




Article

Insect-Based Feed Acceptance amongst Consumers and Farmers in Ireland: A Pilot Study

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Abstract: The potential of insect-based feed (IBF) as a sustainable alternative to conventional animal feed is widely reported, yet there is extremely limited information on its acceptance in Ireland, a country with a strong farming background. Therefore, this study aims to provide baseline data on factors affecting acceptance of IBF amongst a segment of consumers and farmers in Ireland. Quantitative and qualitative data were collected amongst 233 consumers, 73 of which were farmers. Non-parametric statistical tests revealed that the willingness to consume foods from animals fed with IBF depends on the type of food and is affected by a combination of consumer- and product-related factors. Consumers' age, gender, diet, and education level, the foods' packaging information, safety, and price, and whether insects are part of an animal's natural diet or environmentally friendly had a significant effect. Safety concern regarding use of IBF was the main factor affecting farmers' willingness to use it. Qualitative findings revealed concerns emanating from the bovine spongiform encephalopathy outbreak and a general need for more information. Accordingly, information on the benefits of using IBF increased its acceptance. Thus, IBF acceptance might depend on dedicated educational interventions which include addressing the safety aspect of the feed even among those with higher level of education.



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Keywords: insects; animal feed; insect meal; sustainability; consumer acceptance

1. Introduction

As the production of livestock and aquaculture (with the exception of algae) continue to increase worldwide to meet growing consumer demands, so is the use of animal feed ingredients [1,2]. The production of animal feed, however, is currently exploiting approximately a third of global arable land, adding pressure to land and water resources, which, according to the Food and Agriculture Organization of the United Nations (FAO), are now at a “breaking point” [3]. Moreover, life cycle assessments (LCAs) conducted on several fish [4–6] and livestock [7–9] farming systems identified feed as being one of the major contributors to negative environmental impact of these systems. Animal feed (for both livestock and fed aquaculture species) is also reportedly responsible for the largest share of farming costs [1,2,10] as its demand continues to increase along with increased production [1,2]. Thus, methods to improve the sustainability of animal production continue being explored. To support this process, the European Commission (EC), as part of the European Union's (EU) green deal [11] Farm-to-Fork strategy [12], pledged to facilitate the approval of new sustainable feed alternatives for use on animals in the region [12]. Accordingly, the EC approved the use of processed insect protein in the feed given to aquaculture species [13], pigs, and poultry [14], after being risk assessed by the European Food Safety Authority (EFSA) panel [15].

Several LCA studies have reported the potential of insect protein as a sustainable feed ingredient relative to conventional protein feed sources [16] when employing insect-rearing technologies that use low energy [17–19] and substrates of low economic value [17,18,20–23]. Despite the variations in the nutrient profiles of insects depending on the species and the rearing conditions [24], the general inference has been that insect-based feed (IBF) is a suitable alternative to the conventional feeds such as soy and fishmeal [24–26]. In addition, the potential contribution of insects to a circular economy [27], low feed conversion ratios, and subsequent reductions in production costs has also been documented [18].

For the successful adoption of IBF, consumers/farmers' willingness to accept its use on animals is crucial [28]. As such, some studies have over the years been undertaken to understand the factors affecting willingness in this regard in order to provide recommendations for possible intervention pathways [29–37]. Based on findings from such studies, willingness to accept the use of IBF for animals seems to be intricately affected by a combination of factors associated with the characteristics of the participants (consumer-/farmer-related factors) [31–37] and those associated with the characteristics of the IBF itself or the end product (product-related factors) [32,37–39].

Participant characteristics such as previous knowledge of insects being used in feed [31,33], residential location [32], gender [33–37], age [32,35], and level of education [34] are some of the named factors found to be influential in the acceptance of IBF among consumers and farmers. Characteristics specific to the farmers (farmer-related factors) such as the type [37] and quantity of animals being reared, type of animal feed ingredients being used, and previous experience with using IBF [31] have been found to affect their willingness to use IBF. Moreover, the supposed benefits/risks of using IBF are among the product-related factors previous works have found to also be influential in consumers' and farmers' acceptance of IBF [32,37,38]. Accordingly, being informed of the sustainability benefits of using IBF tends to improve its acceptance [30,33,34,36]. How each factor affects willingness to accept IBF, however, tends to vary depending on the country of the participants under investigation [40].

In Ireland, where agricultural production is an integral part of the country's economy [41], achieving the Sustainable Development Goal 12 of responsible consumption and production by 2030 remains a significant challenge [42]. Yet, there is a scarcity in published studies that have been conducted to understand the factors affecting acceptance of IBF amongst consumers/farmers in this state. As such, this study aims to collect data on the factors affecting IBF acceptance amongst a segment of consumers and farmers in Ireland and how this differs from studies conducted in other countries. The specific main research questions of this study are:

1. Which factors affect the willingness of a segment of consumers in Ireland to consume food products derived from animals that have been fed with IBF?
2. Which factors affect the willingness of a segment of farmers in Ireland to use IBF for their animals?

2. Materials and Methods

2.1. Study Design and Sampling

A pragmatic paradigm was adopted to answer the research questions of this study. Therefore, a “convergent parallel mixed-methods design” [43] was employed in the form of an online survey created using Qualtrics™ (first release 2005, copyright year 2022, available at <https://www.qualtrics.com>). Closed-ended questions were developed using themes from a literature review on the field. However, since there was a scarcity in reports on consumers' or farmers' acceptability of IBF in Ireland, open-ended questions were also included. This was done to explore other factors specific to the consumers and farmers in Ireland, which may not be otherwise available from studies undertaken in other countries. This survey was approved by the Institute Research Ethics Committee of the Atlantic Technological University (ATU) in Sligo, Ireland (Ref No. 2022001).

The survey was disseminated to a convenience sample by gatekeepers from Atlantic Technological University (ATU) and University College Dublin (UCD) via email to their respective staff and students based on Sligo, Galway, and Dublin campuses. To attract participants outside of ATU and UCD, a link to the survey was also shared on the researchers' social media accounts (Twitter, LinkedIn, and Facebook) and on farmers' social pages. Furthermore, posters with the survey's QR code were physically distributed at the Sligo Farmers' Market to the farmers selling their produce and those visiting the market. In all the above instances, a request was made for people to share the link or poster with anyone who might also be interested in participating, thus generating a snowball effect [44]. The survey was kept live for a period of three months (April, May and June) in 2022. The survey items used in this study are provided in Table S1.

2.2. Survey Construction

To ensure content validity of the survey, the main research questions of this study were broken down into embedded research questions to facilitate the construction of survey items (see Table S2). The survey was divided into four sections. The first section assessed consumer-related and farmer-related characteristics common for all participants such as their sociodemographic information (age, gender, level of education, location of residence, and workplace if applicable) and previous knowledge of insects being used in animal feed. In addition, participants were asked if they followed a particular diet (Yes/No) and if they did, they were requested to specify the type of diet. In the second section, using 5-point Likert scales, participants were asked to indicate how willing they would be to consume different food products derived from animals fed with IBF. The extent to which participants agreed with provided statements used to complete the sentences: "I am willing to eat food derived from animals that have been fed with insect-based feed if . . ." and "I am NOT willing to eat food products derived from animals that have been fed with insect-based feed if . . .", was used to capture product-related reasons behind their willingness to consume these products. These questions were also asked on a 5-point Likert scale and two of the statements provided were adapted from past studies [34,37]. Participants were given an opportunity through an open-ended question to state "other" reasons (if any) behind their willingness to consume food products from animals fed with IBF. This section of the survey ended with the question "Do you participate in farming activities related to poultry, fish and/or livestock production?" (Yes/No). Those participants who selected "Yes" to this question moved to the third section of the survey, whilst those who selected "No" were automatically directed to the fourth and final section of the survey.

In the third section, farmer-related characteristics such as the type of farming activities, farm size, number of animals being reared, type of feed ingredients currently used, and prior experience with IBF were ascertained. In addition, farmers were asked to indicate their level of agreement with the use of IBF for different animals and how likely they would be to use it (5-point Likert scales). The extent to which farmers agreed with the provided product-related reasons behind their willingness to use IBF was also assessed. Five of these "reasons" were adapted from past studies [32,37]. An open-ended question explored "other" reasons (if any) behind farmers' willingness to use IBF. As a final question to this section, farmers were firstly provided with information that the use of insect protein in feed for pigs and poultry had been recently authorised in the EU. Thereafter, they were asked if there would be any other factors they would consider prior to using IBF for their animals. In the fourth and final section of the survey, participants' acceptance of IBF was assessed again (5-point Likert scales) after they were provided with information on its environmental and nutritional benefits.

A total of 284 participants completed the survey. However, 51 of them did not complete the first section of the survey; therefore, these were excluded from the analysis. The remaining participants (N = 233) who either answered all or at least 75% of the questions in the survey were included in the analysis.

2.3. Data Analysis

The statistical software SPSS (IBM® version 28.0) was used to analyse the quantitative data obtained. Descriptive statistics were used to outline the profile of the participants. The 5-point scales were collapsed to three groups each for analysis to have at least 5 counts in each cell of the cross-tabulation tables in order to run the chi-square test. In line with previous work [33], willingness 5-point scales were collapsed to 1: “unwilling”, 2: “uncertain”, and 3: “willing”. Likewise, degree of likelihood was collapsed to 1: “unlikely”, 2: “uncertain”, and 3: “likely”, while level of agreement was collapsed to 1: “disagree”, 2: “neutral”, and 3: “agree”.

Non-parametric statistical tests (Mann–Whitney U, Kruskal–Wallis, and chi-square) were used to analyse the effect of (1) the consumer-related factors on the willingness of all participants to consume food products from animals fed with IBF and (2) the farmer-related factors on the willingness to use IBF amongst farmers, as shown in Table S3. Spearman’s correlation was used to determine the correlation between participants’ level of agreement to statements on factors relating to the characteristics of the IBF or end product (product-related) and their willingness to accept it. Lastly, the sign test was used to determine the differences between participants’ willingness to accept the use of IBF for animals before and after being provided with information on its environmental and nutritional benefits. Significance for all statistical tests was established at $p < 0.05$.

The question on gender had four options for the participants to choose from (“male”, “female”, “other”, and “prefer not to say”). Since less than one percent of the total participants ($N = 233$) selected “other” and “prefer not to say”, respectively, these two categories were not included when analysing the effect of participants’ gender. However, all four categories were included for the rest of the analysis. Moreover, since less than a fifth of the participants were adhering to a specific diet (vegan, vegetarian, calorie-restricted, or other), all participants were divided into those that followed a particular diet and those that did not when analysing the effect of diet.

To analyse the qualitative data collected through open-ended questions, each participant response was coded using an inductive approach [45]. Codes that linked together were then sorted into sub-themes and themes [46]. This process conducted by one researcher was appraised by a second researcher to ensure accurate reporting of results. Qualitative results are presented according to their themes, together with the quantitative results related to that theme. Participants’ quotes are provided along with a participant’s (consumer [C]/farmer [F]) number.

3. Results

3.1. Participants’ Profile

In reporting the results of this study, the term “consumers” is used to refer to the total participants ($N = 233$) whether they were involved in farming activities or not, whilst the term “farmers” is used for those participants who answered Yes to the question “Do you participate in farming activities related to poultry, fish and/or livestock production?” ($n = 73$).

An overview of the participants’ profile ($N = 233$) is presented in Table 1. Although more consumers worked in Connaught province (37.3%) than those who worked in other provinces, most of them resided in Leinster (42.1%). Connaught was, however, the province where more farmers resided (41.1%) and worked (38.4%) than other provinces. Just above half of the participants were female (58.8% consumers and 54.8% farmers) while those in the 18 to 29 age group (31.8% consumers and 45.2% farmers) numbered more than those in other age groups. All consumers had education at junior certificate level, with 47.6% reporting to have either a masters or a PhD degree. Nevertheless, the percentage of farmers with either a masters or a PhD degree (34.2%) was comparable to those farmers whose highest level of education was an honours degree (37.0%). When this study was conducted, most of the consumers (82%) and farmers (89%) were not adhering to any particular diet and most of them (67.0% consumers and 76.7% farmers) had prior knowledge of insects being used in animal feed.

Table 1. Participants' profile (N = 233 all participants consumers and farmers, n = 73 only farmers).

Profile	Participants	
	Total Consumers (Including Farmers) (N = 233)	Farmers Only (n = 73)
	%	%
Location of residence:		
Connaught	39.5	41.1
Leinster	42.1	30.1
Munster	7.7	5.5
Ulster	10.7	23.3
Location of workplace:		
Connaught	37.3	38.4
Leinster	36.5	26.0
Munster	8.2	8.2
Ulster	9.4	24.7
Not Applicable	8.6	2.7
Gender:		
Male	39.5	45.2
Female	58.8	54.8
Other	0.9	0.0
Prefer not to say	0.9	0.0
Age:		
18–29	31.8	45.2
30–39	18.5	15.1
40–49	22.3	12.3
50–59	17.6	20.5
60 and above	9.9	6.8
Level of education:		
No formal education	0.0	0.0
Junior Certificate	0.0	0.0
Leaving Certificate	6.9	8.2
Advanced certificate	9.0	12.3
Bachelor's degree	9.4	8.2
Honours degree	27.0	37.0
Master's or PhD	47.6	34.2
Follow a specific diet:		
Yes	18.0	11.0
No	82.0	89.0
Previous knowledge of insects being used in feed:		
Yes	67.0	76.7
No	33.0	23.3

Almost half (49.3%) of the farmers were involved in beef farming, followed by those involved in “sheep, goats and other grazing livestock” (41.1%), poultry (30.1%), dairy (19.2%), “mixed crops and livestock” (8.2%), pigs (6.8%), and fish (1.4%) production. When asked to state the sizes of their farms in hectares (Ha), 4.1% of farmers indicated having more than 100 Ha, 20.5% between 51 and 100 Ha, 17.8% between zero and ten Ha, and 17.8% between 31 to 50 Ha. Most farmers (40.3%) reared between 101 and 500 farm animals, followed by 26.4% with zero to 50 animals and 11.1% with 51 to 100 animals. Although none of the farmers reared between 500 and 1000 animals, 7% of them had more than a thousand animals on their farms. To feed these animals, most farmers used grass (80.8%), silage (71.2%), and “cereals including maize, wheat and rice” (79.5%). Approximately a third (34.2%) of the farmers fed their animals soymeal. Other farmers also used molasses

(19.2%), brewer's/distiller's grain (16.4%), rapeseed meal (12.3%), sunflower seeds (6.8%), layers pellets (5.5%), and palm kernel (5.4%) in their animal feed. However, only 2.8% of the farmers reported to have used IBF before.

3.2. Willingness to Consume Foods Derived from Animals Fed with Insect-Based Feed (IBF)

Participants (N = 233) were mostly willing to consume eggs (75.1%), chicken (73%), and dairy products (70%) derived from animals fed with IBF. Around three-fifths of the participants were willing to consume fish (64.4%), beef (62.7%), pork (62.7%), and lamb/mutton (56.7%). Figure 1 shows that although some participants expressed unwillingness to consume these food products, some were uncertain of their willingness.

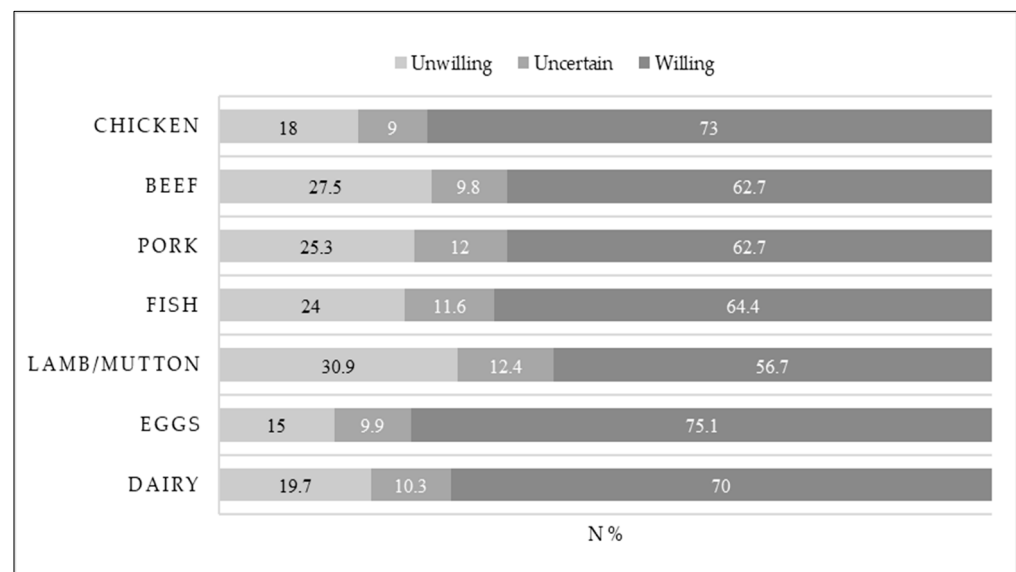


Figure 1. The willingness of participants (N = 233) to consume different food products derived from animals fed with insect-based feed (IBF).

3.3. Factors Affecting Willingness to Consume Foods Derived from Animals Fed with IBF

The effect of consumer-related factors on the willingness to consume foods derived from animals fed with IBF is outlined in Table S4. Province of residence, being involved in farming, or previous knowledge of insects being used in animal feed had no significant effect ($p > 0.05$). On the other hand, level of education had a significant effect only on the willingness to consume fish ($H(4) = 10.761, p = 0.029$). Those who had attained at least an honours degree were significantly more willing to consume fish fed with IBF compared to those who had not.

The province where consumers worked had no significant effect ($p > 0.05$) on their willingness to consume chicken, beef, pork, fish, and lamb/mutton fed with IBF. However, it had a significant effect on consumers' willingness to consume eggs ($H(4) = 10.996, p = 0.027$) and dairy products ($H(4) = 10.974, p = 0.027$). Those working in Connaught province were significantly more willing to consume eggs and dairy products than those who selected the "not applicable" option when asked about the province in which they worked. In contrast, whether consumers were on a particular diet or not had no significant effect ($p > 0.05$) on their willingness to consume eggs and dairy products, but it significantly affected ($p < 0.05$) their willingness to consume the other products. Consumers who were not on any specific diet were significantly more willing to consume chicken ($U = 5483, p < 0.001$), beef ($U = 5893.5, p < 0.001$), pork ($U = 5838, p < 0.001$), fish ($U = 5570.5, p < 0.001$), and lamb/mutton ($U = 5698.5, p < 0.01$) than those who were adhering to specific diets. Qualitative findings revealed that those who followed diets that either restricted or excluded meat were unwilling to eat animal-based products regardless of what the animals were fed:

“I don’t eat beef, pork, lamb or fish—hence my reply to those. It is not the objection to the insect feed” (C18)

“As a vegan I don’t eat animals no matter what they are fed” (C2)

Gender had no significant effect ($p > 0.05$) on consumers’ willingness to consume chicken, eggs, and dairy products. Nevertheless, it significantly affected ($p < 0.05$) their willingness to consume beef ($U = 5680$, $p = 0.048$), pork ($U = 5576$, $p = 0.027$), fish ($U = 5550$, $p = 0.022$), and lamb/mutton ($U = 5342$, $p = 0.008$), such that female consumers were significantly less willing to consume these products compared to the male consumers. In contrast, the age of the consumers had no significant effect ($p > 0.05$) on their willingness to consume beef, pork, fish, and lamb/mutton but had a significant effect ($p < 0.05$) on their willingness to consume chicken ($H(4) = 10.555$, $p = 0.032$), eggs ($H(4) = 14.958$, $p = 0.005$), and dairy products ($H(4) = 15.739$, $p = 0.003$). Those aged between 18 and 29 were significantly the most willing, while those in the 40 to 49 age range were significantly the most unwilling, to consume chicken, eggs, and dairy products.

More than 75% of the participants agreed with the statements that they would be willing to consume food derived from animals fed IBF “if insects are naturally part of the animals’ diet” (79%) and “if feeding animals with insect-based feed has a positive impact on the environment” (79.4%). This was followed by those willing to consume such food products “if the price of the food products is comparable to the existing food products in the market” (61.8%) and “if the information is specified on the food product packaging” (60.9%). Almost half of the consumers (46.8%) agreed that they would be willing to consume foods from animals fed insect-based feed “if the food products are cheaper” (see Figure 2).

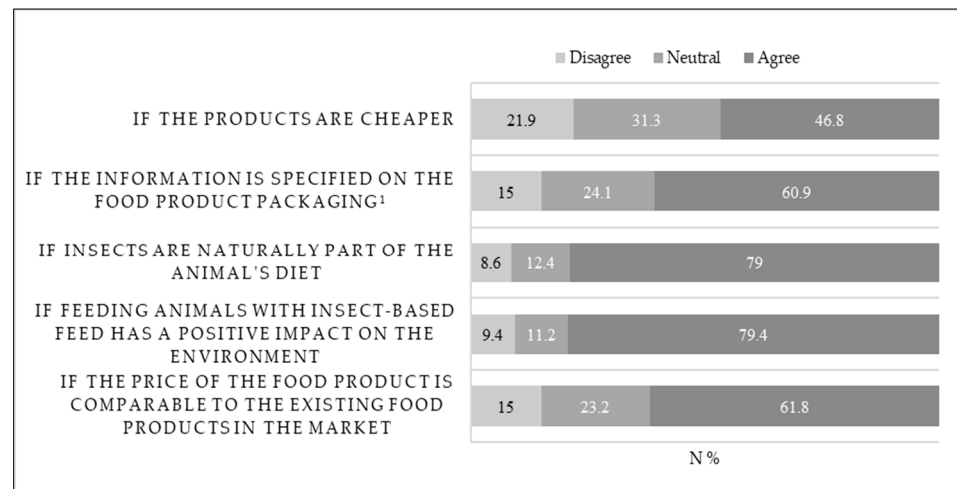


Figure 2. The level of participants’ ($N = 233$) agreement to the statements “I am willing to eat food products derived from animals that have been fed with insect-based feed . . . ” ¹ Statements adapted from [34].

Consumers’ level of agreement to all these statements (insects being a natural part of the animal’s diet, insect-based feed having a positive impact on environment, price of the food products, and information on food packaging) was positively correlated with their willingness to consume the different type of foods from animals feeding on insect-based feed (see Table 2). However, consumers’ willingness to consume lamb/mutton was not significantly affected ($p > 0.05$) by whether insects were naturally part of a sheep’s diet or not.

Table 2. Correlation coefficients between product-related factors and participants' (N = 233) willingness to consume foods from animals fed with IBF.

Reasons for Willingness to Consume Food Derived from Animals Fed IBF:	Willingness to Eat the following If the Animals Were Fed IBF:						
	Chicken	Beef	Pork	Fish	Lamb/Mutton	Eggs	Dairy
	Correlation Coefficients ¹						
If the products are cheaper	0.471 **	0.510 **	0.443 **	0.383 **	0.445 **	0.437 **	0.465 **
If the information is specified in the food packaging	0.396 **	0.373 **	0.290 **	0.310 **	0.284 **	0.389 **	0.378 **
If insects are naturally part of the animal's diet	0.267 **	0.157 *	0.154 *	0.213 **	0.072	0.270 **	0.190 **
If feeding animals with insect-based feed has a positive impact on the environment	0.433 **	0.396 **	0.361 **	0.444 **	0.384 **	0.482 **	0.495 **
If the price of the food products is comparable to the existing food products in the market	0.379 **	0.429 **	0.357 **	0.344 **	0.386 **	0.399 **	0.435 **

¹ * Correlation significant at the 0.05 level; ** Correlation significant at the 0.01 Level.

About half of the consumers disagreed with the provided statements that they would be unwilling to eat food products derived from animals fed with IBF “because I am concerned whether I might have allergic reactions after eating these food products” (53.9%), “because I am concerned about the sensory appeal (i.e., taste, aroma & texture) of the food product” (46.1%) and “because I am concerned about the safety of the food products” (45.6%). Almost half of them, nevertheless, agreed that they would be unwilling to consume “if the food products are more expensive” (49.3%). Nearly a third of the consumers could neither agree nor disagree with all these statements (see Figure 3).

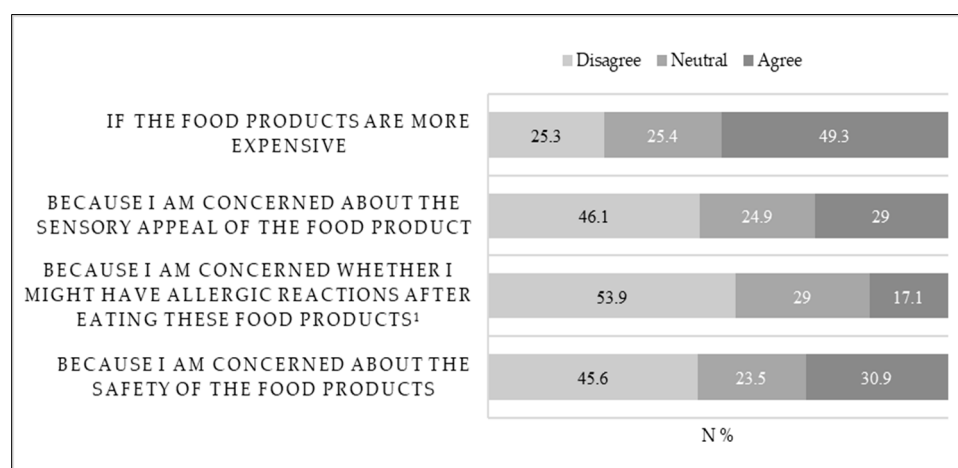


Figure 3. The level of participants' (N = 233) agreement (disagree, neutral and agree) to the statements “I am NOT willing to eat food products derived from animals that have been fed with insect-based feed . . . ” ¹ Statements adapted from a past study [37].

Consumers' level of agreement to most of the provided statements was not significantly correlated ($p > 0.05$) with their willingness to consume foods derived from animals fed with IBF. However, consumers' concern about the sensory appeal of eggs obtained from animals on an IBF diet was negatively correlated with their willingness to consume such eggs ($r(231) = -0.158, p < 0.05$). Similarly, consumers' concern regarding the safety of beef ($r(231) = -0.158, p < 0.05$), pork ($r(231) = -0.210, p < 0.01$), fish ($r(231) = -0.179, p < 0.01$), lamb/mutton ($r(231) = -0.189, p < 0.01$), eggs ($r(231) = -0.169, p < 0.05$), and dairy

($r(231) = -0.217$), $p < 0.01$) was negatively correlated with their willingness to consume those food products.

Analysis of qualitative data related to the research question “Which factors affect the willingness of consumers in Ireland to consume food products derived from animals that have been fed with IBF?” generated two main themes: “consumer-related factors” and “product-related factors”. In relation to the product-related factors, the answers of 59 participants revealed that most of the participants’ concern regarding the safety was further linked to the type of animal and unnatural animal diet. Consumers did not think it was natural for herbivores to feed on IBF and questioned the safety of such a practice for both humans and animals. This concern was linked to consumers’ recollection of the bovine spongiform encephalopathy (BSE) outbreak that was first detected in cattle in the United Kingdom in 1986 and later spread to humans through consumption of meat that was infected with prions [47]:

“I worry about forcing animals to eat an unnatural diet that may cause problems for that animal and may once again cause problems to humans as it did with the Bovine spongiform encephalopathy (BSE) in cows . . . ” (C19)

“I would only eat products if it forms part of the natural diet of the animal, like chickens and fish. I think feeding insects to herbivores isn’t healthy or natural” (C46)

Consumers’ willingness to consume foods from animals fed with IBF was also dependent on the sustainability of the IBF, nutritional value, and the sensory attributes of the foods:

“If the taste and appearance of the food was not significantly altered, if the insects were produced sustainably . . . ” (C26)

“If the eating quality and nutritional value of the products remain consistent” (C32)

Most of the consumers required further information regarding the benefits/risks of feeding animals with IBF:

“I would need more information about whether insects are reasonably part of the animals’ natural diet . . . I understand this would not be natural for cows, sheep, cattle and so more information about this would help my decision making” (C58)

“I would like to have more information about the pros and cons of the differences in food products that have and have not had insects” (C51)

Some consumers had “no reason not to eat” while others had “no reason to eat” foods from animals fed with insect-based feed.

3.4. Willingness to Use IBF Amongst Farmers

Most farmers agreed with the use of IBF for poultry (81.7%), fish (80.3%), and pigs (71.8%), as seen in Figure 4. Nearly 60% of the farmers agreed with the use of IBF for pets whilst slightly over half agreed with its use for cattle (53.5%) and sheep (52.1%). Regarding the use of IBF for cattle and sheep, the other half of the farmers was almost evenly divided between those who disagreed (23.9% and 22.5%, respectively) and those who were unsure (22.6% and 25.4%, respectively) (see Figure 4).

When asked how likely they would be to use IBF for their own animals prior to being provided with information on its benefits, 56.3% of the farmers indicated that they would likely use it while just 18.3% declared that they were unlikely to use it. About 25%, however, were uncertain (“neither likely nor unlikely”).

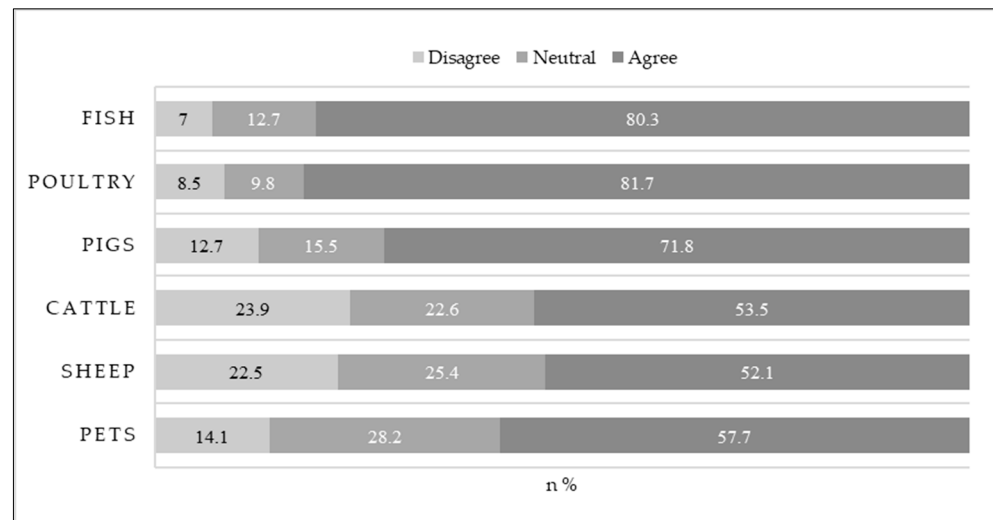


Figure 4. The extent to which farmers ($n = 71$; two farmers did not complete this question) agreed with the use of IBF for different animals.

3.5. Factors Affecting Willingness of Farmers to Use IBF

The farmers' willingness to use IBF for their animals was not significantly affected ($p > 0.05$) by any of the farmer-related factors investigated (location of residence/workplace, gender, age, level of education, previous knowledge of insects being used in animal feed, farm size, number of animals being reared, type of feed ingredients being used, type of farming, and previous experience with using IBF) in this study (see Table S5).

Figure 5 shows that most farmers agreed with all the provided statements that they would be willing to use IBF for their animals "if the feed is of high nutritional value" (91.5%), "if it is safe for animal consumption" (90.1%), "if consumers will purchase products of animals fed with insect-based feed" (88.7%), "if it reduces the price of feed and animal production" (88.7%), and "if the animals will grow faster" (76.1%). Even though most of the farmers agreed to these statements, it was their level of agreement to the statement "if it is safe for animal consumption" that was significantly correlated ($r(69) = 0.307$, $p < 0.01$) with their willingness to use IBF.

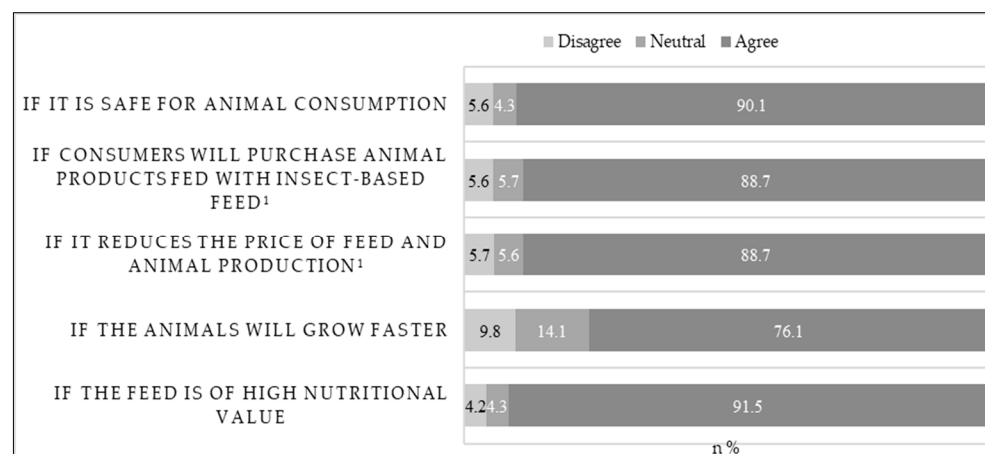


Figure 5. The level of farmers' ($n = 71$; two farmers did not complete this question) agreement (disagree, neutral, agree) with the statements "I am willing to use insect-based feed for my animals ..."; ¹ Statements provided adapted from a past study [37].

Almost all the farmers agreed that they would not be willing to use IBF for their animals "if it introduces microbial contamination or chemical residues to the food chain"

(92.6%) and “if it causes allergic reactions in animals or /and humans” (92.6%). This was followed by those who agreed that they would not be willing to use IBF “if it reduces consumer acceptance of food resulting from animal production” (73.5%) or “because I do not have enough information regarding the benefits/risks” (67.6%). About a fifth (20.6%) of the farmers could neither agree nor disagree to the statement “because I do not have enough information regarding benefits/risks” as their reason for unwillingness to use IBF (see Figure 6). No significant correlations ($p > 0.05$) were observed between the farmers’ willingness to use insect-based feed and their level of agreement with any of these statements.



Figure 6. The level of farmers’ ($n = 68$; five farmers did not complete this question) agreement (disagree, neutral, agree) to the statements “I am NOT willing to use insect-based feed for my animals . . . ”; ¹ Statements adapted from past studies [32,37].

Less than a quarter of the farmers provided “other” reasons for their willingness (21.1%) or unwillingness (11.8%) to use IBF through the open-ended questions, which were mainly “product-related factors” as revealed from the analysis of the qualitative data. Among these factors, sustainability and safety of the IBF were most frequently mentioned, while fewer participants named factors related to its nutritional value or availability. Though some only mentioned the term “sustainable” without further elaboration, the sustainability sub-theme (from the theme “product-related factors”) was mostly linked to the economic and environmental pillars of sustainability [48]:

“There is a lot of wheat used in the chicken meal on our farm . . . If we could feed insects to the chickens, we may be able to use the wheat to make other products which will earn more than the insects cost to produce. Thereby increasing Ireland’s net agricultural outputs” (F6)

“If there is less impact on the environment from using insects as a source of feed” (F5)

Farmers’ concern regarding the safety of IBF was linked to the type of animal. Concerns were raised over herbivores being fed IBF, subsequently causing some to expect its safety to be substantiated through “extensive” research before they are willing to use it:

“If enough research has been done on the environmental impact of the insect production and alterations to the food chain, if it is proven that it is safe for herbivores to eat insects” (F9)

The availability of the IBF was another factor pointed out by some farmers as having an impact on their willingness to use it:

“If it is not available to buy at local stores, I wouldn’t be special ordering in insect meal” (F1)

Others, however, associated IBF with a high protein content and favourable sensory properties in eggs; hence their willingness to use it for their animals:

“Higher protein content than grain, deeper yolk colour and more flavour in eggs” (F13)

Upon being provided information that the use of insect protein in feed given to pigs and poultry had been recently authorised in the EU, some farmers indicated that they would still consider other factors prior to using IBF for their animals. These factors were related to the environmental impact (11.8%), availability of supply (11.1%), amount of research conducted to back any benefits or risks of using IBF (9.5%), cost (7.4%), nutritional value (4.4%), and palatability for animals (4.4%) and the people (4.4%) who would consume the food from animals fed with IBF. Most of these farmers however, still wanted more information, as seen by how they mostly asked questions in their responses:

“Is it likely to cause allergic reaction to individuals with hayfever?” (F24)

“Would there be a way to grow the insects using the waste products from the chicken house? Currently the chicken manure goes to the tillage farmers who plough it in and grow grain to be sold back to us as more feed. If we replace grain with insect protein the tillage men might not take our manure . . . ” (F9)

3.6. Effect of Providing Information on Participants’ Willingness to Accept IBF

After being provided with the benefits of using IBF, 74.6% of farmers indicated that they would likely use it for their animals compared to 56.3% who had done so before. In addition, there was a decrease in the percentage of farmers who were unlikely (5.6%) or neither likely nor unlikely (12.7%) to use IBF after knowing its benefits. The exact sign test confirmed that these differences were significant ($p = 0.011$), as seen in Table 3. Similarly, providing information on the benefits of using IBF for animals induced a significant increase in consumers’ willingness to consume beef ($p < 0.001$), pork ($p < 0.001$), fish ($p < 0.001$), lamb/mutton ($p < 0.001$), and dairy products ($p = 0.005$) from animals that were fed with IBF. However, it did not significantly affect their willingness to consume chicken ($p = 0.127$), or eggs ($p = 0.185$) (see Table 3).

Table 3. Effect of knowing the benefits of IBF on participants’ (N = 207) willingness to consume food from animals fed with such feed and on farmers’ (n = 63) willingness to use it.

Willingness to Consume the following Products from Animals Fed IBF (N = 207 ¹):	Positive Differences	Negative Differences	Tiers	Sign Test
	%	%	%	p-Value ²
Chicken	15.5	9.7	74.9	0.127
Beef	27.1	4.8	68.1	<0.001 *
Pork	25.1	6.3	68.6	<0.001 *
Fish	23.2	8.7	68.1	<0.001 *
Lamb/mutton	31.4	4.8	63.8	<0.001 *
Eggs	13.5	8.7	77.8	0.185
Dairy	18.4	7.2	74.4	0.005 *
Willingness of farmers to use insect-based feed for their animals (n = 63 ³)	28.6	7.9	63.5	0.011 *

¹ Twenty-six consumers did not complete this question; ² p-value significant when * $p < 0.05$; ³ Ten farmers did not complete this question.

4. Discussion

This study explored the factors affecting the acceptance of IBF amongst a segment of consumers and farmers in Ireland. Figure 7 shows a summary of the consumer- and product-related factors found from the analysis of the quantitative data as having an influence in that regard, while Table S6 shows a summary of the factors generated through the analysis of qualitative data.

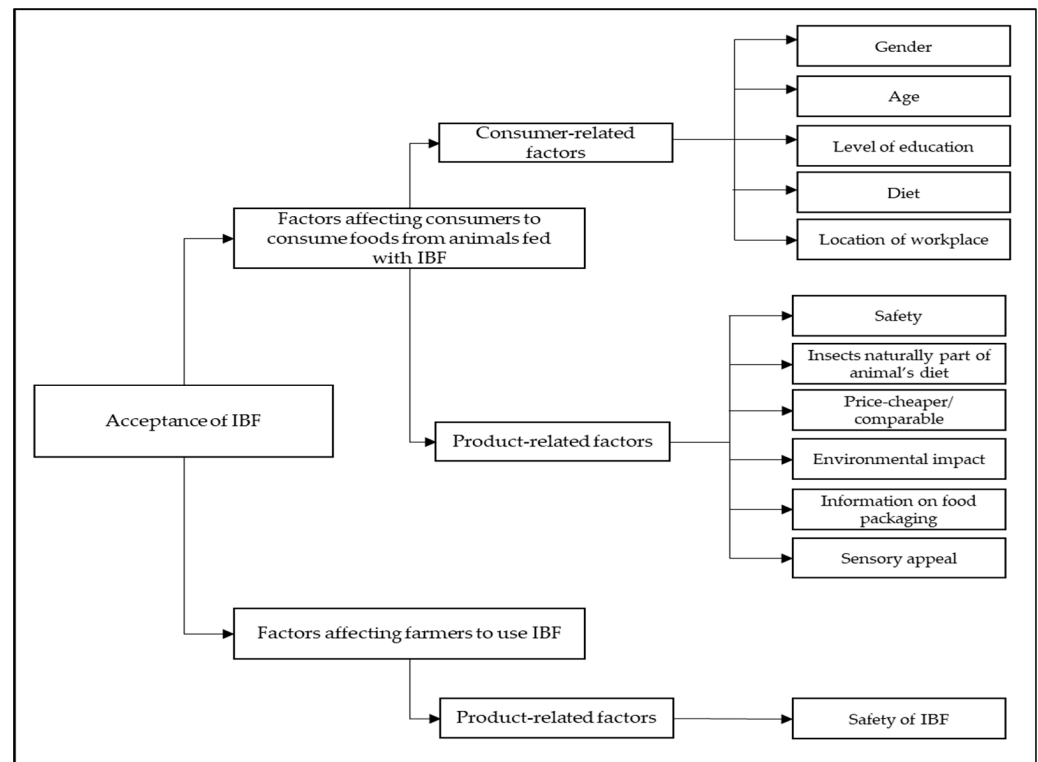


Figure 7. Summary of the consumer- and product-related factors found to influence acceptance of IBF in this study (based on the analysis of the quantitative data).

Several consumer-related factors affected the willingness of participants in this study to consume foods from animals fed with IBF. While gender had no influence on the willingness to consume chicken, dairy, and eggs, men were more willing to consume beef, pork, fish, and lamb/mutton. Several past studies have also reported men to be more willing to consume foods from animals fed with IBF [29,30,33,36]. Moreover, men have been found to generally consume beef, pork, fish, and lamb/mutton significantly more than females [49,50]. Comparably, in Ireland, men's overall animal protein intake is reportedly higher than that of females, who instead tend to consume more plant-based protein than men [51]. All this could have played a role in the gender effect on willingness to consume foods from animals fed with IBF in the present study. Furthermore, females have been reported to likely be more concerned than men about the safety aspect of these foods [30]. In the present study, the safety concern surrounding use of IBF was linked to consumers' recollection of the BSE outbreak in cows and subsequent transmission to humans [47]. The risk of getting infected from consuming dairy products from BSE infected animals was, however, found to be very rare [52,53], which could have led female consumers in this study to view dairy as being relatively safe to consume, whilst the greater acceptance of chicken and eggs from animals fed IBF may be explained by insects being part of the natural diet of poultry [24]. Consumers in the youngest age group (18–29) were significantly more willing than those in other age groups to consume these three products. Other researchers had also found young consumers to be more accepting of the foods from animals fed with IBF [29,32–34]. Most of the farmers in the present study were in the 18–29 age group and there were more female farmers than were male farmers (see Table 1), which could explain why this age group was more willing to consume chicken, dairy, and eggs for the above reasons.

Consumers' diet influenced their willingness to consume meat from animals fed with IBF, with those adhering to a particular diet being less willing in that regard. However, it had no effect on their willingness to consume eggs and dairy products. This could be attributed to the fact that this study did not exclude vegetarians, vegans, or those on

selective meat diets, and most (88%) of the consumers who were adhering to a particular diet (18% of the total consumers: see Table 1), were on diets that did not exclude eggs and dairy (as revealed from their comments). Level of education influenced consumers' willingness to consume fish fed with IBF. Those who had completed an honours degree were more willing to consume IBF-fed fish. This agrees with previous studies that showed having a university degree to positively influence one's willingness to consume fish [30], duck [34], or animal products in general [36] from animals fed with IBF. In a study where less than a third of the participants had a university degree [32], level of education had no influence on willingness to consume foods from poultry, cattle, pigs, and fish fed with IBF. The use of insect protein in EU aquafeed was authorised in 2017 [13], which might have provided ample time for the most educated group of consumers in the present study to get acquainted with this information.

Consumers' willingness to consume foods from animals fed with IBF was also affected by several product-related factors. Concern regarding the safety of beef, pork, fish, lamb/mutton, eggs, and dairy from these animals significantly decreased consumers' willingness to consume them. Accordingly, and in line with results from the qualitative analysis, insects being naturally part of an animal's diet significantly increased consumers' willingness to consume these products. The safety of these foods and insects being a natural part of an animal's diet were also noted as contributing factors in past studies [30,34,36]. However, in the present study, these factors had no effect on the willingness to consume lamb/mutton, possibly because in Ireland, lamb/mutton is generally consumed far less yearly at 3.0 kg/capita compared to beef (19.8 kg/capita), poultry (24.7 kg/capita), or pork (31.1 kg/capita) [54].

The price of the foods derived from animals fed IBF influenced consumers' willingness to consume them. Consumers' willingness increased if the food products were cheaper or comparable to the existing alternatives, but it was not affected if the products were expensive. In a study conducted in Spain, participants were willing to buy fish fed with IBF even if it was more expensive than the alternatives [55]. These participants also believed IBF to be environmentally friendly compared to conventional aquafeeds, which could have contributed to their willingness to pay more for this type of fish [55]. In the present study, the willingness of consumers to consume all the foods (chicken, beef, pork, fish, lamb/mutton, eggs, and dairy) significantly increased when feeding animals with IBF had a positive impact on the environment, possibly explaining why their willingness was not affected by how expensive the products were.

The willingness to use IBF amongst farmers in the present study was not affected by any of the farmer-related factors explored as seen in Figure 7. Similarly, the intention to use IBF amongst farmers in France and the Netherlands was not significantly affected by age, gender, type of feed, and country location [56]. In a study conducted outside the EU, older poultry farmers who might have had more experience with using IBF were found to be more willing to use it than the younger farmers [35]. In the present study, however, most farmers were in the youngest age group (18–29), as they were more willing to complete an online survey. Moreover, almost all (97.2%) the farmers reported having no previous experience with using IBF. This was not surprising considering that the EU regulation allowing the use of insect protein in feed for poultry and pigs [14] came into force relatively recently in Ireland and the EU in general (36.9% were poultry and pig farmers, compared to just 1.4% of fish farmers).

IBF product-related factors, such as its safety, availability, sustainability, consumer acceptability, potential to reduce production costs, nutritional value, and improved growth performance of animals, were all generally important to the farmers in this study. However, safety significantly affected their willingness to use it on their animals. The more the farmers agreed to the statement that they would be willing to use IBF "if it is safe for animal consumption", the more willing they were to use it. Perceived risks associated with using IBF were also found to significantly reduce the willingness of farmers to accept its use in Belgium [37]. However, in that study [37], as well as in another conducted in France and

the Netherlands [56], perceptions regarding the benefits associated with use of IBF had a higher impact on the farmers' willingness to use IBF compared to the perceived risks, which was different from what the present study found. Although important to the farmers, quantitative analysis in the present study revealed no significant correlations between three of the safety aspects of IBF investigated in the present study, i.e., microbial, chemical, and allergenic risks, and willingness to use IBF. However, qualitative analysis of the farmers' comments revealed that the safety aspect most crucial to them was the one dependent on the type of animal. Most responders questioned the safety of IBF for animals that are naturally herbivores, possibly explaining why more farmers agreed with its use for fish, poultry, and pigs than those who agreed with its use for cattle and sheep, as highlighted in the closed-ended questions. Moreover, 2.8% of farmers who had previous experience with IBF were involved in egg production and yet, while they were willing to use IBF, they could not agree with its use for cattle and sheep. It can be assumed that the safety of the IBF was a much higher priority to the farmers than their consideration of the number of animals being reared, farm size, or any farmer-related factors; hence the lack of significant results from the latter.

Providing information about the environmental and nutritional benefits of using IBF increased its acceptance amongst the consumers and farmers in the present study, which agrees with the findings of studies conducted in France and Italy [30,34]. This information, however, did not influence consumers' willingness to consume chicken and eggs, which were already the two most preferred products before the information was provided. Still, some participants (consumers and farmers) in the present study were uncertain of their willingness to accept IBF after being provided with information on its benefits. This could be attributed to the type of information provided, which did not include specific information on the safety for herbivores and/or humans or if insects can feed on manure; these were all details that participants were interested in, according to their comments. In addition, along with responses to the open-ended questions, most participants asked some questions that would suggest a general need for more information around the use of IBF. This need for information could explain the increased willingness to consume foods from animals fed with IBF "if the information is specified on the food packaging", as was also reported in another study [34]. Lack of information regarding the use of IBF has been found to cause uncertainties regarding its acceptance among consumers and stakeholders [57]. It can be assumed that the lack of significant results found on some participant-related factors in the present study, such as previous knowledge of insects being used in feed, for example, might have been influenced by this need for more information.

There were several strengths and limitations to this study. This is the first study to assess IBF acceptance amongst a segment of mostly younger and educated consumers and farmers in Ireland, a country with a substantial livestock production sector. Hence, the results could provide baseline data for IBF-related future studies in Ireland. This study also sheds light on the acceptance of IBF among an educated group of consumers and the future generation of farmers, as it mostly involved younger participants with a university education. Considering results from this study and other previous studies that found those younger [32–34] with a high level of education [36,58,59] to be more accepting of IBF, this group of consumers/farmers could potentially be among the early adopters of IBF. Identifying and understanding the factors affecting IBF acceptance among early adopters could aid targeted intervention strategies among this group of consumers/farmers. This is especially important since, according to several studies, attempts to introduce a novel practice might be best targeted at specific segments of the population who may be early adopters, in order to firstly establish some level of adoption before shifting the focus to the general population [60,61]. A limitation to the present study was that it did, however, prove challenging to recruit older farmers and those without a university education through online surveys; the latter was also observed in other studies [62].

5. Conclusions

This study aimed to provide baseline data on factors affecting the acceptance of IBF amongst a segment of younger and educated consumers and farmers in Ireland. The study found that a combination of consumer- and product-related factors affect consumers' willingness to consume foods from animals fed with IBF. This effect, nevertheless, depended on the type of food. Consumers' gender, age, level of education, and diet were the consumer-related factors found to significantly affect their willingness. On the other hand, safety, insects being a natural part of an animal's diet, environmental impact, price, and information reported on food packaging were the product-related factors found to influence consumers' willingness to consume foods from animals fed with IBF. Yet, the safety of the IBF for animal consumption, particularly herbivores, was a strong factor found to significantly affect the willingness of farmers to use it as feed on their own animals, unlike what was found in other studies conducted in the EU, where the benefits of using IBF were the stronger factors. The farmers in the present study were generally open to using IBF once its safety is substantiated through extensive research. This therefore calls for more research to be conducted to investigate the safety of IBF, particularly for ruminants, just as was recommended by the EFSA. In addition, providing information on the environmental and nutritional benefits of IBF increased its acceptance by both consumers and farmers. Future success on the adoption of IBF might depend on assuring farmers and consumers about its safety through enacting evidence-based educational strategies. Furthermore, EU public policy changes could be implemented to include a statement on the food packaging information that the food is from an animal fed with IBF, since this kind of transparency was shown to increase consumer acceptance in the present study. However, due to the relatively small sample size and participants' profile restrictions in this study, these conclusions may not be generalised for the entire Irish population. Therefore, for the future, this study could be extended using pen and paper questionnaires or face-to-face interviews with older farmers and those without university education, who were underrepresented in the current study. Recruitment for farmers could be focused on marts or the physical farmers markets across the different provinces of Ireland, although it is important to note that not all farmers in Ireland sell their produce at these markets. In addition to the farmers markets, recruitment for farmers could be undertaken via the different farmers' associations.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su151411006/s1>, Table S1: Survey items used in the present study; Table S2: How each main research question of this study was broken down (into embedded research questions) to facilitate survey construction and ensure content validity of the survey; Table S3: Statistical tests used to analyse the effect of various factors on the willingness of farmers and consumers to accept the use of insect-based feed on animals; Table S4: An outline of the effect of consumer-related factors (left) on the willingness of participants (N = 233) to consume foods (top) derived from animals fed with insect-based feed (IBF); Table S5: The effect of farmer-related factors on their willingness to use insect-based feed; Table S6: Themes, sub-themes, and corresponding quote examples generated from the qualitative analysis of the data from the open-ended questions.

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