Categorical	1: Farmer, 2: Civil servant, 3: Self-employed
GRPMEM	Whether the respondent belongs to any poultry farmer group	Dummy	1: Member 0: Otherwise
OFF-FARM	Whether the respondent participates in off-farm activities	Dummy	1: Participate 0: Otherwise
AWARN	Whether the respondent is aware of the BSFL attributes and incorporation in chicken feeds	Dummy	1: Aware 0: Otherwise
AGRIEXTEN	Number of contacts with agricultural extension officers	Continuous	Number of contacts made
CRDT	Amount of credit borrowed	Continuos	Kenyan shillings

Table 1 above describes the smallholder chicken farmer's characteristics used in a linear regression model as predictors for farmers' perception of BSFL. The variables capture chicken farmer's age, gender (GEN), education level (EDUC), occupation (OCC), group membership in poultry groups (GRPMEM), Participation in off-farm activities, awareness of BSFL attributes (AWARN), access to agricultural extension services (AGRIEXTEN), amount of credit borrowed (CRDT), and number of contacts with agricultural extension officers.

2.4. Analytical Framework: Principal Component Analysis

The Principal Component Analysis (PCA)[30] was used to group the perception statements into clusters called principal components. The PCA was used to construct three perception indices that were used in a linear regression to assess the smallholder chicken farmers' perceptions of black soldier fly larvae-based feed. PCA is a widely recognized method for reducing the dimensions of data, specifically targeting correlated variables. By incorporating new and relevant variables, PCA helps minimize redundancy and allows for the extraction of important information from large datasets [29]. The use of PCA was validated through the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy, where a value of at least 0.6 was preferred.

Components with Eigen values of at least one were retained based on the Kaiser criterion [31]. Further, the component loadings were subjected to an orthogonal varimax rotation to produce uncorrelated factor scores for ease of interpretation. PCA is in compressing data size by extracting the most critical information, simplifying the description of the data set and analysing the structure of observations and variables [32].

The original variance was accounted for by the uncorrelated components. The first Principal components, which had the highest percentage of explained variance and served as an indicator of goodness of fit, were selected due to their significant variance. The remaining components with lesser percentages of explained variance were excluded [33]. The reduced dataset (groups) was then used as dependent variable subsequently in the linear regression model to evaluate factors influencing smallholder chicken farmers perception of BSFL-based feed in Uasin Gishu County.

$$P_i = \sum_{i=1}^{k} b_k \,(a_{ik} - a_k)/s_k \quad (1)$$

where Pi is the perception index of the ith farmer, kth is the factor loading of the kth perception statement, aik represents the response of the ith farmer for the kth perception statement, and ak and Sk represent the mean and standard deviation of the kth particular statement with slight adjustments to fit the current study [30].

This study estimates four multiple regression equations. The dependent variables of the four equations are perception indices computed using the PCA method. The indices comprise of three individual BSFL-Based feed component indices derived from the factor scores of three key BSFL perception components (performance, acceptability, and marketability) and a composite index of the three individual BSFL-Based feed components. linear function of the parameters is specified as follows [31]:

$$Yn = Xk\beta k + \varepsilon \quad (2)$$

where Yn is the nth factor score, βk denotes the vector of the parameters to be estimated; Xk is the vector of the farmer specific characteristics such as: age, gender, education level, monthly income, awareness of incorporation of insects in animal feeds, participation in off farm activities, number of contacts with extension officers, and membership in poultry groups, while ε captures the statistical random term that accounts for measurement error.

3. Results and Discussion

3.1. Descriptive Results

Smallholder chicken farmers' level of agreement with the various BSFL attributes ranking is presented in Table 2. The mean scores range was between 3.66 and 4.49 with values closer to five indicating more favourable perceptions and values closer to value one suggesting less preferred perceptions of BSFL, based on a five-point Likert scale. The statement, "BSFL-Based feed should have special features for easy identification by farmers" had the highest mean score ranking of 4.49, "BSFL is acceptable in my religion" with a mean of 4.13, BSFL is acceptable in my culture" with a mean of 3.98, "BSFL is acceptable in my religion" with a mean of 4.13, which implies that BSFL as an alternative protein source is socially accepted showing its religious and cultural appropriateness indicating favourable societal acceptance of BSFL in Uasin Gishu County by the smallholder chicken farmers. The idea of feeding BSFL to all types of livestock had a lower mean of 3.66 because smallholder farmers kept more than one type of livestock on their farm like cows that are kept for milk that were fed with a specific type of meal, hence the reason for the low mean recorded.

Based on the opinions of smallholder farmers, consumers are very likely to embrace chicken products that have been raised on BSFL and would choose them over other feeds that are protein-based. This is supported by a mean score of 3.92.In accordance with the study conducted by Khaemba et al., 2022 [23], it was revealved that individuals who consume eggs from chickens raised on BSFL hold a favorable viewpoint. The findings are consistent with the results of Okello et al., 2021 [28], who argued that farmers in Kiambu County had a positive perception of insect-based feed as an alternative source of protein for their livestock.

***Table 2.** Smallholder Chicken Farmers' Ranking of Perceptions of BSFL-Based Feeds.*

Rank	Rankings of smallholder farmers' perceptions of BSFL-Based feed	Mean	SD
1	BSFL-based feed should have special features for easy identification by farmers	4.49	0.739
2	BSFL is acceptable in my religion	4.06	0.621
3	Insects have a high protein content	4.00	0.921
4	Chicken fed on BSFL will grow faster	3.66	0.715
5	I am willing to use BSFL once it is commercially available	4.13	1.080
6	The level of knowledge influences the willingness to purchase insect feed	4.06	1.156
7	BSFL will lead to affordable chicken product price	4.10	0.691
8	BSFL is acceptable in my culture	4.07	0.568
9	Buyers and consumers of chicken products will buy products that were fed on BSFL	3.98	1.266
10	BSFL will result in affordable chicken feed price	3.89	0.956
11	Insect production can contribute to increase the income of families in low-income areas	3.92	0.407
12	BSFL can be fed to all livestock	3.71	1.361

Note: scale ranging from 1 (strongly disagree) to 5 (strongly agree)

3.2. Principal Components of Chicken Farmers' Perceptions of BSFL-Based Feed and Their Associated Loadings

Prior to the extraction of factors, pre-estimation tests were conducted to assess the suitability of the data and adequacy of the sample size for principal component analysis. The data was screened for out-of-range values by observing the factor loadings on each of the factors that were analysed for the model. As a result, variables with factor loadings of less than 0.30 were identified and dropped a test that strengthened the Cronbach's alpha [32].

Excluding the loadings less than 0.30 yielded a three-factor solution from 4 factors that recorded an Eigen value of 1. Premised on literature regarding the appropriate or minimum sample size for principal component analysis to be effective, the data was satisfactory for the model as a sample size of at least 100 has been suggested to be sufficient since the survey was conducted on 245 smallholder chicken farmers then it was sufficient [32-34].

Kaiser-Meyer-Olkin (KMO), a measure of sampling adequacy and Bartlett's test of Sphericity was conducted prior to the principal component analysis to determine if PCA was a suitable model for this data. The pre-estimation tests proved that PCA was a suitable model since it resulted in a KMO of 0.687 with an associated p-value of < 0.001. This indicated that the sampling was adequate for PCA as a KMO of at least 0.6 has been suggested to be suitable; thereby indicating that partial correlation was minimal [35]. Cronbach's alpha for reliability was conducted; Cronbach's alpha of 0.851, .546 and 0.726 for acceptability, marketability and performance components respectively were obtained which is above the minimum threshold of 0.5 [34], [35]. The Cronbach's alpha, a measure of internal consistency, for each factor score was above the threshold of 0.5 [34], [36], this indicates a good internal consistency and reliability, further indicating that Principal component analysis was a suitable model for this data.

The results of the principal components that were retained and their corresponding loadings for each of the 12 perception statements are shown in Table 3. The internal consistency of each factor score, as measured by Cronbach's alpha, exceeded the threshold of 0.5. This indicates that the perception statements used in PCA were reliable. Based on the Kaiser criterion, the factors that were retained explained a total of 60% of the variability. The component of acceptability accounted for the highest amount of variation, with a maximum of 27.96%. The marketability component explained 19.98% of the variation, while the performance of BSFL accounted for 12.09% of the overall variability.

Chicken farmers typically agreed with statements such as, 'BSFL is acceptable in my religion', 'BSFL is acceptable in my culture', 'BSFL will lead to affordable chicken product price' 'BSFL will result in affordable chicken feed ingredient,' The component of acceptability explained 27.96% of the cumulative variation and with six statements recording factor loadings above the 0.5 threshold. On the other hand, It was common for farmers to indicate that 'I am willing to use BSFL once it is commercially available,' 'The level of knowledge influences the willingness to purchase insect feed,' 'Buyers and consumers of chicken products will buy meat and eggs that were fed on BSFL.' satisfied the 0.5-factor loading threshold, and cumulatively explained 19.96% of the marketability component. Finally, the performance component explained 12.89% of the total variation with three statements recording 0.5 threshold factor loadings.

Table 3. *Principal Components of Chicken Farmers Perceptions of BSFL-Based feed and Their Associated Loadings.*

Perception statements	Rotated	Components	
	Acceptability	**Marketability**	**Performance**
BSFL is acceptable in my religion	0.765	0.114	-0.248
BSFL is acceptable in my culture	0.617	-0.016	0.311
BSFL will lead to affordable chicken product price	0.626	0.045	0.029
BSFL will result in affordable chicken feed ingredient	0.597	-0.109	0.137
BSFL-Based feed should have special features for easy identification by farmers	0.559	-0.301	0.200
Insect production can contribute to increase the income of families in low-income areas	0.770	0.157	0.180
I am willing to use BSFL once it is commercially available	0.144	0.781	0.078
The level of knowledge influences the willingness to purchase insect feed	-0.185	0.820	-0.092
Buyers and consumers of chicken products will buy products that were fed on BSFL	0.020	0.906	-0.081
Chicken fed on BSFL will grow faster	0.338	0.181	0.809
BSFL has high protein content	0.312	-0.051	0.815
BSFL can be fed to all livestock	-0.254	-0.250	0.561
Eigenvalues	3.355	2.396	1.451
Variance explained (%)	27.960	19.958	12.089
Cumulative variance explained (%)	27.960	47.918	60.008
Cronbach's alpha	0.851	0.546	0.726

Note: Cronbach's alpha = 0.851; Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy = 0.687; Bartlett's test of sphericity: Chi-square (df) = 1100.556 (66). P-value<0.001 Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

3.3. Econometric Results

The perception of individual smallholder chicken farmers regarding the acceptability of BSFL components, marketability of products derived from BSFL-based feeds, and performance of the feed aligns with and is in line with the composite perception index. The factors that influence these perceptions are consistent across both. The measure of goodness of fit for this study, known as the adjusted R-squared, varies from 3.2% to 28.6%. Although the R-squared values are low, they fall within the range observed in similar studies [28, 37]. In addition, Greene, 2012 [38] argued that it is usual to record low goodness of fit when employing a regression analysis using cross-sectional data.

The overall findings indicate that the number of contacts with agricultural extension officers, group membership, education level, awareness of the attributes of BSFL, and participation in off-farm activities significantly influenced smallholder chicken farmers' perception of BSFL as an alternative protein source. The farmers' perception of black BSFL as a feed ingredient for their chickens is significantly and positively influenced by their awareness and knowledge of BSFL attributes. At a 1% significance level, farmers who are aware of these attributes tend to have a more favorable perception compared to those who are unaware. This is in line with the expectations of the study that farmers' prior knowledge would affect how they perceive the BSFL-based feed.

Farmers' educational level was found to have a positive and significant effect on the composite perception and marketability aspect. The possible explanation is that educated farmers have a better understanding of the importance of incorporating BSFL in their feed formulation. Farmers with a higher number of contacts with agricultural extension officers had a positive perception of BSFL as an alternative protein source, the coefficient was positive for composite, acceptability, marketability and performance indices. The farmers participating in off-farm activities were more likely to perceive BSFL positively, the coefficient was positive for the marketability index as well as the performance index. Finally, respondents who belonged to poultry organizations displayed a greater tendency to view the integration of insects in their feed formulation process on the farm as positive.

Table 4. *Multiple Regression Estimates of the Factors Influencing Smallholder Chicken Farmers' Perception on BSFL-Based Feed.*

Regression parameter estimates				
Explanatory variable	**Composite perception index**	**Acceptability index**	**Marketability index**	**Performance index**
Age of the respondent	-0. 038 (0.102)	0.033 (0.097)	0.158 (0.226)	0. 010 (0. 190)
Gender	-0.008 (0.014)	-0. 005 (0.013)	-0.005 (0.030)	0. 014 (0.025)
Education level	0. 004 (0.002)**	-0.004 (0.002)**	0.015 (0.004)***	0. 001 (0.003)
Awareness of BSFL attributes	0. 221 (0.066)***	0.519 (0.063)***	0.129 (0.146)	0. 0149 (0.123)
Number of contact with agricultural extension officers	0.635 (0.166)***	0.547 (0.158) ***	0. 627 (0.368) *	0.731 (0.309)**
Group membership	0.116 (0.035)***	-0.132 (0.033)***	0.594 (0.077)***	0.114 (0.065)*
Participation in off-farm activities	0. 065 (0.053)	-0.044 (0.051)	0.446 (0.118)***	0.295 (0.099)***
Constant	2.839 (0.219)	3.511 (0.209)	1.547 (0. 485)	3.461 (0.409)
Adjusted R-squared	0.161	0.286	0.242	0.032
Observations	245			

Note: *** P≤ 0.01 significance level, ** P ≤ 0.05 significance level, * P ≤ 0.1 significance level and standard errors are presented in parentheses.

4. Conclusions and Recommendations

Incorporating BSFL into chicken feeds has the potential to diversify the commercial feed formulation industry. The use of BSFL as an alternative to conventional protein sources like soybean and fishmeal in animal feed offers both economic and environmental advantages. Despite the associated benefits little is known on how smallholder chicken farmers perceive BSFL being incorporated in chicken feeds. The previous research primarily examined how consumers perceive and accept chicken and its products from BSFL farming. In contrast, this study focuses on small-scale chicken farmers in Uasin Gishu County, Kenya. The reason for this focus is the increasing interest and rapid adoption of insect farming industries in the area. Our findings reveal that chicken farmers had a positive perception of BSFL in Uasin Gishu County with regard to feed performance in comparison with fishmeal and soybean, social acceptability of the BSFL feed, and marketability of chicken meat and egg from chicken reared on BSFL.

Smallholder chicken farmers' awareness of the attributes of BSFL as an ingredient in chicken feed, education level of the respondents, number of contacts made with agricultural extension services, participation in off-farm activities and group membership were significant drivers and positively influenced their perception of BSFL as an alternative protein source. Over 72% of the chicken farmers were aware of the attributes of BSFL as an alternative protein source. To enhance the current study's findings, future research should investigate how farmers perceive new feed ingredients, focusing on aspects beyond the socioeconomic factors examined. The findings presented here offer a foundation for the poultry feed sector and decision-makers to effectively convey important details about using BSFL as premium protein components in animal feeds to chicken farmers. This can be achieved through methods such as conducting farm demonstrations and providing training sessions, which will enhance awareness among farmers about the benefits of incorporating BSFL into their chicken feed. Additionally, it is crucial to improve farmers' understanding and familiarity with this technology since their lack of knowledge currently serves as a significant obstacle in adopting new advancements. Lastly, it is important to interpret the findings cautiously and not generalize them as representative of all smallholder chicken farmers in Kenya. The survey was conducted specifically in Uasin Gishu County, which is just one out of the 47 counties in Kenya. Therefore, the findings can only be seen as a reflection of Uasin Gishu County, rather than the entire population of Kenyan smallholder chicken farmers.

Disclosure

The authors declare no conflict of interest.

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