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Food safety perceptions and risk-mitigation strategies: spillover effects of African swine fever on consumer meat choices in Vietnam

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Abstract

Purpose – This study examines how animal disease outbreaks influence consumer behaviour beyond directly affected species. It investigates food safety perceptions and risk-mitigation strategies during the 2019 African Swine Fever outbreak, focusing on spillover effects on goat meat consumption in Vietnam.

Design/methodology/approach – A cross-sectional survey of 470 goat meat consumers in ten provinces of Vietnam was analysed using multinomial logistic regression to identify socio-demographic, perceptual and attitudinal drivers of risk-mitigation strategies.

Findings – While most consumers did not alter goat meat consumption, 17% changed their behaviour due to perceived spillover risks. Among them, 12.5% became more cautious, 4.2% reduced consumption and 1.5% increased it. Urban consumers were more likely to adopt cautious behaviours. Spending a larger share of income on food and viewing goat meat as convenient increased the likelihood of reducing consumption, while familiarity with goat meat and perceiving it as natural reduced this likelihood.

Research limitations/implications – There is a need for clear communication and trust-building to avoid unwarranted demand shifts across unrelated meats. Strengthening safety assurance, certification and consumer education is critical to sustaining confidence and market stability. Future studies could examine cross-country responses to assess spillover effects globally.

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Originality/value – This is the first study linking food safety perceptions with risk-mitigation strategies and highlighting spillover effects of disease outbreaks on unrelated meats. It advances the understanding of consumer behaviour in crises and provides insights for policy and industry.

Keywords Food safety, Consumer behaviour, Risk mitigation, Spillover effects, Meat consumption, Vietnam

Paper type Research article

1. Introduction

Intensive animal production systems have increased public concerns about production practices, animal welfare, sustainability and the associated risk of disease outbreaks, with implications for both human health and market stability (Clark *et al.*, 2017; Acosta *et al.*, 2023; Nguyen *et al.*, 2026). Animal diseases pose significant threats to the meat industry and the broader economy, affecting producers, processors, retailers, consumers at local, national and international levels (Pritchett *et al.*, 2005; Acosta *et al.*, 2023; Chang, 2025). These outbreaks can cause food-related hazards by increasing food safety risks, disrupt value chains, affect international trade and influence food prices, income distribution, food access and dietary patterns (Verbeke and Viaene, 2000; Acosta *et al.*, 2020; Savary *et al.*, 2020). The economic consequences of foodborne disease scares are well documented, with evidence showing negative impacts on consumer demand and prices across supply chain actors, as reported by Lloyd *et al.* (2001), Marsh *et al.* (2004), Clark *et al.* (2019) and Acosta *et al.* (2023). In this scenario, consumers adopt different strategies, with some of them reducing and even avoiding completely the consumption of some products to mitigate perceived food safety risks (Smed and Jensen, 2005; De Backer and Hudders, 2014), while others underestimate or disregard the risk to contract a food-borne illness entirely (Redmond and Griffith, 2004; Rieger *et al.*, 2017). To address asymmetries of information and rebuild consumer trust, several countries have implemented food safety policies and regulations to increase traceability and quality assurance (Verbeke and Viaene, 2000; Han and Choi, 2018; Akinwehinmi *et al.*, 2022; Morales *et al.*, 2024; Chang *et al.*, 2025). In response to growing concerns, many countries have introduced labelling and certification schemes to guarantee food safety and animal welfare. These strategies have proven successful, as they have allowed the development of demand-driven guaranteed products, based on consumers' willingness to pay premiums for safer meat items (Mørkbak *et al.*, 2010; Clark *et al.*, 2019).

Consistent with these concerns, previous research has shown that meat recalls and adverse media coverage about food contamination and animal disease outbreaks can significantly influence consumer demand patterns, which may include reduced consumption, increased caution or substitution with other meats or non-meat alternative items (Marsh *et al.*, 2004; Wang and de Beville, 2017). These behaviours depend on perceived health risk, familiarity with the product and beliefs about the substitutability between meat products (Redmond and Griffith, 2004; Ibsen *et al.*, 2019; Teixeira and Rodrigues, 2021). Some consumers could consider different meats as not related products and do not vary their consumption, increase the consumption of one type of meat or generalise the risk to other meat products not directly affected, leading to spillover effects by reducing their consumption of all meat products and substitute them for other products (Smed and Jensen, 2005; Hoek *et al.*, 2011; De Backer and Hudders, 2014; Ibsen *et al.*, 2019; Acosta *et al.*, 2023).

Understanding consumer responses to animal disease outbreaks requires distinguishing between actual biological risk and perceived food-safety risk. African Swine Fever (ASF) is a non-zoonotic livestock disease that severely affects pigs but, in contrast to zoonotic diseases, it does not infect humans (Ceruti *et al.*, 2025). However, even in the absence of direct human health risk, such outbreaks may undermine consumer confidence, disrupt supply chains, affect food prices and provoke shifts in dietary choices and demand for alternative meats or non-meat alternative products. In the 2019 ASF outbreak in Vietnam, sharp pork shortages and price surges encouraged some consumers to seek alternative meats, including goat. Simultaneously, extensive media coverage of diseased pigs generated generalised food-safety concerns,

prompting some consumers to infer risk across meat categories. Goat meat therefore provides a relevant behavioural test case for understanding spillover effects: changes in consumer behaviour toward an unaffected product resulting from a disease outbreak in another species.

This study examines how Vietnamese meat consumers responded to the 2019 ASF outbreak by analysing the variables that shape risk-mitigation strategies under heightened food safety perceptions. While prior research has examined consumer trust, government communication and the credibility of information during food safety crises, little attention has been given to how perceived risks spill over to unrelated meat products. In our conceptual framework, substitution appears in two distinct risk-mitigation strategies: (1) substituting the affected meat with another type of meat, and (2) substituting meat with a non-meat alternative. These are only two alternative behavioural responses that consumers may adopt when confronted with food safety concerns, which also include reduced consumption and increased caution. Thus, the focus of this study extends beyond substitution to consider the full range of behavioural responses consumers adopt when interpreting food-safety signals. To the best of our knowledge, this is the first empirical study that assesses the spillover effects of a non-zoonotic animal disease outbreak on consumer behaviour toward an unrelated meat product. The findings offer valuable insights for both policymakers and the food industry on how to communication strategies can be designed to sustain consumer confidence and minimise unnecessary disruptions during future food-safety crises.

The rest of this article is organised as follow. Section 2 describes how consumers assess meat quality and safety, followed by a conceptual framework for different risk-mitigation strategies. Section 3 presents the data and econometric modelling used in this study. Section 4 reports the empirical results of the data analysis, followed by a discussion of findings and implications for industry and policy in Section 5.

2. Food quality, safety perceptions and risk-mitigation strategies

Consumer preferences for fresh food items are influenced by a combination of external influences, product features and consumer characteristics (Grunert *et al.*, 2004; Froehlich *et al.*, 2009; Morales *et al.*, 2024). These factors shape consumer trust in food products, their perceived food safety risk and ultimately their expectations of meat quality (McFadden, 2001; Redmond and Griffith, 2004; Jaafar *et al.*, 2012; Morales *et al.*, 2013; Rieger *et al.*, 2017; Nguyen *et al.*, 2019; Yang and Baker, 2024). Although food quality and food safety are different concepts, consumers often use quality cues, such as colour, freshness and origin, to infer whether a product is safe to eat. For this reason, some of the literature discussed in this section relates to quality perceptions, while other sources focus specifically on food safety and risk. In this study, however, the primary emphasis is on food safety perceptions and the ways these perceptions shape consumer risk-mitigation strategies. Grunert *et al.* (2004) introduced the Total Food Quality Model (TFQM), which incorporates several food product attributes, including visual appearance, convenience and non-observable characteristics, such as production process, origin and their potential impact on health and nutrition. According to Grunert *et al.* (2004), and Aboah and Lees (2020), consumers in-store rely on intrinsic and extrinsic quality cues to predict the quality of meat products and make purchase decisions. Intrinsic quality cues include colour, cut marbling and fat content, while extrinsic quality cues comprise price, origin, quality labels/certification, packaging, animal welfare and seller.

Perceptions about food safety risks are particularly important due to their economic and social implications for the food industry and the community (Bolek, 2020). For instance, Ishra *et al.* (2022) found that consumers who buy at supermarkets in urban areas of Bangladesh are more concerned about food safety. Therefore, consumers attitudes and behaviours vary widely in response to negative food safety news that could stimulate them to vary their purchase behaviour when there is an increase in the perceived risk related to food safety issues (Marsh *et al.*, 2004; Smed and Jensen, 2005; Kennedy *et al.*, 2008). Hence, risk perceptions, attitudes and risk-mitigation responses to a food scandal vary greatly among different consumer

segments, with some consumers showing no reaction to media coverage of food scandals, while others exhibit a reduction in their demand (Rieger *et al.*, 2017; Chang, 2025). For this reason, some consumers might not change their consumption behaviour when there is negative news about food safety, while others could reduce or even avoid completely the consumption of some products to reduce their food safety risk perception (Smed and Jensen, 2005; De Backer and Hudders, 2014).

Consumer responses to food safety scandals can also be examined through the lens of risk communication and consumer trust theories. The social amplification of risk framework developed by Kasperson *et al.* (1988) suggests that media coverage and information channels can amplify perceived risks, influencing consumer reactions well beyond the actual hazard. At the same time, source credibility and institutional trust play are critical in determining whether consumers accept reassurances from government agencies, industry or third-party certifiers (Yang and Baker, 2024). These perspectives highlight that spillover effects arise not only from product cues or individual risk perceptions, but also from how effectively risk information is communicated and by the degree of confidence consumers place in food system actors. These insights highlight the need to examine not only the behavioural strategies consumers adopt but also the institutional context that shapes them.

In this framework, substitution emerges in two distinct forms: substituting the affected meat with another type of meat or substituting it with a non-meat alternative. These represent two of the four risk-mitigation strategies consumers may adopt when faced with food safety concerns, alongside maintaining their usual behaviour or adopting more cautious purchasing practices. This distinction clarifies how spillover effects can manifest not only through substitution, but also through caution or reduced consumption of an unrelated meat product. Building on these constructs, this study assumes that consumers use intrinsic and extrinsic quality cues to infer meat safety influenced by their perceived risk. Higher perceived risk leads consumers to adopt one of several risk-mitigation strategies, including reducing consumption, being more careful or seeking substitutes. These behavioural pathways are summarised in Figure 1 and provide the conceptual basis for the empirical model. To reduce the perceived

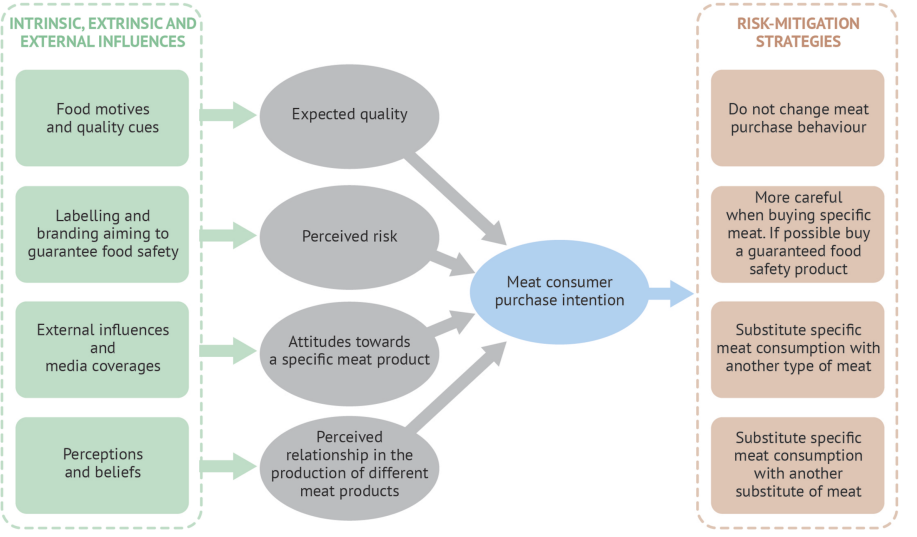

Figure 1. Meat purchase intention and risk-mitigation strategies under food safety risk. *Source*: Developed by the authors based on the works of McFadden (2001), Grunert *et al.* (2004), Jaafar *et al.* (2012), Nguyen *et al.* (2019), and Morales *et al.* (2024)

food safety risk among consumers, the meat industry in several countries has introduced labelled and certified safety-guaranteed products as a form of risk-mitigation strategy, often with positive outcomes (Mørkbak *et al.*, 2010; Clark *et al.*, 2019). As illustrated in Figure 1, consumer responses to food safety risks vary, some of them might not change their meat purchase behaviour, while others may adopt more cautious purchasing habits, such as choosing certified safe products, switching to other meat types or even substituting meat altogether. These choices depend on consumers' perceived risk, their perceived relationship between different meat products and their preferred risk-mitigation strategy (Hoek *et al.*, 2011; Han and Choi, 2018; Dang and Tran, 2020; Majcher, 2025). These strategies are influenced by product cues, trust, risk perception and perceived relationships between meat types.

This study is grounded in the economic theory of consumer choice (McFadden, 2001) and in the TFQM, which conceptualises how consumers use intrinsic and extrinsic cues to form expectations about food quality and safety (Grunert *et al.*, 2004). Within the TFQM, perceived quality, including safety, is shaped by prior beliefs, information signals and trust in market actors, all of which influence the utility derived from different meat options. Building on this framework, food safety cues originating from an animal disease outbreak can reshape expected quality, increase perceived risk and alter attitudes toward specific meats, thereby affecting purchase intentions. Drawing on Jaafar *et al.* (2012), Nguyen *et al.* (2019) and Morales *et al.* (2024), our theoretical framework presented in Figure 1 links quality expectations, perceived risk and beliefs about cross-species associations to discrete behavioural responses such as avoidance, increased caution or substitution toward other meat or non-meat alternatives. This theoretical foundation directly informs the empirical strategy that consumer behaviour is modelled as a discrete choice problem in which perceived risk shifts the relative utilities of available options, generating observable adjustments in meat consumption. In this study, we extend this framework by examining how animal disease outbreaks associated with a specific meat can influence consumer behaviour toward other meat products. We focus on the spillover effects driven by perceived associations between different meat types and the risk-mitigation strategies consumers adopt to manage food safety concerns. The following section outlines the data collection process, and the empirical methods used to examine these relationships.

3. Materials and methods

3.1 Survey data

This study draws on original data collected between April and October 2022 as part of a cross-sectional survey in Vietnam. Prior to full deployment, the survey instrument was piloted with 20 goat meat consumers to assess clarity, sequencing and response categories. Minor refinements were made to wording and the ordering of items to improve comprehension and flow. The final version was then implemented across all study locations. The study received approval from the Human Research Ethics Committee of the University of New England (Approval HE20-208, granted 15 December 2020). All respondents provided informed consent before participating. Meat consumers were interviewed on-site in a face-to-face mode in restaurants across ten provinces in Vietnam, including Dien Bien, Son La, Hoa Binh, Ha Noi, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue and Da Nang, which were selected for their relevance to goat meat production and consumption (highlighted in Figure 2).

Respondents were randomly selected among those who eat goat meat, are over 18 years old and voluntarily consent to participate in this study. A total of 470 completed questionnaires of goat meat consumers were used in the data analysis, with a sampling error of 5 and 95% confidence (Rea and Parker, 2014). Goat meat in Vietnam is mostly consumed in restaurants, with very limited retail purchases or home killing for preparation. Accordingly, all respondents in our sample were interviewed at restaurants, resulting in small variation in place of purchase. In this context, this variable provides limited explanatory value and was not included as a control in the econometric analysis.

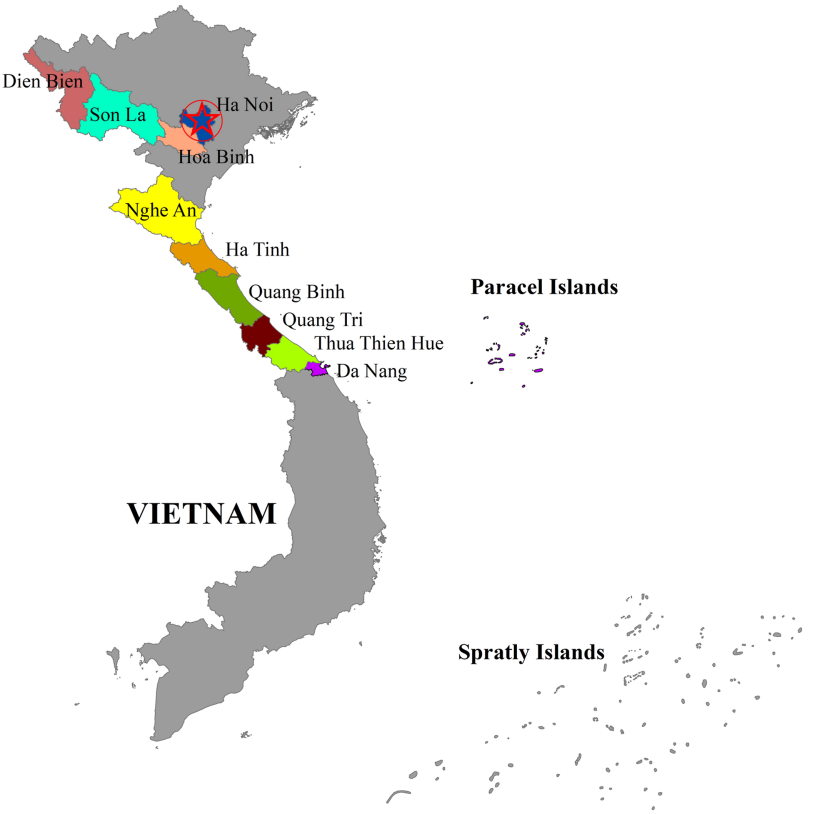

Figure 2. Map of consumer survey locations in Vietnam

The survey questionnaire was structured into nine sections, covering respondent's socio-demographic characteristics, perceptions/attitudes about different meats, meat consumption preferences and purchase habits, food motives, propensity to buy and willingness to pay for goat meat. To assess behavioural responses to the 2019 ASF outbreak, respondents were asked: "When the African Swine Fever increased pork price significantly due to its negative effects on production, how did your goat meat consumption vary?". Their answers were captured through a set of predefined response options, which were subsequently grouped into five distinct risk-mitigation strategies. These response categories, summarised in Table 1, reflect the diverse ways in which consumers may perceive and respond to spillover food safety risks.

The four behavioural responses shown in Figure 1 are represented through the survey responses in Table 1. The predefined options were grouped into these risk-mitigation strategy categories to align empirical measurement with the conceptual model. The survey question used the increase in pork price caused by ASF as a salient market signal of the severity of the outbreak and stricter safety controls implemented in the pork industry. Consumers may interpret such price movements as indicators of broader safety concerns. Accordingly, the behavioural responses reflect consumers' perceived safety risks rather than price sensitivity alone. Because the survey was conducted three years after the 2019 ASF outbreak, respondents had to recall their past behaviour, which introduces the potential for recall bias, particularly if memories were influenced by more recent experiences or general attitudes toward food safety.

Table 1. Strategies of risk-mitigation based on pre-defined response options of the survey to variations on goat meat consumption under African Swine Fever (ASF)

Question: "When the African Swine fever increased pork price significantly due to its negative effects on production, how did your goat meat consumption vary?"	
Strategy	Response option
Strategy 1: Reduced goat meat consumption	I stopped eating goat meat
	I consumed/bought less goat meat than the normal amount
Strategy 2: More careful when buying goat meat	I learn more about goat disease so that I could adjust the goat meat consumption correctly
	I only buy/eat goat meat when I could make sure the goat meat is from non-disease goats
Strategy 3: No change in goat meat consumption	I continued to buy goat meat as normal
Strategy 4: Increased in goat meat consumption	I consumed/bought more goat meat because of the lower price
Strategy 5: Other	Other

Although recall-based questions are commonly used in consumer behaviour research, this limitation should be considered when interpreting the results. To analyse underlying consumer motives related to goat meat, 33 belief items were measured using a five-point Likert scale and grouped into nine food motive factors derived from Steptoe *et al*. (1995) and Carrillo *et al*. (2011). These factors represent widely used dimensions of food choice motives in the literature. The results of the confirmatory factor analysis (in Table 2) indicate that most standardized factors loadings exceed 0.5, demonstrating strong relationships between the items and their corresponding constructs despite the diversity of underlying variables. Furthermore, most extracted variance measures are also above the 0.5 threshold, suggesting that the factors explain a substantial proportion of the variability in the observed variables (Hair *et al*., 2018), while the internal consistency across factors is generally high, with Cronbach's α values above 0.417. In addition, we tested the discriminant validity using the Fornell-Larcker criterion (Fornell and Larcker, 1981).

Although these nine food motive factors are not food safety constructs in themselves, they play a central role in the decision-making pathway illustrated in Figure 1. Even though a Cronbach's α value of 0.70 is often recommended for established psychometric scales, lower thresholds have been accepted in exploratory applications and in heterogeneous consumer contexts where belief constructs are formative rather than reflective (Hair *et al*., 2018). In this study, food motive factors are not treated as latent traits but as explanatory belief dimensions that shape perceived risk and behavioural responses. Accordingly, factors with α values close to or above 0.50 are retained, but their effects are interpreted cautiously. These motives shape expected product quality, which in turn influences perceived risk, attitudes toward specific meats and perceived relationships between meat types. By contributing to baseline trust in goat meat, they also affect how consumers interpret a food safety signal originating from another species. During an animal disease outbreak, these underlying perceptions help determine which risk-mitigation strategy consumers adopt. Their inclusion in the empirical model therefore reflects their role as antecedents in the broader behavioural process through which food safety perceptions translate into specific responses. This diversity of behavioural responses highlights the importance of understanding how consumers perceive relationships between different meat types and the risk-mitigation strategies they adopt under uncertainty. In the following sections, we examine the factors driving these responses, using a multinomial logit model to explore how socio-demographics, familiarity, food attitudes and risk perceptions influence meat consumption behaviour during disease outbreaks.

Table 2. Confirmatory factor analysis results for nine goat meat food motive factors in Vietnam

Beliefs about goat meat and factors	Mean	SD	Standardised factor loading	Extracted variance	Cronbach's α composite reliability
GMF1: Health				0.593	0.642
Goat meat contains a lot of vitamins and minerals	3.845	0.772	0.460		
Goat meat keeps me healthy	3.968	0.731	0.770		
Goat meat is nutritious	4.270	0.585	0.650		
GMF2: Mood				0.591	0.764
Goat meat helps me to relax	3.232	0.844	0.720		
Goat meat makes me feel good	4.330	0.616	0.420		
Goat meat helps me to cope with stress	2.964	0.663	0.810		
Goat meat cheers me up	3.077	0.777	0.730		
GMF3: Convenience				0.752	0.835
Goat meat is easy to prepare	3.309	1.071	0.940		
Goat meat can be cooked very simply	3.217	1.055	0.880		
Goat meat takes a short time to prepare	3.211	0.854	0.570		
GMF4: Sensory appeal				0.493	0.736
Goat meat looks nice	3.789	0.679	0.590		
Goat meat tastes good	4.323	0.552	0.590		
Goat meat has a pleasant texture	3.600	0.664	0.510		
Goat meat smells nice	3.830	0.862	0.600		
Eating goat meat gives me pleasure	3.500	0.786	0.730		
GMF5: Natural content				0.785	0.907
Goat meat contains no added chemicals	3.823	0.736	0.880		
Goat meat contains no artificial ingredients	3.781	0.734	0.920		
Goat meat contains no additives	3.740	0.725	0.910		
Goat meat contains natural ingredients	3.957	0.723	0.660		
GMF6: Price				0.474	0.417
Goat meat is not expensive	3.049	1.018	0.370		
Goat meat is cheap	2.164	0.731	0.860		
Goat meat represents an important part of my expenditure on food	2.881	0.830	0.230		
GMF7: Weight control				0.591	0.746
Goat meat is low in calories	3.004	0.671	0.550		
Goat meat helps me to control weight	2.851	0.678	0.890		
Goat meat helps me to lose some weight	2.698	0.665	0.840		
Goat meat is low in fat	3.419	0.834	0.380		
GMF8: Familiarity				0.684	0.763
Goat meat is what I usually eat	2.979	0.979	0.670		
Goat meat is an important component of my diet	2.666	0.874	0.630		
Goat meat is regularly consumed in my household	2.602	0.840	0.890		
GMF9: Ethical concern				0.509	0.757
Goat meat comes from farms and other countries I approve of	3.562	0.709	0.480		
I generally buy goat meat considering its origin	3.581	0.827	0.560		
I generally buy goat meat considering its processing method	3.328	0.753	0.580		
I generally buy goat meat considering the animal welfare	2.923	0.752	0.780		
I generally buy goat meat produced in an environmentally friendly way	3.368	0.861	0.690		

Note(s): *GMF* stands for goat meat factor

3.2 Modelling risk-mitigation strategies

Consumers choose products with attributes that maximise their utility, subject to their budget restrictions (Lancaster, 1966; Varian, 1992). In this study, the utility derived from a given risk-mitigation strategy is influenced by consumers' socio-demographic and attitudinal characteristics, as well as their perceptions of product attributes and food safety risk (Carlsson *et al.*, 2003; Tonsor *et al.*, 2005). Therefore, the effect of these variables on the utility perceived by an individual consumer can be summarised as follows:

$$U_{ij}(a) = \alpha + \beta A_i + \gamma C_i + \varepsilon_{ij} \tag{1}$$

where $U_{ij}(a)$ is the consumer i utility in the space of product attributes for a risk-mitigation strategy j; α is a constant of consumer's preferences; A_i is a matrix of perceptions of consumer i about meat product attributes; β is a vector of the influences of the attributes and attitudes of meat products on the utility perceived by consumer I; C_i is a matrix of the socio-demographic and attitudinal characteristics of the individual consumer i and γ is a vector of the influences of these socio-demographic and attitudinal characteristics on the utility perceived by consumer i. Finally, ε_{ij} is a stochastic error component. Following discrete choice theory, if the respondent i chooses the risk-mitigation strategy j, then the person perceives a higher utility of it compared with the alternative strategy k (where $k \neq j$), as specified by Greene (2017):

$$Prob\left(U_{ij} > U_{ik}\right) for\ all\ other\ k \neq j \tag{2}$$

Given the categorical nature of each risk-mitigation strategy outcome j and the assumption of non-constant marginal effects, a multinomial logistic regression model is appropriate for estimating the probability that a consumer respondent i selects a given risk-mitigation strategy over alternatives (Long and Freese, 2014; Greene, 2017). Figure 1 outlines the conceptual relationships underlying consumer responses to food safety risks affecting another meat product. It highlights the influence of expected quality, perceived risk, attitudes towards a specific meat product and perceived relationship in the production of different meat products on four risk-mitigation strategies: no change, cautious purchasing, reduced consumption and increased consumption. These behavioural pathways directly inform the dependent variable in our multinomial logistic regression, where each strategy represents one of the four outcome categories. The explanatory variables correspond to the individual characteristics and the determinants highlighted in Figure 1, including goat meat beliefs, and individual perceptions, that affect the meat consumer purchase intention, allowing the empirical model to test the conceptual associations embedded in the framework.

To better understand the behavioural drivers behind these strategies, we use a multinomial logistic model to identify the distinctive features of respondents who follow different risk-mitigation alternatives. The model tests the association between consumer characteristics, goat meat beliefs and risk perceptions and the likelihood of choosing each risk-mitigation strategy. This structure allows us to evaluate how the pathways outlined in the conceptual framework translate into behavioural responses during an animal disease outbreak. Hence, we model the probability that a consumer respondent i chooses the strategy j, based on his or her preferences and characteristics, as:

$$Pr(y_i = j \mid x_i) = P_{ij} = \frac{e^{\left(\alpha + \beta_{j|b} A_i + \gamma_{j|b} C_i\right)}}{\sum_{j=1}^{J} e^{\left(\alpha + \beta_{k|b} A_i + \gamma_{k|b} C_i\right)}} for j = 1, \ldots, J. \tag{3}$$

where j represents a specific risk-mitigation strategy, which can take values 1 to J, and b is the base outcome used for comparison purposes and called sometimes the reference category (Long and Freese, 2014; Greene, 2017). This model contrasts between strategies and it can be

seen as a set of binary logistic regressions that compares pairs of outcomes with respect to a base or reference category (Long and Freese, 2014; Hardin and Hilbe, 2018). It can be also represented using a matrix $x_i = [A_i, C_i]$, that encompasses the perceptions about meat attributes, and socio-demographic and attitudinal characteristics of the individual consumer *i*. By applying natural logarithms to Eq. (3), this model can be presented in the following way:

$$ln\,\Omega_{j|b}(x_i) = ln\frac{Pr(y_i = j|x_i)}{Pr(y_i = b|x_i)} = \alpha + \beta_{j|b}A_i + \gamma_{j|b}C_i for j = 1, \ldots, J. \quad (4)$$

This formulation estimates the odds (or relative risk) that the individual consumer *i* with specific product perceptions about meat attributes and socio-demographic and attitudinal characteristics, selects the risk-mitigation strategy *j*, to the base alternative *b*. The resulting relative-risk ratios quantify the likelihood of a strategy being chosen, helping to identify the variables most associated with each behavioural response to perceived food safety risk compared with the base one (Long and Freese, 2014; Greene, 2017; Hardin and Hilbe, 2018).

4. Results and discussion

The socio-demographic characteristics of the complete sample respondents and the case of each preferred risk-mitigation strategy when buying goat meat under the presence of ASF outbreak are presented in Table 3. Most respondents (81.42%) did not to alter their goat meat consumption during the ASF outbreak (81.42%), suggesting they did not perceive goat meat to be a risk. However, 12,53% reported being more cautious, applying safety measures when buying goat meat, and 4.18% reduced their goat meat consumption, likely due to generalised concerns about meat safety. Surprisingly, only 1.46% increased their goat meat consumption despite lower pork availability and rising prices, highlighting that perceived food safety risks can suppress even expected substitution effects when consumers perceive broader risks of the food industry.

To contextualise the modelling results, it is important to clarify the characteristics of the sample population. The survey includes 470 Vietnamese goat meat consumers recruited through on-site interviews at restaurants across ten provinces selected for their relevance to goat meat production and consumption. Respondents were randomly approached within these locations, resulting in a diverse sample in terms of age, gender, occupation and income. Because the aim of the study is to analyse behavioural responses among individuals who consume goat meat, the target population is goat meat consumers rather than the general Vietnamese consumers population. The sampling strategy therefore ensures representativeness of this specific consumer group. Focusing on this sub-population is essential for identifying behavioural adjustments, such as reduced intake or increased caution, that cannot be observed among non-consumers.

As shown in Table 4, the square of the correlations between each pair of food motive factors is lower than the average extracted variance for each factor, confirming the distinctiveness of the nine constructs. These results validate the factor structure and confirm the relevance of food motives identified in earlier studies, as reported by Steptoe *et al.* (1995) and Carrillo *et al.* (2011).

Following the validation of the underlying food motive factors, we estimated multinomial logistic regression models to examine how motivational variables, socio-demographics, preferences and beliefs influence the likelihood of adopting specific risk-mitigation strategies. The analysis focused on respondents who (1) reduced their goat meat consumption or (2) became more careful when purchasing and eating goat meat, relative to those who (3) did not change their consumption during the ASF outbreak. Respondents who reported increased consumption or selected "other" strategies were excluded due to their low frequencies. Within the conceptual framework, substitution appears in two of the four strategies, substituting pork with another meat (such as goat) or substituting meat with non-meat alternatives, but each of

Table 3. Socio-demographic characteristics of the complete sample and respondents' risk-mitigation strategies on goat meat consumption under an African Swine Fever (ASF) outbreak in Vietnam

Variable	Complete sample $N = 479$ (percentage)	Strategy 1: Reduced consumption $n = 20$ (percentage)	Strategy 2: More careful $n = 60$ (percentage)	Strategy 3: No change $n = 390$ (percentage)	Strategy 4: Increased consumption $n = 7$ (percentage)	Strategy 5: Other $n = 2$ (percentage)
All	100.00	4.18	12.53	81.42	1.46	0.42
Location						
Urban	79.33	90.00	93.33	76.67	85.71	50.00
Rural	20.67	10.00	6.67	23.33	14.29	50.00
Gender						
Male	56.37	50.00	53.33	56.92	71.43	50.00
Female	43.63	50.00	46.67	43.08	28.57	50.00
Age						
18–24 years old	2.71	5.00	5.00	2.31	0.00	0.00
25–34 years old	21.71	10.00	25.00	21.03	42.86	100.00
35–44 years old	40.08	55.00	45.00	38.97	27.57	0.00
45–54 years old	21.92	20.00	11.67	23.85	14.29	0.00
55–64 years old	11.48	10.00	13.33	11.28	14.29	0.00
Over 65 years old	2.09	0.00	0.00	2.56	0.00	0.00
Education						
None	0.00	0.00	0.00	0.00	0.00	0.00
Primary school	24.80	0.00	3.33	15.13	0.00	0.00
High school	42.68	20.00	18.33	23.08	0.00	0.00
College/ technical degree	16.67	5.00	5.00	9.23	0.00	50.00
University degree	89.43	65.00	56.67	42.82	85.71	0.00
Postgraduate studies	21.14	10.00	16.67	9.74	14.29	50.00
Marital status						
Single	9.60	5.00	13.33	8.97	14.29	50.00
Married	90.40	95.00	86.67	91.03	85.71	50.00
Household size						
1 person	1.67	0.00	3.33	1.54	0.00	0.00
2 persons	5.22	0.00	8.33	4.87	14.29	0.00
3 persons	14.20	10.00	15.00	14.62	0.00	0.00
4 persons	46.14	75.00	41.67	45.38	42.86	50.00
5 persons	20.67	5.00	18.33	21.28	42.86	50.00
6 persons or more	12.11	10.00	13.33	12.31	0.00	0.00
Children at home						
No	23.17	15.00	26.67	23.08	14.29	50.00

(*continued*)

Table 3. Continued

Variable	Complete sample $N = 479$ (percentage)	Strategy 1: Reduced consumption $n = 20$ (percentage)	Strategy 2: More careful $n = 60$ (percentage)	Strategy 3: No change $n = 390$ (percentage)	Strategy 4: Increased consumption $n = 7$ (percentage)	Strategy 5: Other $n = 2$ (percentage)
Yes	76.83	85.00	73.33	76.92	85.71	50.00
Household income per month						
Below USD200	7.10	10.00	6.67	6.67	14.29	50.00
USD200–USD399	21.92	20.00	13.33	22.82	42.86	50.00
USD400–USD599	33.61	45.00	41.67	32.56	0.00	0.00
USD600–USD799	21.92	15.00	23.33	22.31	14.29	0.00
USD800–USD1,000	7.10	5.00	6.67	7.44	0.00	0.00
Over USD1,000	8.35	5.00	8.33	8.21	28.57	0.00

Note(s): During October 2022, 1 US Dollar (USD) was on average equivalent to 24,145.00 Vietnamese Don (VND)

Table 4. Discriminant validity using mutual variances between food motive factors of goat meat

	GMF1	*GMF2*	*GMF3*	*GMF4*	*GMF5*	*GMF6*	*GMF7*	*GMF8*	*GMF9*
GMF1: Health	0.593								
GMF2: Mood	0.204	0.591							
GMF3: Convenience	0.008	0.069	0.752						
GMF4: Sensory appeal	0.194	0.344	0.049	0.493					
GMF5: Natural content	0.009	0.020	0.102	0.058	0.785				
GMF6: Price	0.000	0.028	0.049	0.041	0.034	0.474			
GMF7: Weight control	0.038	0.084	0.075	0.026	0.029	0.015	0.591		
GMF8: Familiarity	0.020	0.041	0.076	0.067	0.077	0.185	0.039	0.684	
GMF9: Ethical concern	0.067	0.022	0.036	0.098	0.000	0.017	0.004	0.018	0.509

these groups represented only a small proportion of the sample. Given their limited size, these responses could not be modelled reliably. Accordingly, the empirical analysis focuses on the three dominant behavioural responses, while recognising that substitution remains an important component of the broader framework. The final models are therefore based on 470 respondents.

The estimated models presented in Table 5, reveal key variables that drive strategy choice under perceived food safety risk. Consumers with greater familiarity with goat meat and stronger beliefs in its natural content are less likely to reduce their consumption. In contrast, those who allocate a larger share of their income to food and who view goat meat as a convenient product are more likely to reduce consumption, possibly due to heightened sensitivity to food risk or price uncertainty. Moreover, those consumers who live in urban areas are more likely to adopt cautious purchasing behaviour, consistent with previous findings on food safety awareness in urban Bangladesh (Ishra *et al.*, 2022). However, consumers who perceive goat meat as mood-enhancing, convenient and natural are less likely to become more careful, suggesting that positive product associations may reduce perceived food safety risk.

Table 5. Variables affecting reduced or more cautious goat meat consumption during the African Swine Fever outbreak relative to no change in purchase behaviour

	Reduced goat meat consumption		More careful when buying goat meat	
Variable	Coefficient	Relative-risk ratio	Coefficient	Relative-risk ratio
Constant	−6.951***	0.001***	−3.303**	0.037**
Location (Urban = 1)	0.793	2.209	0.974*	2.648*
Gender	−0.141	0.869	−0.058	0.944
Age	0.001	1.001	0.001	1.001
Marital status (Married = 1)	0.642	1.901	−0.209	0.812
Household size	−0.084	0.919	−0.008	0.992
Have children at home	0.289	1.335	−0.370	0.691
Years of education	0.047	1.048	0.061	1.063
Monthly household income (in USD)	0.001	1.001	0.000	1.000
Proportion of income spent on food	3.907**	49.766**	−1.256	0.285
Frequently eats goat meat	−0.256	0.775	−0.594	0.552
Meat origin is important	0.608	1.837	0.492	1.636
GMF1: Health	0.047	1.048	0.095	1.099
GMF2: Mood	−0.216	0.806	−0.649***	0.522***
GMF3: Convenience	0.577*	1.780*	−0.356*	0.700*
GMF4: Sensory appeal	−0.324	0.724	−0.009	0.991
GMF5: Natural content	−0.580*	0.560*	−0.729***	0.483***
GMF6: Price	0.420	1.522	0.248	1.281
GMF7: Weight control	0.161	1.175	0.174	1.190
GMF8: Familiarity	−0.541*	0.582*	−0.446*	0.640*
GMF9: Ethical concern	0.459	1.583	0.117	1.124
McFadden Pseudo R-squared	0.209		0.209	
Observations in this group	20		60	
Number of observations	470		470	

Note(s): (+), (*), (**) and (***) correspond to significance levels at $\alpha = 10$, 5, 1 and 0.1%, respectively. The relative-risk ratio indicates how much more (or less) likely a consumer is to reduce goat meat consumption when there is ASF with respect to no change in purchase behaviour (Long and Freese, 2014; Greene, 2017)

The effects associated with price and health related beliefs should be interpreted as indicative behavioural correlates rather than precise psychometric measurements, which is consistent with the exploratory nature of the food motive factors.

These results illustrate the dynamics of risk communication and the social amplification of risk. Although ASF posed no direct threat to human health or goats, media coverage and perceived associations between meat types shaped consumer behaviour. Urban consumers, who are often more exposed to food safety information, demonstrated heightened caution. These outcomes highlight the importance of how risk signals are transmitted and perceived through product cues, communication channels and the degree of trust placed in institutional actors.

5. Conclusions

Previous studies have shown that adverse media coverage of meat contamination and animal disease outbreaks can significantly influence consumer purchasing and consumption behaviours. In some cases, this leads to greater demand for substitute meats or even a broader shift toward non-meat protein sources. However, consumer perceptions of health risks, and the corresponding risk-mitigation responses, vary markedly across segments.

This study identified nine goat meat belief factors consistent with food motives reported in the literature. While most Vietnamese goat meat consumers surveyed did not change their

behaviour during the 2019 ASF outbreak, 17% adjusted their goat meat consumption due to perceived spillover risks. Specifically, 12.5% became more cautious, and 4.2% reduced their consumption, indicating spillover effects of ASF on an unrelated meat product. In contrast, only 1.5% increased their intake, suggesting limited substitution from pork to goat meat. While substitution is a recognised risk-mitigation mechanism and appears in two of the four strategies in our conceptual framework, only a very small minority of consumers substituted pork with goat meat during the ASF outbreak. The spillover effects observed in this study therefore manifested primarily through increased caution or reduced goat meat consumption. Importantly, a reduction in goat meat intake may itself reflect a form of substitution, as some consumers may shift away from meat altogether and increase their reliance on non-meat alternatives. This highlights a key nuance: spillover does not necessarily lead to substitution between meat products alone, and consumers may respond to the same food safety signal through different behavioural pathways.

The analysis further reveals that consumers who spent a larger proportion of their income on food, or considered goat meat as convenient, were more likely to reduce their consumption. In contrast, those more familiar with goat meat and who believed it had natural content were less likely to decrease their intake. Notably, urban consumers were more likely to adopt cautious purchasing behaviours, reflecting how informational and environmental contexts influence risk-mitigation strategies. These results demonstrate that spillover effects from animal disease outbreaks can affect consumption beyond the directly impacted species, particularly among specific consumer groups. Hence, he results clearly indicate a behavioural segmentation among consumers. Urban residents and consumers allocating a higher share of income spent on food are more responsive to perceived spillover risks, whereas familiarity with goat meat and beliefs about its natural content significantly reduce risk-avoidance behaviour. These patterns suggest that spillover effects are not uniform across the population, as they are mediated by experience-based trust and income constraints.

For policymakers and the food industry, these findings emphasise the importance of transparent communication strategies and credible certification that build consumer confidence and prevent unnecessary disruptions to food markets. Messaging that highlights the safety, traceability and integrity of unaffected meat products is especially relevant in urban markets, where consumers are more responsive to perceived food safety risks. Therefore, this study demonstrates that consumer perceptions and risk-mitigation strategies are central to managing animal health crises, and communication should not be seen as a corrective measure once consumer concerns arise, but as an ongoing strategy to strengthen consumer trust and enhancing the resilience of food systems.

A key limitation of this study is its reliance on recall data. Because the ASF outbreak occurred three years before the survey, some respondents may not accurately remember their behavioural adjustments, which could weaken the estimated associations. Nevertheless, the consistency of results across models suggests that the patterns identified remain meaningful. In addition, the restaurant-based nature of goat meat consumption in Vietnam results in minimal variation in place of purchase, limiting its usefulness as a control variable. A further limitation is that very small numbers of respondents reported increased goat meat consumption or selected "other" strategies, meaning statistical inference applies primarily to the three dominant behavioural responses. The relatively low pseudo R^2 values are typical of behavioural choice models and reflect the complex nature of food safety decision-making, which is influenced by many unobserved psychological and contextual factors. The impact of trust in specific media sources, exposure to food safety news, perceived credibility of government and industry communication, social networks and prior experience with food safety incidents were not assessed in this study, but they are likely to play an important role in shaping spillover risk-mitigation responses. Incorporating those variables in future studies would help to better explain behavioural heterogeneity and improve predictive performance. Future studies could address these limitations by collecting real-time or longitudinal data during food safety events and by sampling larger groups of substitution-driven consumers.

Future research could also examine how risk-mitigation strategies differ across countries, cultural contexts, meat types and disease characteristics, which would further strengthen understanding of how food safety signals shape consumer behaviour across global meat supply chain.

Credit authorship contribution statement

L.E.M.: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft. N.H.: Validation, Methodology, Formal analysis. A.F.C.: Data curation, Writing – review and editing, Project administration. N.X.B.: Investigation, Data curation. B.T.N.: Investigation, Data curation. N.T.K.C.: Investigation, data curation. N.T.L.Q.: Investigation, Data curation. N.H.V.: Validation, Data curation, Project administration.

Ethics approval statement

This research study was approved by the Human Research Ethics Committee of the University of New England on 15th December 2020. Approval number HE20-208.

Data availability

Data will be made available on request.

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