



Do consumers accept processed animal proteins in feed of food producing animals?

A quantitative exploration in five European countries

Gemma Tacke, Marcel Kornelis, Paul Bikker, and Patricia Jaspers



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In this study, we focus on the consumer acceptance of processed animal proteins (PAPs) in feed for pigs and poultry. The use of PAPs can be seen as a more sustainable alternative than other feed ingredients with benefit for a more sustainable eco-system. Critical for the eventual market success of PAPs is the response of consumers who buy and eat the animal products. Consumers may vary in the way they trade off the perceived positive and negative consequences of PAPs in feed. In an empirical study in Germany, the Netherlands, Poland, Spain, and the UK, we studied consumer acceptance of animal products when it is communicated, in the form of two media messages, that the animals were raised with PAPs-based feed. The empirical models included drivers of consumer decision making, such as food choice motives, and perceived personal knowledge, to determine whether these can further help to understand variation in consumer acceptance. In our empirical analysis, we found that among the consumers in the five countries, there was substantial variation in the acceptance of PAPs in feed, with a peak at the neutral opinion. In addition, empirical evidence was found that, in four of the five countries, consumers who were more ecology conscious and were more health oriented (partly enhanced by the COVID pandemic), showed higher levels of fear, in comparison to other respondents, after reading the messages. In all five countries, consumers found, on average, that the two media messages were persuasive. Consumer acceptance was higher among consumers who had more knowledge about PAPs in feed. It was concluded that it may be of strategic relevance to consider communication campaigns about the use of PAPs in animal feed that target specific consumer groups within each country of interest.

Key words: Consumer acceptance, social dilemma, sustainable behaviour, perceived health, animal feed

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1 Introduction

Due to worldwide trends such as population growth and economic development, a higher consumer demand for meat, eggs, and dairy products is expected across the globe (Verbeke, Spranghers, De Clercq, De Smet, Sas, & Eeckhout, 2015; Altmann, Anders, Risius, & Mörlein, 2022). A higher consumption of these animal products leads to an increased need for animal feed, which may jeopardise sustainability goals. For example, soybean meal is the main protein source in compound feed for farm animals, but a higher production of soya beans may cause more deforestation, more water use, and an increased use of pesticides and fertilisers (Ankamah-Yeboah, Jacobsen, & Olsen, 2018). Next to that, arable land no longer used for feed, can be used for food again. Therefore, the use of alternative, more sustainable feeding practices based on human inedible feed materials has become an important objective in feed and food industries and among governments. Critical for a successful change is whether alternative feeding practices are accepted by consumers, as they are the end-users who buy and eat the produced animal products.

Promising protein sources that can be used as alternative for soybean products include by-products of the slaughter of farm animals (EFPPRA, 2021). Examples are porcine and poultry meal, which are derived from animal parts that are unfit for human consumption, or not appreciated by human consumers. More than two decades ago, in 2001, use of slaughter by-products was prohibited in the EU as a feed ingredient for ruminants, as research indicated that their use may cause Bovine Spongiform Encephalopathy (BSE, also known as 'mad cow disease') in ruminants, and that meat from infected animals may cause Creutzfeldt–Jakob disease among human consumers. The feed ban was temporarily extended to all food producing animals because of insufficient canalisation in the production of feed, i.e., incomplete separation of production lines for ruminant and non-ruminant feed. Furthermore, the feed ban was extended to the (processed) proteins from all species because of the lack of analysis methods to distinguish between animal species. Nowadays, new processing technologies and new detection methods have been developed that guarantee higher feed and food safety for animals and humans. Proteins derived from animals following these new standards are called Processed Animal Proteins (PAPs) and are legally allowed again for use in pig and poultry diets in the European Union.

In contrast to, for example, the use of insects in feed for farm animals, empirical research on consumer acceptance of PAPs in feed is still scarce. The small number of studies can be explained by the prohibition of PAPs in the EU in 2001. In this study, we focus on the consumer acceptance of PAPs. More specifically, we examine the consumer acceptance of pork and poultry meat and eggs in five European countries, when it is communicated, in the form of media messages, that the pigs and poultry were raised with PAPs-based feed. In this way, we aim to uncover potential barriers that consumers may experience in buying animal products, when the feed and food chain use PAPs in animal feed.

We first review the relevant literature on consumer responses to alternative feed practices for animals used in the food chain. Thereafter, we introduce our approach in which we introduce the variables of focal interest. Subsequently, we present and discuss the empirical results and conclude with key implications of our study and areas for future research.

2 Literature review

The introduction of novel feed ingredients in the food chain has become of key interest to researchers in many disciplines. Over the years, relevant research has identified a number of potential barriers that may hamper a successful entry of novel feed ingredients to the market. These obstacles can be broadly classified as potential production barriers (Józefiak, Józefiak, Kierończyk, Rawski, Świątkiewicz, Długosz, & Engberg 2016, Popoff, MacLeod, & Leschen 2017, and Sogari, Amato, Biasato, Chiesa, & Gasco 2019), potential legal barriers (Bataglia 2014, Moruzzo, Riccioli, Espinosa Diaz, Secci, Poli, & Mancini 2021, and Wang & Shelomi 2017), and potential demand-side barriers (Borrello, Caracciolo, Lombardi, Pascucci, & Cembalo 2017, Verneau, Zhou, Amato, Grunert, & La Barbera 2021, and Altmann et al. 2022). Our study belongs to this third line of research, and to position our work in this stream, we elaborate on its earlier findings.

2.1 Consumer response to novel feed ingredients

In line with the classification scheme of White, Habib, & Hardisty (2019) that is explicitly designed to analyse pro-environmental behaviour changes among consumers, we use the categories *tangibility*, *individual self*, *cognition and affection*, *habit formation*, and *social influence* to categorise the published findings so far that consider consumer response to novel feed practices.

2.1.1 Tangibility

Consumers may perceive sustainable initiatives as being tangible, i.e., concrete or close to the self, or intangible, i.e., abstract or distant from the self (Reczek, Trudel, & White 2018). Previous research suggests that potential (in)tangibility regarding the food production system and regarding sustainable initiatives, may play a role in consumer acceptance of novel feed ingredients. Indeed, most consumers are not involved in the complete food production process. Instead, they can purchase and eat the end products, without any knowledge about the previous phases in the food supply chain, such as animal feeding practices. Popoff et al. (2017), Ferrer Llagostera, Kallas, Reig, & De Gea (2019), and La Barbera, Amato, Fasanelli, & Verneau (2021), all report low knowledge levels about feeding practices among consumers. Hence, animal feeding practices may be an intangible issue for many consumers. In addition, Altmann et al. (2022) and Baldi, Mancuso, Peri, Gasco, & Trentinaglia (2022) found that consumer acceptance of insect- and algae-based feeds was lower if consumers were less environmental conscious. Intangibility towards the ecosystem may, at least partly, explain this choice motive. Intangibility among consumers can be a barrier for changing their behaviour, as is argued by Griskevicius, Tybur, & Van den Bergh (2012), and White et al. (2019).

2.1.2 Cognition and affection

Consumer behaviour can be driven by affection, i.e., positive and negative emotions, or cognition (Shiv & Fedorikhin 1999). Appealing to positive emotions can be used as leverage to influence sustainable consumers choices. For example, Altmann et al. (2022) found that affinity towards nature positively affects the preference for meat from insect-fed chickens. In contrast, negative emotions may form barriers among consumers to engage in pro-environmental behaviour. Based upon a survey among Italian consumers, Borello et al. (2017) concluded that disgust was a potential barrier for insect-fed meat acceptance. This finding was confirmed in Verneau et al. (2021), and Altmann et al. (2022). Another negative feeling is fear. In an analysis of the potential market for insect-fed poultry products, Saatkamp et al. (2022) argued that the fear of contamination with pathogens, toxins, and chemicals in the production process, may result in a decrease in consumer trust and acceptance.

When consumer behaviour is driven by cognition, providing information through appeals that highlight why a product is sustainable can be effective in giving consumers the initial knowledge they need to make their decisions (Peattie & Peattie, 2009). In a UK study on consumer acceptance of insect-fed fish, Popoff et al.

(2017) observed that many consumers have little initial knowledge about regular and alternative animal feed practices. This is in line with the conclusions of Ferrer Llagostera et al. (2019) and La Barbera et al. (2021), of whom the latter studied consumer acceptance of insect-fed animals in Italy. In addition, both Gasco et al. (2020) and Baldi et al. (2022) showed that providing Italian consumers with information about regular and more sustainable feed practices positively stimulated consumer acceptance of insect-fed fish products. New technologies may play a crucial role in offering consumers the information they need. In a UK and Irish-based study on non-ruminant PAPs in animal feed, Woodgate, Wan, Hartnett, Wilkinson, & Davies (2022) argued that new traceability technologies can provide factual information that may help to eliminate consumer concerns about food contamination with pathogens.

2.1.3 Individual self

Factors linked to the individual self include self-interest, individual differences, and self-efficacy. Motives of self-interest can play an important role in accepting or rejecting new choice behaviour (White et al. 2019). Key self-interest motives that were found in previous literature on novel feed practices relate to price, nutritional value, personal health, religion, and taste. For example, Altmann et al. (2022) observed, among German consumers, that a lower price for animal products from algae-fed chickens resulted in a higher consumer preference for these products. In a Belgian study, Verbeke et al. (2015) concluded that consumers perceive animal products obtained from insect-fed animals to have a better nutritional value, and to be healthier. Ferrer Llagostera et al. (2019) found that Spanish consumers believed that insect-fed fish would have a worse taste in comparison to those fed the traditional feeds. Another relevant factor may be religion. Consumers who prefer to eat halal or kosher, may be less likely in accepting PAPs in animal feed as compared to others. Lane, Hough, & Bostock (2014) studied the EU aquaculture, and documented that salmon fed with porcine blood meal will not be purchased by consumers of halal and kosher food.

Individual differences, which may help to explain heterogeneity in sustainable consumer behaviour, relate, among others, to personal experiences and demographics. For example, in a study among Chinese consumers, Verneau et al. (2021), concluded that consumers who experienced insect consumption by themselves have a more positive attitude towards insect-based feed than unexperienced consumers. Differences in age, gender, and education can also influence consumer acceptance. Baldi et al. (2021) demonstrated that consumer acceptance of insect-fed fish was higher among Italian males and youngsters as compared to others, and highly educated consumers have been found to be more likely to engage in pro-environmental behaviour (Casaló & Escario, 2018; Sánchez, López-Mosquera, & Lera-López 2016) as compared to others.

Self-efficacy implies that consumers can engage the required action and that it will result in the intended impact (Bandura, 1977). For example, Altmann et al. (2022) showed that almost one-third of the German participants did not believe that using insects or algae as chicken feedstuffs would reduce environmental impacts as compared to soybean-fed chicken.

2.1.4 Habit formation

Food consumption is strongly habitual. Ways to encourage new habit formation include actions that stimulate repetition, such as making new choices easy to do (Van Houten, Nau, & Merrigan 1981), or the use of repeated prompts, i.e. messages that are given before the choice is made to remind consumers what the new behaviour is about (Lehman & Geller, 2004). In their study about fish consumption among German consumers, Ankamah-Yeboah, Jacobsen, & Olsen (2018) recommend producers using insect-based feed to develop fish products that are easy to prepare, as convenience plays an important role in the food preparation by consumers who are sensitive towards insect-based feed. Indeed, for these sensitive consumers, preparation convenience could make their choice for more sustainable produced fish easier to make. Altmann et al. (2022) show that the use of algae-based feed may give chicken meat a different colour, without affecting its quality, which consumers are not used to eat. This may hamper new habit formation. Here, the use of repetitive prompts, for example, in the form of messages on the chicken meat packages, may be used to stimulate new habit formation.

2.1.5 Social influence

The presence, behaviours, and expectations of others often influence consumer behaviour, and factors of social influence include social norms, social identities, and social desirability. Social norms, or beliefs about what is socially appropriate and approved of in each context, can have a powerful influence on consumers (Cialdini, Demaine, SagarinBarrett, Rhoads, & Winter 2006). Consumers' social identities or sense of identity stemming from group memberships may also stimulate behaviour change (Han & Stoel 2017). In addition, consumers may also select sustainable options to make a positive impression on others or to promote their social status (White et al. 2019). To the best of our knowledge, these factors have not yet been empirically investigated within in the context of consumer acceptance of alternative feeding practices in animal production.

3 Our approach

In our empirical study, we investigate to what extent factual information about PAPs in animal feed affects consumer acceptance of the associated animal products. Moreover, we try to explain the potential heterogeneous response among consumers by factors that are related to tangibility, cognition, affection, and the individual self.

3.1 Tangibility

A way to tackle the barrier of intangibility is to provide consumers with concrete information about the issues of interest. In our study, we consider two text messages about the use of PAPs in feed for pigs and poultry that can be used to inform consumers. In the first message, factual information about PAPs in feed, its relation to the natural diet of pigs and chickens, and its contribution to a more sustainable food production system was provided. In the second message, additional information was provided about the EU's reaction to the BSE crisis of 2001, in terms of laws and regulation, why PAPs are nowadays permitted for use in animal feed, by policy makers and implemented by the feed industry, and the assurance was given that this novel production process was completely safe for human consumption. The two messages are presented in Appendix 1.

3.2 Cognition and affection

We investigate whether consumers find the content of the messages convincing, because consumer differences in this perceived *persuasiveness* may influence their attitude to and acceptance of PAPs in animal feed.

As consumers may differ in their perceived *knowledge* about the desired behavioural change, we consider (the lack of) perceived personal knowledge about feeding practices as a relevant explanation for variation in consumer acceptance rates. We expect that a lower perceived personal knowledge reflects a lower involvement, and therefore a lower acceptance rate.

With respect to affective drivers, we consider *fear* to be a potentially important obstacle for the consumer acceptance of PAPs in feed. Messages about PAPs may strengthen the negative feeling of fear if they cannot assure consumers that food products from PAPs-fed animals are completely safe. This is a realistic situation in our setting, as consumers may recall the BSE crisis of 2001, or be influenced by negative information streams in the media about this disease. In addition, the outbreak of the *COVID pandemic* may have increased health concerns among consumers. We therefore study the levels of fear among consumers after they have read the messages, and the impact of COVID on the consumers' health orientation.

3.3 Individual self

A number of self-interests may prevent consumers from accepting PAPs in feed of farm animals. As aforementioned, perceived *healthfulness* is seen as a relevant potential barrier in our setting. Another barrier may be the fear among consumers that PAPs lead to less *tasteful*, or *sensory appealing* products. A third relevant barrier may be *religion*. Consumers who prefer to eat halal or kosher, may be less likely in accepting PAPs-based animal products as compared to others as discussed above.

Products from PAPs-fed farm animals may contribute to a more circular and sustainable food production system (EFPRA 2021). Hence, PAPs in feed may be welcomed by *environmental conscious* consumers if they are informed about the benefits for the ecosystem.

Age, gender, and education may be relevant individual differences that can further explain differences in consumer acceptance. Especially age is of interest in our study because elder consumers may recall the BSE crisis and/or the feeding practices before this crisis, and also eco-friendly behaviour may differ between young and older consumers.

In conclusion, the offering of information about PAPs in feed may cause various response patterns among the consumers. In our study we investigate this impact in five European countries, viz. Germany, the Netherlands, Poland, Spain and the UK.

4 Methodology

4.1 Respondents

In total 5000 respondents between 18 and 65 years old participated in this study, which was part of a larger survey that was performed in the Netherlands, Germany, Spain, Poland and the UK. In each country, 1000 participants completed the survey. MSI-ACI Europe (an international market research company) recruited respondents from a representative consumer panel by means of quota sampling, thereby ensuring that the demographic profile, in terms of gender, age, education, and income, was representative for the population of each country. People who consider themselves to be vegan were excluded from the study, as they do not eat animal products. Data were collected in September 2021, using a computerised questionnaire that could be answered by phone or computer. The distribution of males (48-50%) and females (50-52%) was about equal for each country, and the average age was between 41 and 43 years old (SD \pm 13).

4.2 Measures

The offering of information about PAPs in feed and the associated responses of respondents were operationalised as follows. The first message was offered to all participating respondents, and, after reading the message, the perceived *persuasiveness* of the offered information and feelings of *fear* were measured. Subsequently, the respondents were asked to read the second message. Again, *fear* and *persuasiveness* were measured, together with *consumer acceptance* of PAPs in feed (seven-point multi-item scale). The variable *fear* (seven-point multi-item scale) was adopted from Richins (1997) (see also, among others, Laros & Steenkamp (2005), and the variable *persuasiveness* (seven-point multi-item scale) was in line with Chandran & Menon (2004).

To explore and explain potential consumer variation in levels of fear, persuasiveness, and acceptance we considered the variables that were introduced in the previous section. The food-choice motives *ecological welfare* (reflecting the environmental consciousness of consumers), *healthfulness*, *religion*, expected *taste*, and sensory *appeal* were adopted from the Food Choice Questionnaire (Steptoe, Pollard, & Wardle 1995; Onwezen, Reinders, Verain, & Snoek 2019). Ecological welfare was measured with a seven-point multi-item scale, and all other motives were measured with a seven-point single-item scale. Perceived *personal knowledge* was adopted from Verain (2015). The variables impact of *COVID* on health consciousness, *gender*, and *education* (at least college, or not) were dichotomous variables, and *age* was measured as a continuous variable. In Appendix 1, we summarise the used variables in Table A1.

4.3 Methodological framework

Our methodological framework consisted of four main steps: (i) reliability analyses, (ii) a repeated-measures model analysis, (iii) ANOVA analyses, and (iv) linear regression model analyses. First, we conducted reliability analyses to verify that the constructs *consumer acceptance*, *fear*, *persuasiveness*, *ecological welfare*, and *personal knowledge* were well measured. For these variables we used Cronbach's α values to establish their reliability.

Second, a repeated-measures general linear model for each country was used to analyse the impact of the second information message on fear and perceived persuasiveness, as compared to the first information message. In this model, the within-respondents variation is decomposed into a systematic variation due to the set-up of providing a second message, and a random variation that cannot be explained by the set-up. F-ratio tests are used to determine if the size of the systematic variation is significantly larger than the size

of the random variation. If this is the case, we conclude that the second message has a significant impact on the levels of fear and persuasiveness in comparison to the first message, and we compare the mean scores of the first and second message to obtain the size and sign of this impact. Doing so, we included *message text* (text message 1 vs text message 2) as a within-subjects factor, and *ecological welfare, healthfulness, COVID, personal knowledge, religion, taste, appeal, age, gender, and at least college education* as individual difference covariates in the models.

Third, we considered the potential country differences regarding consumer acceptance, and the fear and persuasiveness after the respondents had read both messages. For each of these three variables, we used an ANOVA model, including country membership as an between-subjects factor, and we used Tukey's honestly significant-difference test to assess pairwise comparisons between the countries. In addition, we studied histograms of the item-question scores related to acceptance, and the fear and persuasiveness after the respondents had read both messages, because these histograms may provide an insightful picture of the variation among consumers across countries.

Fourth, we applied linear regression models to further explore the similarities and dissimilarities among countries and the variation among respondents. These models were applied to explain, for each country, variation in the performance variables of *fear, persuasiveness, and consumer acceptance* by the possible drivers *ecological welfare, healthfulness, COVID, knowledge, religion, taste, appeal, age, gender, and at least college*. The drivers that were measured with a seven-point scale were, per country, mean centred for the ease of interpretation. We used the adjusted R^2 statistic as an indicator for the (un)explained variance in the models.

5 Empirical Results

5.1 Reliability of the multi-item scales

The outcomes of the reliability analysis indicated that all multi-item constructs were reliably measured through the associated item questions. Their Cronbach's α values were as follows: *respondent acceptance*, .97; *fear* after reading the first and second message, .86 and .90, respectively; *persuasiveness* of the first and second message, .86 and .87, respectively; *ecological welfare*, .84; *personal knowledge*, .94.

5.2 The relative impact of the two information messages

For each country, we applied a repeated-measures model to analyse the impact of the second information message on fear and perceived persuasiveness, as compared to the first information message. In the case of fear, we did not find empirical evidence that the second message changed the levels of fear among the respondents in comparison to the first message. In the case of persuasiveness, we found evidence for an impact of the second information message, in comparison to the first one, in the Netherlands ($F(1,999)=7.325$, $p < .01$). In this country, the respondents perceived persuasiveness of the second message as being lower than the first one (4.82 (SD 1.16) versus 4.94 (SD 1.12)), although both rates were, on average, above the midpoint of the scale, which is four on a seven-point scale. In all other countries, there was no significant difference in impact between the two messages on persuasiveness.

5.3 Country differences in respondent acceptance, fear, and persuasiveness

We used an ANOVA model with country membership as between-subjects factor to investigate potential country differences regarding the constructs *fear* after reading the second message, *persuasiveness* of the second message, and *respondent acceptance* of PAPs in feed after reading the second message. The outcomes are presented in Table 1.

The scores for fear were below the midpoint of the seven-point scale. Respondents in Spain had the highest fear level, which was significantly higher than those of respondents in the Netherlands and Poland, who had the lowest fear levels. The scores for persuasiveness were all above the midpoint of the seven-point scale, with only minor and insignificant differences between countries. The respondent acceptance scores at a seven-point scale were below the midpoint of the scale for Germany, Poland, Spain, and the UK. Only in the Netherlands, the average acceptance score was (slightly) above the midpoint of the scale. The acceptance in the Netherlands was higher than in the other countries apart from the UK. The lowest acceptance rate was found in Germany, with a mean score significantly below that in the Netherlands and UK, but not different from Poland and Spain.

Table 1 Scores¹ on fear, persuasiveness, and acceptance (mean and SD) across five countries in a consumer survey to determine the perception of using processed animal proteins (PAPs) in the diets of pigs and poultry

Country	Fear	Persuasiveness	Acceptance
Germany	3.32 (1.55) ^{a,b}	4.76 (1.26) ^a	3.67 (1.63) ^a
The Netherlands	3.12 (1.53) ^a	4.82 (1.16) ^a	4.09 (1.59) ^c
Poland	3.10 (1.63) ^a	4.78 (1.27) ^a	3.85 (1.58) ^{a,b}
Spain	3.38 (1.65) ^b	4.80 (1.32) ^a	3.78 (1.65) ^{a,b}
UK	3.34 (1.67) ^{a,b}	4.84 (1.24) ^a	3.93 (1.62) ^{b,c}

¹ Scores on fear (being afraid, worried, or nervous), persuasiveness (persuasive, informative, strong, and believable), and acceptance reflect respondents' feelings and opinion about the use of PAPs in animal feed after reading two text messages in the survey measured with a seven-point scale from low to high.

^{a,b} In each column, means without common superscript are significantly different following Tukey's HSD test (p value < 0.05).

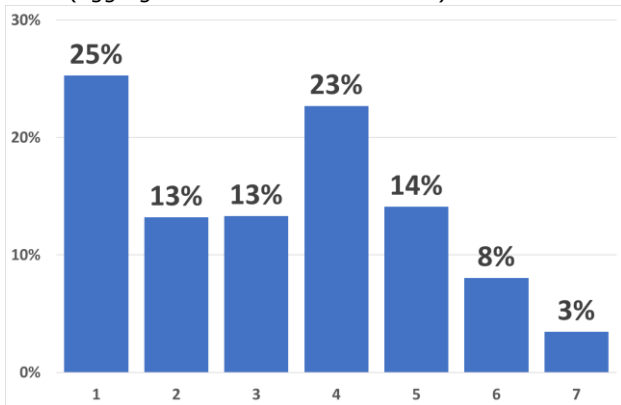
In addition to the ANOVA model, we analysed histograms of the item-question scores for fear, persuasiveness, and acceptance after reading the second message, since these histograms provide a more detailed picture of the existing variation among the respondents. It appeared that the five countries showed very similar patterns of variation regarding the corresponding scores for each of the constructs fear, persuasiveness, and acceptance. We therefore concentrate on the scores aggregated over all five countries, for which Figure 1 shows the histograms, as these overall pictures are consistent with the variation patterns that we found in each of the five countries separately. In Figure 1, the horizontal axis indicates that all item-question scores were measured on a seven-point scale, and the vertical axis shows the number of each of the seven item scores as a percentage of the total number of item-question scores. For example, 5,000 respondents in the survey answered three item questions related to the construct fear, as is indicated in Table A1 in Appendix 1. This gives a total number of 15,000 item-question scores. Out of these scores, a score of one was given 3,789 times, which is, rounded, 25% of 15,000, as is shown in Figure 1.

With respect to fear, the largest percentage of the scores was found at the lowest fear level (one on the seven-point scale, 25%), followed by the midpoint of the scale (23%). A total of 51% of the scores was below the midpoint of the scale, and a total of 25% was above the midpoint of the scale. Regarding persuasiveness, the largest percentage was found for score five on a seven-point scale (26%), followed by the midpoint of the scale (23%). A total of 61% of the scores were above the midpoint of the scale, and 17% of the scores were below the midpoint. For acceptance, the largest percentage of the scores was at the midpoint of the scale (22%), followed by a score of five (19%). Out of the scores 39% was below the midpoint, and 39% was above the midpoint of the scale.

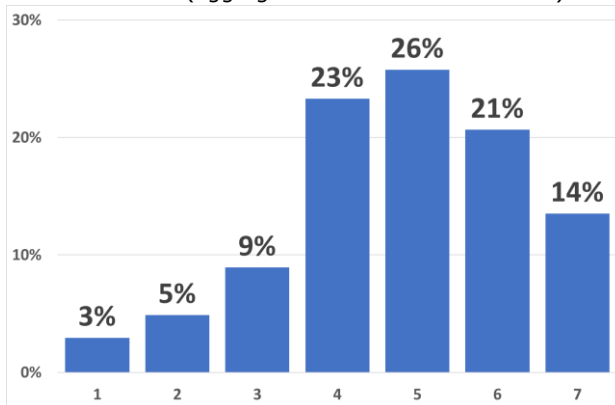
5.4 Explaining variation in fear, persuasiveness, and respondent acceptance

For each country, linear regression models were applied to explain variation in the response variables of fear (Table 2), persuasiveness (Table 3), and acceptance (Table 4), after reading the second message. The rows in these tables provide the regression coefficient for a number of explanatory factors for each country. These coefficients indicate to what extent the respective factors affect the three response variables fear, persuasiveness, and acceptance in addition to the baseline score represented by the intercept.

Fear (aggregated over all five countries)



Persuasiveness (aggregated over all five countries)



Acceptance (aggregated over all five countries)

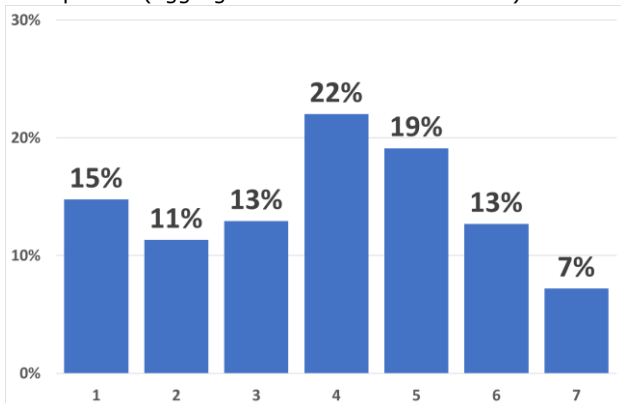


Figure 1 Histogram of item-question scores¹ on fear, persuasiveness, and acceptance in a consumer survey to determine the perception of using processed animal proteins (PAPs) in the diets of pigs and poultry ¹ Scores on fear (being afraid, worried, or nervous), persuasiveness (persuasive, informative, strong, and believable), and acceptance reflect respondents' feelings and opinion about the use of PAPs in animal feed after reading two text messages in the survey measured with a seven-point scale from low to high. In each histogram, the horizontal axis gives the seven-point scale by which the item-question scores were measured. The vertical axis shows the number of each of the scale scores as a percentage of the total number of item-question scores. For fear, persuasiveness, and acceptance, the total number of item-question scores were, respectively, 15,000, 20,000, and 50,000.

Concerns about ecological welfare, COVID impact, knowledge about feeding practices, and religion enhance fear in most of the countries, as shown in Table 2. Consumer interest in taste reduces fear in each of the countries. The impact of age differed among countries. In Germany, the Netherlands, and the UK, but not in Poland and Spain, a higher age reduced levels of fear after reading the second message.

The variation among the respondents that is explained by the factors of interest substantially differed among countries, as indicated by the adjusted R² ranging from .07 (Spain) to .19 (Germany, and the Netherlands). Overall, more than 80% of the variation in response within a country was determined by other factors than those in the model.

Table 2 Influence of a number of drivers on feelings of fear¹ after reading a second text message with emphasis on health and safety aspects in a consumer survey to determine the perception of using processed animal proteins (PAPs) in the diets of pigs and poultry. Values represent regression coefficients (and SD) in a country-specific linear regression model

Drivers ²	Germany	The Netherlands	Poland	Spain	UK
Intercept	3.047 (.200) **	2.921 (.206) **	2.862 (.251) **	3.320 (.228) **	3.222 (.223) **
Ecological welfare	.137 (.042) **	.077 (.041)	.132 (.048) **	.150 (.049) **	.176 (.044) **
Healthfulness	.009 (.042)	-9.402E-05 (.044)	-.070 (.051)	-.125 (.053) *	-.018 (.043)
COVID impact	.257 (.047) **	.180 (.047) **	.146 (.057) **	.117 (.067)	.152 (.054) **
Knowledge	.107 (.032) **	.137 (.032) **	.040 (.035)	.124 (.036) **	.130 (.035) **
Religion	.165 (.024) **	.133 (.023) **	.109 (.031) **	.078 (.029) **	.117 (.028) **
Taste	-.167 (.045) **	-.213 (.052) **	-.185 (.057) **	-.111 (.056) *	-.234 (.053) **
Appeal	-.010 (.036)	.003 (.041)	-.104 (.050) *	-.020 (.053)	-.020 (.046)
Age	-.011 (.004) **	-.017 (.003) **	-.005 (.004)	-.007 (.004)	-.010 (.004) **
Female	-.031 (.046)	.003 (.047)	-.013 (.052)	.005 (.052)	.096 (.051)
Education	-.060 (.046)	-.042 (.047)	-.042 (.055)	.000 (.052)	-.017 (.051)
Adjusted R ²	.19	.19	.08	.07	.17

¹ Scores on fear (being afraid, worried, or nervous) reflect respondents feelings about the use of PAPs in animal feed after reading the second text message in the survey measured with a seven-point scale from low to high.

² Respondent interest or concern for ecological welfare, healthfulness, knowledge, religion, taste, and appeal are measured with a seven-point scale and mean centred. COVID impact, female, and education are dichotomous (0/1) variables. Age is a continuous variable. Intercept is the mean score of fear for male respondents without higher education, and with all other variables at the central level.

** and * indicate a significant effect of the respective factor at $p < 0.01$ and 0.05 , respectively.

The results of the linear regression models with respect to the persuasiveness of the second message are given in Table 3. An increased respondent awareness of knowledge and appeal had a positive impact on the persuasiveness of the second message in Germany, the Netherlands, Poland and the UK. In addition, increased respondent emphasis on taste had a positive effect on persuasiveness of the message among German, Dutch, Polish, and Spanish respondents. The adjusted R² ranges from .06 in Germany to .11 in the Netherlands. As with the fear levels (Table 2), the explanatory power of the models differs across countries.

Table 3 Influence of a number of drivers on perceived persuasiveness¹ of a second text message with emphasis on health and safety aspects, in a consumer survey to determine the perception of using processed animal proteins (PAPs) in the diets of pigs and poultry. Values represent regression coefficients (and SD) in a country-specific linear regression model

Drivers ²	Germany	The Netherlands	Poland	Spain	UK
Intercept	4.798 (.176) **	4.996 (.164) **	4.576 (.194) **	4.678 (.181) **	5.100 (.170) **
Ecological welfare	.064 (.037)	.051 (.033)	.046 (.037)	.051 (.039)	.068 (.034) *
Healthfulness	-.002 (.037)	.080 (.035) *	.020 (.039)	.062 (.042)	.032 (.033)
COVID impact	.081 (.042) *	.065 (.037)	.133 (.044) **	.057 (.054)	.051 (.041)
Knowledge	.090 (.028) **	.125 (.025) **	.079 (.027) **	.055 (.028)	.110 (.027) **
Religion	.005 (.021)	-.057 (.018) **	.046 (.024)	.084 (.023) **	.021 (.022)
Taste	.092 (.040) *	.083 (.041) *	.099 (.044) *	.118 (.045) **	.040 (.040)
Appeal	.114 (.031) **	.088 (.033) **	.141 (.039) **	.079 (.042)	.162 (.035) **
Age	.005 (.003)	.012 (.003) **	.007 (.003) *	1.626E-06 (.003)	-.001 (.003)
Female	-.028 (.041)	-.081 (.037) *	.000 (.040)	.021 (.041)	-.027 (.039)
Education	.009 (.041)	.040 (.037)	-.034 (.043)	-.023 (.041)	.066 (.039)
Adjusted R ²	.06	.11	.09	.07	.10

¹ Scores on persuasiveness of the second text message about the use of PAPs in animal feed in the survey measured with a seven-point scale from low to high.

² Respondent interest or concern for ecological welfare, healthfulness, knowledge, religion, taste, and appeal are measured with a seven-point scale and mean centred. COVID impact, female, and education are dichotomous (0/1) variables. Age is a continuous variable. Intercept is the mean score of fear for male respondents without higher education, and with all other variables at the central level.

** and * indicate a significant effect of the respective factor at $p < 0.01$ and 0.05 , respectively.

The outcomes of the linear regression models with respect to the acceptance of PAPs in feed after reading a second message are given in Table 4. A main result was that respondents with relatively high levels of perceived personal knowledge also had a higher acceptance rate in all countries in the survey. Another main finding was that in all five countries, females showed a lower acceptance rate than male respondents. Emphasis on halal or kosher food showed mixed influences among the five countries. In the Netherlands, it had a negative effect on respondent acceptance, whereas in Poland, Spain, and the UK, this motive had a positive effect on acceptance. The effect of awareness of ecological welfare was only significant in Germany and the Netherlands, with a negative effect on acceptance. The adjusted R² of the regression model ranges from .06 in Poland and Spain to .13 in the UK, so again, the five countries differ regarding the explanatory power of the models.

Table 4 Influence of a number of drivers on acceptance¹ of using slaughter by-products in animal feed after reading two text messages, in a consumer survey to determine the perception of using processed animal proteins (PAPs) in the diets of pigs and poultry. Values represent regression coefficients (and SD) in a country-specific linear regression model

Drivers	Germany	The Netherlands	Poland	Spain	UK
Intercept	3.596 (.223)**	4.183 (.223)**	3.796 (.245)**	3.709 (.229)**	4.133 (.218)**
Ecological welfare	-.257 (.047)**	-.138 (.044)**	-.080(.047)	-.058(.049)	-.041(.043)
Healthfulness	.108 (.047)*	-.007(.048)	-.095(.050)	.032(.053)	-.019(.043)
COVID impact	-.090(.053)	-.079(.050)	.022(.055)	-.087(.068)	-.125 (.053)*
Knowledge	.247 (.036)**	.256 (.034)**	.172 (.035)**	.152 (.036)**	.275 (.034)**
Religion	.045(.027)	-.049 (.025)*	.080 (.030)**	.151 (.029)**	.069 (.028)*
Taste	-.043(.051)	.085(.056)	.098(.056)	.017(.056)	-.004(.052)
Appeal	.063(.040)	.078(.044)	.049(.049)	.056(.053)	.050(.045)
Age	-.003(.004)	.014 (.004)**	.013 (.004)**	-.001(.004)	.006(.004)
Female	-.140 (.052)**	-.255 (.051)**	-.107 (.050)*	-.032(.052)	-.195 (.050)**
Education	-.018(.052)	.020(.050)	-.011(.054)	-.028(.052)	.040(.050)
Adjusted R ²	.09	.12	.06	.06	.13

¹ Scores on acceptance of the use of slaughter by-products in animal feed in the survey measured with a seven-point scale from low to high.

² Respondent interest or concern for ecological welfare, healthfulness, knowledge, religion, taste, and appeal are measured with a seven-point scale and mean centred. COVID impact, female, and education are dichotomous (0/1) variables. Age is a continuous variable. Intercept is the mean score of fear for male respondents without higher education, and with all other variables at the central level.

** and * indicate a significant effect of the respective factor at $p < 0.01$ and 0.05 , respectively.

6 Discussion

Overall, we found that a substantial number of respondents have a neutral opinion regarding the acceptance of PAPs in feed of food producing animals. When we consider the acceptance scores, aggregated over all countries, we found that 22% of these scores were at the midpoint of the scale. In addition, we found substantial variation around the midpoint among the respondents. Again, when considering the acceptance scores, aggregated over all countries, 39% of the scores were below, but also 39% of the scores were above the midpoint of the scale. This pattern of variation among respondents that we found at the aggregated level was consistent at country level: each of the five countries showed a very similar variation among respondents.

The empirical findings further showed that the second message did not change the level of perceived fear among the respondents, and that the level of persuasiveness of the second message was similar to the first one in four of the five countries, and lower in the fifth country (the Netherlands). For the strategic decision making it is relevant to know that the second message was ineffective in lowering fear levels or increasing information persuasiveness among consumers who already read the first message. In addition, it may be of interest to consider if the order in which information about PAPs is offered to consumers has an impact on the eventual levels of fear and persuasiveness. We consider this as an interesting topic for future research.

When comparing the countries in our empirical analysis, we found that the average levels of fear after reading the second message, i.e., the situation in which the consumers had read all offered information about PAPs in feed, differed across these countries. We also observed substantial variation within each of the countries. Linear regression models were applied to investigate if a set of drivers of consumer behaviour could explain the existing variation among consumers within a country. These drivers appeared to have higher explanatory power in Germany, the Netherlands, and the UK as compared to Poland and Spain. This suggests that the influence of impactful drivers of consumers' levels of fear may be country specific. In general, consumers with relatively high levels of fear were driven by the following factors. In comparison to others, these consumers were more ecology conscious, they were more health oriented (enhanced by the COVID pandemic), they perceived to have knowledge about feeding practices, and they more strongly followed religious principles when consuming animal products. In summary, these empirical findings suggest the strategic relevance of country-specific communication campaigns to reduce the level of fear regarding PAPs in feed among consumers. In such a strategy, it is of interest to know if consumer groups with relative high levels of fear are identifiable and accessible so that they can be targeted by a communication campaign. We also regard this as an interesting topic for further research.

The empirical outcomes regarding the persuasiveness of the two offered messages showed that, on average, consumers in all five countries considered the offered messages persuading, but also that there was substantial variation among consumers within each country. We applied a linear regression model to explain the variation among consumers in the perceived persuasiveness of the second message. We found that German, Dutch, Polish, and British consumers with a higher level of perceived knowledge about feeding practices, and a higher score on the importance of tasty animal products, indicated a higher level of persuasiveness of the second message. In addition, in Germany, the Netherlands, Poland, and Spain, consumers with higher scores on the importance of pleasurable sensations of animal products showed higher scores with respect to the persuasiveness of the second message in comparison to others. In summary, this empirical evidence again suggests the potential benefits of country-specific communication campaigns that consider target groups within each country.

The main results of the linear models used to explain variation among consumers in accepting PAPs in animal feed after having read the two messages were as follows. In comparison to others, consumers with higher levels of perceived knowledge of the way in which animals are nowadays fed also had higher acceptance rates of PAPs in feed. This suggest that increasing the level of knowledge among these consumers may benefit a higher acceptance rate. Another empirical finding was that female consumers had a lower

acceptance rate in all countries in the survey. This raises the question what specific aspects of PAPs in feed drives female consumers to their acceptance rates. We consider this as a relevant topic for future research. Religion as a driver of acceptance gave mixed results across the countries. In the Netherlands, the impact of religion, i.e. halal or kosher consumption, on acceptance was negative, which was expected based on literature discussed above, whereas in Poland, Spain, and the UK it was positive. An explanation for this positive effect in these countries may be that these consumers accept PAPs as a feeding practice, as long as they can keep purchasing their desired animal products in the way they are used to, for example, from halal or kosher butchers. In our study, we hypothesised that, in general, consumers who were more ecological conscious in their decision making than others would be more willing to accept PAPs in feed if they were informed about the benefits of this feeding practice for a more sustainable food system. In contrast to our expectation, however, we found that German and Dutch respondents showed lower acceptance levels of PAPs in feed, and a non-significant effect in the other three countries. This suggests that, for German and Dutch consumers, the perceived negative consequences of PAPs in feed dominate the positive benefits for the eco-system. For communication campaigns that use the argument of a better eco-system it is of vital relevance to understand what these dominating factors are. Again, we see this as an important topic for future research.

Not all observed variation among consumers and among countries could be explained by the variables that we considered in our study. The linear models for fear, persuasiveness, and acceptance showed R^2 values that ranged from .06 to .19. So, much of the variation is unexplained. Two factors that have been found of relevance regarding pro-environmental behaviour changes among consumers are habit formation and social influence. These factors were not considered in our study, and, therefore, we see them as potentially fruitful additions to our set of explanatory variables. Indeed, they may help to further explain the variation among consumers.

In summary, our empirical study revealed a number of drivers that should be taken into account when targeting specific consumer groups in specific countries with messages about the practice of PAPs in feed of food producing animals.

7 Conclusion

We performed an empirical study on the potential consumer response to the use of PAPs in diets for monogastric farm animals. We explored the potential similarities and dissimilarities in the acceptance levels of consumers in Germany, the Netherlands, Poland, Spain, and the UK. We measured the persuasiveness of two messages that contained fact-based information about PAPs from a consumer perspective. In addition, the potential feelings of fear among consumers after reading the messages was determined, and, finally, the acceptance levels of consumers were derived.

We not only found consumer differences among countries, but also consumer variation within countries. Our empirical findings may help to allocate resources in communication campaigns that target specific consumer groups in specific countries. This is not only relevant for the chain actors that aim to stimulate a higher valorisation of scarce ingredients in feed and food, but also for other parties involved, including NGOs and public policy makers, who inform consumers about food-safety issues. Thus, in summary, our study may benefit food-chain actors and public policy makers who want to communicate with the consuming audience about PAPs in an effective way.

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Appendix 1 The text messages and the survey questions

The first message reads:

Information about animal proteins in animal feed

Pigs and chicken are omnivores by nature, which means they eat plants and other animals. In nature, for example, pigs eat small animals in combination with carrots, seeds and nuts. In nature, chicken eat plants, fruit and especially insects, worms, and sometimes other small animals.

Although chicken and pigs are not vegetarian by nature, on EU farms they only receive plant-based feed nowadays. Feeding animal proteins is not allowed. Besides unnatural, feeding pigs and chicken exclusively with only plant-based feed is not circular. Feeding pigs and chicken with animal proteins made of slaughter by-products (from other animal species) would contribute to the efficiency of the animal production system. In addition, it is more sustainable to feed animals with animal proteins than exclusively vegetarian diets. This is because it allows to reduce the import and use of plant-based feed ingredients like soybeans.

Recently, an improved animal feed ingredient has been developed based on animal protein, to meet all food safety standards. How this ingredient is processed is explained in the next section.

These animal proteins are made of the carcasses and other parts of slaughtered animals, that are fit for human consumption but not preferred by consumers. When slaughtering animals, everything is first processed for consumer use. However, certain parts of the animal are not suitable for human consumption, such as feathers and bones. Other parts are hardly bought by consumers, such as blood and intestines. Nevertheless, these parts contain valuable nutrients, such as proteins, fats and minerals.

These parts that consumers do not eat are first properly heated and dried to ensure safety for animals and consumers. These are then mixed with plant-based ingredients into feed for pigs and chicken. This allows animals to eat vegetable and animal proteins in a healthy and more sustainable way.

The second message reads:

Livestock receive animal proteins for feed

In 2001, feeding animal proteins to all farm animals was banned in the EU due to BSE (mad cow disease). Although BSE did not affect pigs and chicken, all animal proteins used in feed for food were banned, because measuring methods couldn't identify the source of animal proteins, and therefore control institutions couldn't guarantee whether animal proteins contained proteins originating from cows. Since this ban, all farm animals have been fed with plant-based diets, despite the fact that pigs and chicken are omnivores.

Because of these regulations, since 2001 by-products from slaughterhouses have been processed, cooked and used for non-food applications (e.g. fertilisers and pet food). Using these by-products or animal proteins for animal feed would be much better for the environment and the animal.

That is why feed companies and the European Parliament have proposed that animal proteins should be reused as an animal feed ingredient for chicken and pigs.

According to leading animal feed companies, these new animal proteins are good and healthy proteins. Today's animal feed proteins only come from healthy slaughtered animals. In addition, they are produced safely (high temperature) without risks to human health and due to improved detection technology nowadays animal proteins in feed can be efficiently analyzed to trace back from which animal they originate.

Therefore it is completely safe to feed pigs and chicken with animal based proteins.

Table A1 The survey questions.

Variables	Question in Survey	Category
Consumer acceptance of PAPs (7-points scale)	How acceptable do you think it is if (very unacceptable – very acceptable): (1) Chicken are fed with slaughter by-products from pigs; (2) Chicken are fed with slaughter by-products from ruminants (cows, sheep); (3) Chicken are fed with slaughter by-products from fish; (4) Pigs are fed with slaughter by-products from chicken; (5) Pigs are fed with slaughter by-products from ruminants (cows, sheep); (6) Pigs are fed with fish slaughter by-products; (7) Farmed fish are fed with chicken slaughter by-products; (8) Farmed fish are fed with slaughter by-products from pigs; (9) Farmed fish are fed with slaughter by-products from ruminants (cows, sheep); (10) Farmed fish are fed with fish slaughter by-products	Performance
Fear (7-points scale)	To what extent did you experience the following feelings while reading the message? (not at all – very strongly): (1) scared/afraid; (2) worried; (3) nervous	Affection
Persuasiveness of the message goal (7-points scale)	After reading the message, what did you think of the content? (1) (unpersuasive – persuasive); (2) (uninformative – informative); (3) (weak – strong); (4) (unbelievable – believable)	Cognition
Ecological welfare motive (7-points scale)	How important are each of the following aspects when choosing food on an average day? (very unimportant – very important): (1) environmental friendly; (2) animal friendly; (3) fairly traded	Individual self
Healthfulness motive (7-points scale)	How important is the following aspect when choosing food on an average day? (very unimportant – very important): healthy	Individual self
Appeal motive (7-points scale)	How important is the following aspect when choosing food on an average day? (very unimportant – very important): provides me with pleasurable sensations (e.g. texture, appearance and smell)	Individual self
Taste motive (7-points scale)	How important is the following aspect when choosing food on an average day? (very unimportant – very important): tasty	Individual self
Religion motive (7-points scale)	How important is the following aspect when choosing food on an average day? (very unimportant – very important): halal or kosher	Individual self
(Perceived personal) Knowledge (7-points scale)	Would you say that you (totally disagree – totally agree): (1) know more about feed for pigs and chicken than other people do; (2) have a lot of knowledge about how animal feed is made; (3) have a lot of knowledge about the ingredients of animal feed; (4) know that by-products from the food sector are often used in animal feed; (5) know that by-products of human food, suitable for animal consumption, is often used in animal feed	Cognition
COVID impact (2-points scale)	Do you think you are more health oriented now, than before the COVID pandemic?	Individual self
Demographics	Age, gender, at least college education	Individual Self

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The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,700 employees (7,000 fte), 2,500 PhD and EngD candidates, 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

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