# PERCEPTION OF CONSUMERS AND POULTRY INDUSTRY STAKEHOLDERS ON THE USE OF INSECT MEAL IN BROILER CHICKEN FEED IN THE SOUSS MASSA REGION (MOROCCO)

***Abstract***

*In the face of global population growth and food security challenges, identifying sustainable alternative protein sources is crucial. Black soldier fly (Hermetia illucens) larval meal (BSFLM) represents a promising substitute for conventional protein in animal feed. This cross-sectional, survey-based study used structured questionnaires to assess perception among 391 consumers and 35 poultry-sector stakeholders in the Souss Massa region (Morocco). Statistical associations were assessed using a chi-square test ($\alpha = 0.05$). Overall consumer awareness of insects in animal feed reached 53.2%. Acceptability of BSF larval meal (BSFLM)-fed broilers was 37.3% favorable, 34.8% neutral and 27.9% unfavorable. Younger respondents showed significantly ($p<0.05$) higher acceptability than seniors. Key consumer concerns were health risks, food safety and limited scientific information. Among stakeholders, prior knowledge was high (94.3%) and openness was conditional on safeguards; principal barriers were regulatory uncertainty, need for stronger evidence, limited production capacity and cost. The development potential is real but hinges on coordinated action by public authorities and regulators, industry stakeholders, health and food safety authorities and researchers to: clarify the regulatory framework, fund applied safety and performance studies, scale competitive BSFLM supply and communicate transparently on health assurances and environmental benefits.*

***Keywords:*** acceptability; alternative protein sources; black soldier fly; *Hermetia illucens*; poultry nutrition.



## INTRODUCTION

Global population growth, estimated at 9.6 billion people by 2050, and food security challenges require resilient food systems and innovation in animal production (FAO, 2013). Poultry meat is among the major and fast-growing share of global meat demand, several studies project that poultry consumption grows the most among major meats over the next decade (e.g., ~21% by 2034), outpacing other meats (OECD-FAO, 2025). Broader feed diversification efforts in broiler production, including the use of plant-derived materials and agro-industrial by-products, have been explored to support performance and meat quality, reflecting a wider search for locally adaptable alternatives (Olusola et al., 2018; Aondoakaa et al., 2025). In parallel, black soldier fly (*Hermetia illucens*) larvae (Figure 1) have been proposed as a sustainable alternative protein for animal feed due to their nutritional composition and their potential to valorise organic side streams (Makkar et al., 2014; Veldkamp et al., 2012; Van Huis et al., 2013). Broiler studies have also reported promising zootechnical and meat-quality outcomes depending on inclusion levels and processing (Sembada et al., 2022; Ayuningtyas et al., 2023). However, using insect-based feed ingredients is not just a technical issue. It also relies on market acceptance and industry viability. Research on consumer attitudes shows that acceptance of insects, whether as food or indirectly through animal feed, is influenced by factors like perceived safety, trust, familiarity and reluctance to try new foods. Younger groups often show more willingness to embrace these innovations (Verbeke, 2015; Tan et al., 2015; Menozzi et al., 2021; Bazoche & Poret, 2021). On the supply side, industry professionals may see potential benefits but often hesitate due to uncertainty about regulations, quality standards, and reliability of supply (Lähteenmäki-Uutela et al., 2021; Sogari et al., 2019).

Morocco's poultry sector, strategic for national food security, remains highly dependent on imported protein sources such as soybean meal and on internal resources

exploitation to produce fish meal. This dependence exposes producers to price volatility and supply risks. At the same time, Morocco generates substantial agri-industrial side streams that could support insect production. Moreover, climatic conditions are broadly compatible with BSF farming, which can reduce energy input. Despite this potential, there is limited empirical evidence documenting (i) consumer acceptance of broilers fed with insect meal and (ii) the conditions under which poultry-sector stakeholders would consider adoption under Moroccan realities.

Therefore, this study assesses knowledge, attitudes and acceptance levels of consumers and industry stakeholders in Souss Massa region, and identifies perceived levers and barriers to BSFLM adoption as a broiler chicken feed-ingredient in Morocco. Based on prior literature and Moroccan context, we formulated the following hypotheses:

- H1. Consumer acceptability of broilers fed with BSFLM differs across age groups, with higher acceptability expected among younger respondents.
- H2. Poultry-sector stakeholders report high prior awareness of insect meals and willingness to adopt BSFLM is conditional on clear regulatory and safety assurances.

Figure 1: Black soldier fly (*Hermetia illucens*) larvae

## MATERIALS AND METHODS

### *Study area and participants*

This study was conducted in the Souss-Massa region of Morocco, an Atlantic coastal area centered on Agadir with a developed agri-food base and concentrated broiler value chain. A cross-sectional survey design was used to capture perspectives from two populations in the region: consumers and poultry-sector stakeholders. Participants were recruited through a mixed-mode approach (face-to-face and online) to reach diverse profiles; therefore, findings reflect the surveyed population rather than a probability-based regional estimate. Two groups were included:

- Consumers (n=391): Residents of Souss Massa were surveyed using a structured questionnaire covering demographics, prior awareness of insects in poultry feed, and attitudes toward broilers fed insect meal.
- Industry stakeholders (n=35): Active poultry-sector professionals in Souss Massa (farmers, feed producers and other relevant actors) completed a tailored questionnaire focusing on technical, economic and regulatory considerations related to insect meal in poultry nutrition.

Using Cochran's formula with finite-population correction, the consumer sample size corresponds to an approximate ±5% margin of error at 95% confidence for proportion estimates. Eligibility criteria were defined a priori: consumers had to be residents of Souss-Massa and stakeholders had to be active poultry-sector professionals in Souss-Massa. Participation was voluntary and anonymous. Exclusion criteria were non-residents, professionals outside the poultry sector, and incomplete or duplicate questionnaires. Incomplete questionnaires were excluded.

### *Questionnaire content and data collection*

Two structured questionnaires were developed, one for consumers and one for poultry-sector stakeholders. The consumer questionnaire captured socio-demographic characteristics (including age and gender), prior awareness of insects as a feed

ingredient, perception/acceptability of broilers fed insect meal, purchase intention and the main concerns or factors influencing acceptance. The stakeholder questionnaire captured professional profile, prior awareness, acceptability and willingness to test/use insect meal and perceived barriers and enabling conditions related to technical, economic and regulatory aspects.

Data were collected from January to December 2024 using face to face administration (46%) and an online version (54%). Participation was voluntary and anonymous. For the online survey, one entry per device was allowed. The full wording of all questionnaire items and response options is provided in the supplementary material (S1: consumer questionnaire; S2: stakeholder questionnaire).

***Data analysis***

Descriptive statistics were used to summarize participant characteristics and response distributions. Associations between explanatory variables (gender, age category, prior awareness) and outcome (perception/acceptability category; purchase intention category) were assessed using Pearson's chi-square test for independence (two-sided $\alpha = 0.05$). Although perception was measured on an ordered Likert-type scale, results are reported primarily as category distributions; chi-square testing was applied to the categorical groupings used in the Results. Analyses were performed using Jamovi v2.6.26 (R-based).

## RESULTS

### *1. Consumer perception results*

#### *1.1. Socio-demographic characteristics*

Socio-demographic data were collected from a diverse sample of participants. The age distribution indicates that the majority of respondents are in the 31-45 (33.8%) and 18-30 (32.2%) age groups, followed by the 46-60 age group (21%). Those under 18 (6.1%) and over 60 (6.9%) represent a small minority (Table 1). Regarding gender, the sample is relatively balanced, with a very slight predominance of women (50.4%) over men (49.6%) (Table 1).

Table 1: Distribution of respondents (%) by gender and age category

| Age group | Female (%) | Male (%) | Total (%) |
|---|---|---|---|
| 18-30 years | 18.4% | 13.8% | 32.2% |
| 31-45 years | 15.9% | 17.9% | 33.8% |
| 46-60 years | 9.7% | 11.3% | 21.0% |
| < 18 years | 4.1% | 2.0% | 6.1% |
| > 60 years | 2.3% | 4.6% | 6.9% |

#### *1.2. Knowledge of the use of insect meal in animal feed*

A majority of respondents (53.2%) reported being aware of the use of insect meal in animal feed, while 46.8% were unaware of it prior to this study (Figure 2).


Figure 2: Knowledge of the use of insect meal in animal nutrition

#### *1.3.Perception and concerns regarding the use of insect meal in broiler feed*

Regarding acceptability, 37.3% of participants expressed a favorable opinion (12.5% very favorable; 24.8% somewhat favorable), 27.9% expressed an unfavorable opinion (17.4% very unfavorable; 10.5% somewhat unfavorable) and 34.8% were neutral (Figure 3).

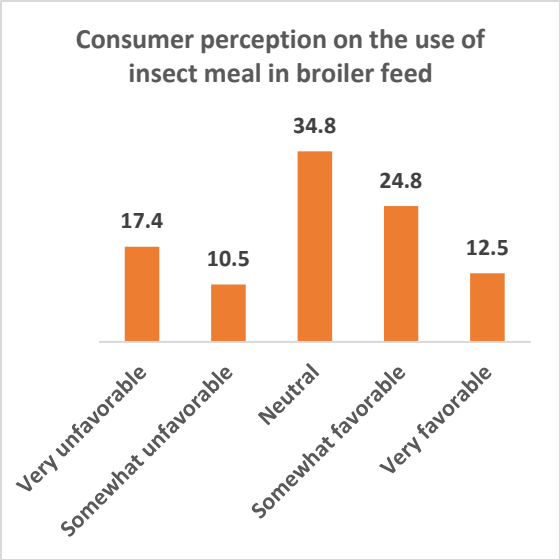


Figure 3: Consumer perception on the use of insect meal in broiler feed

Among the respondents, 35.8% expressed concerns about the safety of chicken meat from farms using insect meal, 33.0% reported no concerns and 31.2% were unsure. The main concerns identified were: health risks and diseases (55.0%), meat quality and safety (18.0%), limited scientific information (14.0%), religious considerations (5.0%), psychological aversion (5.0%) and other factors (bioaccumulation, environmental impacts, costs; 3.0%).

### *1.4. Purchasing behavior and influencing factors*

Purchase intentions were heterogeneous: 26.1% positive, 37.1% rejection and 36.8% neutral. Perceived health benefits (43.9%) and professional recommendations (40.8%) emerged as the top decision levers, surpassing environmental benefits (29.6%), certification labels (22.4%) and competitive price (21.4%), while unconditional rejection accounted for 29.6% of mentions.

### *1.5. Statistical associations between sociodemographic variables and perception/purchase intention*

The analysis of the associations between explanatory variables (sex, age, prior knowledge) and the perception/purchase intention variables reveals several significant associations (Table 2).

Table 2: Results of the Chi Square independence tests

| Hypothesis tested | $\chi^2$ | df | p-value |
|---|---|---|---|
| Gender x Perception | 4.04 | 4 | 0.4011 |
| Age x Perception | 51.13 | 16 | 0.0006 |
| Gender x Purchase Intention | 14.42 | 2 | 0.0007 |
| Age x Purchase Intention | 47.17 | 8 | 0.0008 |
| Knowledge of use x Perception | 16.816 | 4 | 0.0021 |

Chi-square tests (Table 2) indicated no evidence of association between gender and overall perception ($p = 0.4011$), while perception differed across age categories ($p = 0.0006$). Purchase intention differed by gender ($p = 0.0007$) and by age category ($p = 0.0008$). Prior awareness was also associated with perception ($p = 0.0021$).

## *2. Poultry industry stakeholders perception results*

### *2.1. Socio-demographic characteristics and stakeholder profiles*

The stakeholder sample comprised 35 respondents representing the different aspects in the poultry industry. Men represented 69% and the majority of respondents (46%) fall into the 31-45 age group, which typically corresponds to the working classes occupying technical and decision-making management positions, followed by respondents aged 18-30 (29%), and those aged 46-60 (23%). Participants over 60 represent a minority (3%). The typology of the stakeholders interviewed includes broiler chicken farmers (11%), veterinarians (23%), feed mill managers (23%), and other professionals in the sector (43%).

### *2.2. Knowledge, acceptability and intention to use*

A salient finding is the very high prior awareness among stakeholders, 94.3% reported prior knowledge of insect meals

for broiler chicken diets. Chi-square tests did not detect statistically significant associations between stakeholder characteristics (type, gender, age) and key outcomes (knowledge, acceptability, willingness to test) ($p > 0.05$).

### *2.3. Perceived constraints and concerns*

Qualitative analysis of open-ended answers identified four main barriers to adoption of insect meal. Regulatory uncertainty was cited by 64% of respondents, the lack of sufficient applied scientific evidence was reported by 53% of participants. Shortages in production capacity were mentioned by 31% of stakeholders, while the high cost of this ingredient was cited by 25% of participants. A small minority referred to other issues (3%) (Table 3).

Table 3: Frequency of perceived constraints to the adoption of insect meal.

| Perceived constraints | Mentions frequency (%) |
|---|---|
| Uncertain regulatory framework | 64 |
| High cost of raw material | 25 |
| Lack of scientific evidence | 53 |
| Shortages in production capacity | 31 |
| Others | 3 |

## DISCUSSION

### *1. Interpretation of consumer findings and associations*

The consumer results show three segments: a favourable group (37.3%), an unfavourable group (27.9%), and a large neutral group (34.8%). A sizeable undecided segment suggests that acceptance may depend on information and reassurance rather than fixed opposition. These results mirror findings from European studies, where a sizeable undecided segment coexists with early adopters and refusers (Verbeke, 2015; Menozzi et al., 2021; Bazoche & Poret, 2021). The distribution of concerns indicates that safety-related issues dominate (health risks/diseases; meat quality and safety), together with limited scientific information. These patterns are consistent with literature highlighting the role of perceived safety, familiarity and food neophobia in shaping acceptance of alternative proteins (Tan et al., 2015).

Purchase intention results further support the centrality of credibility and reassurance. Perceived health benefits and professional recommendations were the strongest decision levers, exceeding environmental benefits, labels and price. This suggests that health/safety credibility outweighs purely economic considerations in this context.

Age was associated with perception and purchase intention ($p < 0.05$), and prior awareness was associated with perception ($p < 0.05$). These results support the interpretation that familiarity may reduce reluctance and that acceptance varies across age categories. Prior studies similarly report that younger respondents tend to be more open to food innovations and that awareness and familiarity shape acceptance (Verbeke, 2015; Menozzi et al., 2021).

Purchase intention differed by gender ($p < 0.05$). This aligns with published work suggesting that gender differences may reflect varying risk perception and reassurance needs, with women often requiring stronger safety-related reassurance (Bazoche & Poret, 2021; Laureati et al., 2016; Menozzi et al., 2021; Verbeke, 2015). Bazoche and Poret (2021) also highlight that the terminology “insect meal” can trigger reluctance, particularly among older consumers and women. Future research could integrate psychological determinants such as food neophobia and familiarity to better explain these patterns (Tan et al., 2015; Verbeke, 2015).

### *2. Interpretation of stakeholder findings and implications for market development*

Stakeholders showed very high prior awareness (94.3%), suggesting that the concept of insect meals has already entered professional discussions in the sector. This is consistent with international reports describing high familiarity among professionals in contexts where insects-as-feed has gained policy and market visibility (Sogari et al., 2019).

Although no statistically significant associations were detected between stakeholder characteristics and key outcomes ($p > 0.05$) and while the sample was limited ($n = 35$), stakeholder responses were broadly aligned around structural barriers: regulatory uncertainty, evidence needs, supply capacity and cost.

Taken together, the constraints mentioned by the sector stakeholder are primarily structural and systemic (regulatory, scientific, logistical and economic) and point to the need for a coordinated response between public authorities and industry stakeholders to establish a clear regulatory framework, invest in applied research, and develop production units capable of driving down costs. These findings are consistent with international reports showing that regulatory pathways for insects-as-feed vary widely across regions (Lähteenmäki-Uutela, A. et al., 2021) and evolve over time, which sustains uncertainty for firms until clear authorisations and specifications are issued.

Taken together, the consumer and stakeholder findings indicate that consumer acceptance may not be the only limiting factor; rather, system-level constraints, especially regulatory clarity and locally relevant evidence, appear central to adoption. Communication strategies should prioritize safety evidence, transparent messaging, and professional validation, and should be tailored by age and gender groups. The neutral consumer segment represents a priority group for targeted communication and reassurance.

### *3. Policy implications and recommendations*

The findings highlight that adoption barriers are mainly structural, with regulatory uncertainty and evidence needs cited most frequently by stakeholders, alongside cost and supply limitations. Policy priorities therefore include clarifying the national regulatory framework for insects as feed, supporting applied local studies on safety and performance to address evidence gaps; and establishing quality assurance and traceability expectations to build value-chain confidence.
Given the large neutral consumer segment, targeted risk communication led by trusted actors may support informed acceptance and responsible market development.

### *4. Synthesis and implications (SWOT-informed)*

To translate the quantitative findings into actionable implications for market development, we synthesised the main perceived drivers and barriers into a SWOT-informed framework. This analysis distinguishes the intrinsic strengths and weaknesses of the insect sector, as well as the opportunities and threats linked to its external environment, from the perspective of the respondents.

***Strengths***

The study highlights several advantages for integrating insect meal into broiler feed in Morocco. On the demand side, consumers' attitudes are broadly favorable or movable, 37.3% express a positive view of BSFLM-fed broilers and 34.8% are neutral, indicating a large segment open to persuasion based on credible safety and performance information. Within the value chain, prior awareness is exceptionally high among professionals (94.3%), and stakeholders report openness to adoption provided robust health safeguards and specifications are in place, findings that align with evidence on industry receptivity

to insect-based feeds (Okello et al., 2021) and with reports of the nutritional quality and meat-quality benefits of Hermetia illucens-derived meal (Cullere et al., 2019).

***Weaknesses***

A number of internal limitations currently hamper the acceptance and diffusion. First, health and safety concerns persist especially among less informed groups, which hinders spontaneous adoption. These concerns are reinforced by limited scientific outreach, which leaves gaps in understanding of processing steps, hazard controls and the actual benefits of BSFLM. This has been documented in other studies highlighting the need for rigorous controls and hygiene certifications for insect-based products (Heath et al., 2024). Qualitative analysis also reveals an absence of clear segmentation within target audiences (younger consumers, industry decision-makers, opinion leaders, etc.), which complicates the identification of priority segments for communication campaigns. Furthermore, the lack of scientific outreach hinders understanding of the processing steps and real benefits of this alternative protein source. The batch-to-batch non-standardization (Oddon et al., 2024) documented in the literature can translate into variability in nutrient profiles and digestibility. This heterogeneity increases formulation risk for feed manufacturers, can depress zootechnical performance at farm level, and ultimately erodes stakeholder confidence if not mitigated through tighter QA/QC and specifications. Finally, psychological barriers, such as sensory aversion or a feeling of disgust, although expressed in a minority, remain likely to negatively influence purchase intention. This phenomenon is well documented in the literature devoted to entomophagy (Kröger et al., 2022).

***Opportunities***

On the other hand, several external factors are supporting the growth of this industry. A strong interest in experimenting with and adopting insect meal is expressed by the industry stakeholders, including broiler farmers, veterinarians and feed manufacturers. Similar efforts have been reported internationally, where numerous studies have demonstrated the feasibility of incorporating *Hermetia illucens* meal as a partial or complete substitute for conventional protein sources in broiler diets (Ahmed et al., 2023). On the commercial level, a strategic positioning focused on environmental sustainability, protein autonomy, and national food security is likely to increase acceptability among stakeholders and consumers (Lisboa et al., 2024). At the policy level, this pathway also aligns with Morocco's Green Generation 2020-2030 strategy, which advances food security and resilient agri-food value chains, reinforcing a favorable strategic window for pilots and scale-up. Market prospects are also encouraging: recent analyses project alternative proteins to reach ~11% of the global protein market by 2035, indicating room for a Moroccan insect-meal supply to secure a small but meaningful share in broiler feed, provided quality standards and reliable volumes are met (Boston Consulting Group & Blue Horizon, 2021). The Moroccan context, driven by a well-structured and adaptable poultry sector, provides fertile ground for agri-food innovation. Finally, the integration of this practice could contribute to diversifying animal protein sources, thus responding to a strategic challenge of increasing global demand and resource constraints for conventional protein sources (Guiné et al., 2021).

***Threats***

Several external threats could slow the development of this sector. First, the absence of a clear and specific regulatory framework governing the use of insects in animal feed in Morocco constitutes a major obstacle to investment and widespread adoption. This challenge is frequently cited in studies examining the industrialization of insect production in Global South (Barragán-Fonseca et al., 2025). Halal compliance, although rarely raised by respondents, is a critical concern in the local

context. The current absence of explicit national guidance creates uncertainty for producers and buyers. Cost efficiency represents another major challenge. As noted by van Huis (2013), ensuring reliable and cost-effective production of high-quality insect biomass is one of the key challenges to scaling this sector, which may limit its competitiveness with conventional protein sources. Furthermore, the limited availability of specialized infrastructure and technical support continues to constrain the scale-up of insect production. According to Kolobe et al. (2024), the production capacity of farmed insects is still limited by high production costs and rising market prices, which undermine the viability of commercial insect farming, keeping unit costs elevated. This challenge slows the transition from pilot initiatives to fully competitive industrial operations.

These threats are mutually reinforcing. Regulatory ambiguity raises financing risk and constrains capital and limited infrastructure keeps unit costs high. A focused public response, clear regulations and standards, funded demonstration plants, targeted fiscal support and technical assistance can break this cost, infrastructure, confidence loop and enable compliant, competitive scale-up.

## CONCLUSION

This study provides the first integrated assessment of consumer and industry perceptions regarding the use of black soldier fly (*Hermetia illucens*) larval meal in broiler feed in Morocco, combining two populations and linking attitudes to adoption conditions. The results reveal a broad recognition of nutritional and environmental benefits, especially among younger consumers, and conditional openness among professionals when robust health and safety assurances are in place; conversely, regulatory uncertainty, cost and limited production capacity remain the main brakes. Translating these findings into action, Morocco would benefit from a clear, specific regulatory framework, combined with targeted education and scientific outreach to address safety questions and inform the large neutral consumer segment. Building competitive local supply, supported by quality assurance, scale-up and predictable offtake, would help lower costs and reduce variability; engaging trusted health authorities can further strengthen legitimacy and acceptance. Future research should include controlled zootechnical trials to quantify performance and meat-quality outcomes with BSFLM, life-cycle assessment to document environmental benefits under Moroccan conditions and economic modeling at industrial scale to test cost-competitiveness and investment pathways under alternative regulatory and market scenarios. Based on the questionnaire findings, the next step is to strengthen decision-making with clearer standards and locally relevant evidence. Future surveys should expand beyond Souss Massa and include additional adoption determinants.

### Disclaimer (Artificial intelligence)

Author(s) hereby declare that no generative AI technologies such as Large Language Models and text-to-image generators have been used during the writing or editing of this manuscript.

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**Supplementary materials**

**Supplementary 1: Consumer Questionnaire**

Section 1: Demographic information

1. What is your age?
    - Under 18
    - 18-30
    - 31-45
    - 46-60
    - Over 60

2. What is your gender?
    - Male
    - Female

Section 2: Awareness of insects in animal feed

3. Have you ever heard about the use of insect meal in animal feed, such as for broiler chickens?
    - Yes
    - No

Section 3: Perception of using BSF insect meal in broiler feed

4. What do you think about using BSF insect meal in broiler chicken feed?
    - Very favorable
    - Somewhat favorable
    - Neutral
    - Somewhat unfavorable
    - Very unfavorable

5. Do you have concerns about the food safety of products from chickens fed BSFLM?
    - Yes
    - No
    - I don't know

If yes, what are your concerns?

Section 4: Purchasing and consumption behavior

6. Would you be willing to buy broiler chicken products from chickens fed BSFLM if they were available on the market?
    - Yes
    - No
    - Maybe

7. What factors could influence your decision to buy broiler chicken raised with insect meal? (Check all that apply)
    - Price of insect-meal-fed broiler chicken
    - Information on health benefits
    - Certification or origin labels
    - Recommendations from health professionals or nutrition experts
    - Explanations about positive environmental aspects
    - None; I would not buy this type of product

**Supplementary 2: Stakeholders Questionnaire**

Section 1: Demographic information

1. You represent:
    - Feed mill
    - Veterinarian
    - Interprofessional organization / industry association
    - Farmer / producer

2. What is your gender?
    - Male
    - Female

3. What is your age?
    - 18-30
    - 31-45
    - 46-60

- Over 60

Section 2: Awareness, perceptions, acceptability, and barriers

4. Do you know that insects are a high-protein source?
   - Yes
   - No

5. Do you know that insects like BSF can be included in animal feed?
   - Yes
   - No

6. Do you have concerns about the food safety of products from chickens fed BSFLM?
   - Yes
   - No
   - I don't know

7. Does this farming practice (including BSFLM in animal feed) seem acceptable to you, provided there is no health or environmental risk?
   - Yes
   - No

8. In your opinion, what are the main constraints to using BSFLM in Morocco? (check all that apply)
   - Regulation
   - Limited research in this area
   - High cost of insects
   - Shortage of production units/capacity
   - Other

9. Do you have an idea about the nutritional value of these insect meals?
   - Yes
   - No

10. Would you like to explore the nutritional potential of this meal through analyses/trials on technical performance/costs?
    - Yes
    - Maybe
    - Not interested