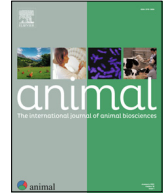




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Public acceptance of microbiome management strategy in dairy calves: a European survey on colostrum, probiotic provision and prolonged cow-calf contact



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ABSTRACT

The microbiome plays a crucial role in the calves' early stages of life. Several management practices can be considered to enhance the development and composition of the microbiome in calves. However, their social acceptance is largely unknown. The aim of this study was to investigate the public acceptance of innovative microbiome management practices aimed at improving the health and welfare of calves and to assess the factors influencing these levels of acceptance. Data used in the analysis were obtained from an online survey conducted in July 2023. The final sample consists of 3 220 citizens from four EU countries (Finland = 813, France = 803, Ireland = 801 and Poland = 803). Participants were asked to assess four management practices designed to improve calves' health and welfare: (1) using colostrum, (2) providing mix probiotics powder, (3) providing probiotics as yogurt or kefir and (4) prolonged cow-calf contact. Participants were provided with different levels of information: one group received only a short description of the intervention, while the other group received both the intervention description and information on aspects such as potential costs and environmental impact of the intervention. Participants were asked to rate the acceptance on a standardised scale ranging from 1 to 5, with 1 indicating "strongly agree" and 5 indicating "strongly disagree". Additionally, the participants were questioned about their socio-demographic background (e.g. age, education). They were also asked to provide their perspectives on various dimensions concerning familiarity with farming and microbiome, food safety, environmental awareness, cost consideration, and cultural perspective of consuming dairy products. Obtained data were analysed using the ordinary least squares regression model. The findings reveal that prolonged cow-calf contact was the most acceptable measure among tested interventions in all countries (79% of responders agreed or strongly agreed). Attitudinal and socio-economic variables were found to have a differential effect across the studied management strategies. For instance, individuals with greater familiarity with farming systems and microbiomes were more inclined to accept all four interventions, while women, compared to men, showed higher acceptance of prolonged cow-calf contact. Results also indicate that the provision of additional information to the participants was associated with a decrease in the acceptance of the measures. In conclusion, the public's perceptions regarding microbiome management strategies in dairy calves are shaped by complex factors. Also, our discussion emphasises the importance of clarity and transparency of messages, ethical dissemination of scientific knowledge, and the necessity for balanced and coherent communication.

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Implications

The gastro-intestinal microbiome is essential to ensure optimal growth, health, and welfare of calves. Several early life practices, such as the use of colostrum, the provision of probiotics, and pro-

longed cow-calf contact, can help maintain a balanced microbiome in calves. Our results show that prolonged cow-calf contact was the most endorsed microbiome management practice among the respondents. Providing more information about microbiome management strategies, even when presented clearly and concisely, may not be sufficient to change public acceptance. Since different microbe strategies may have different target audiences, it is essen-

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tial to further personalise campaigns aimed at enhancing the sustainability of animal production.

Introduction

In recent years, the microbiome research in human observational studies has received growing attention in scientific journals and newspapers (Prados-Bo and Casino, 2021). At the same time, the global market for products containing live microorganisms has been growing rapidly and reached approximately \$58 billion in 2022 (Markets and Markets, 2024). However, as discussed by Bimbo et al. (2017), many products will be withdrawn from the market due to a lack of focus on consumers' acceptance and preferences during the product development phase.

There is an increasing number of studies investigating the implementation of microbial management strategies with the goal of improving the welfare and health of livestock (Peixoto et al., 2021) and dairy calves in particular (Malmuthuge and Guan, 2017). These microbial management strategies for calves may include, but are not limited to, the use of pre- and probiotics (Cangiano et al., 2020), colostrum supplementation (Lopez and Heinrichs, 2022) or vertical microbial transfer through prolonged cow-calf contact (e.g. Wenker et al. (2022)). At the same time, farm management practices related to calf rearing are not well-known among the public. For instance, as documented by Placzek et al. (2021), approximately 65% of consumers are unaware of the cow-calf separation procedure. Consumers become more attentive towards farm animal welfare (Blanc et al., 2020) and there is a growing level of concern among EU citizens regarding the wellbeing of dairy calves, coupled with a compassionate attitude towards these animals (Herrier et al., 2023). Therefore, in response to public expectations, there is a pressing need for both farmers and policymakers to recognise and recommend a sustainable approach to managing calves (Mikuš et al., 2020). Since consumers' environmental awareness and health considerations are changing, the demand for dairy products originating from alternative production systems is likely to increase (European Commission, 2021). Therefore, gaining more insight into consumers' preferences may benefit both dairy manufacturers and consumers (Bimbo et al., 2017). While there has been extensive research on consumer acceptance for various product types containing microbiomes (e.g. yogurts) for human nutrition (Annunziata and Vecchio, 2013; Conti-Silva and Souza-Borges, 2019), to the best of the authors' knowledge, there is limited evidence on how various microbiome management approaches in dairy calves are perceived by Europeans.

Public acceptance of new agrifood strategies is influenced by a range of psychological factors, as well as the 'temporal context' in which these strategies were introduced (Frewer, 2017). Previous studies demonstrated that the level of information may influence consumer choices as discussed, for example by Siegrist and Hartmann (2020), for instance, the provision of accurate consumer information was crucial for the widespread adoption of foods modulating gut microbial in the human diet (Stanton et al., 2001). Therefore, we hypothesised that the provision of additional explanatory information may play a role in shaping the public' perspectives concerning various microbiome management options in dairy calves. Given the above, the aims of this study were twofold: (1) to quantitatively investigate the public' acceptance of microbiome management practices aimed at improving the health and welfare of calves; (2) to assess the factors influencing these acceptance levels.

This study was conducted within an international project (HoloRuminant), which aims to elucidate the role of ruminant-associated microbiomes and their interplay with the host animal in its early life (see Morgavi (2023) and Scully et al. (2023)). Within

study, four management practices were evaluated; (1) using colostrum as additional treatment for diarrhoea or respiratory disease; (2) providing mix probiotics powder to improve calves' digestion, support immune function, and prevent disease in calves; (3) providing probiotics as yogurt or kefir to enhance the health of animals and (4) prolonged cow-calf contact with their mothers or with nurse cows until they are 3 months old to enhance the health and welfare. The selected microbial management strategies clearly differ in terms of their prevalence in commercial farms. For instance, many dairy farmers use probiotics for various reasons, including more effective calf rearing (Várhidi et al., 2022) and the use of "direct-fed microbials" in calves is well-documented in the literature (Yáñez-Ruiz et al., 2015). The use of colostrum to improve calf health has a long history. However, colostrum management programmes can vary between farms (Godden et al., 2019). In contrast, using kefir or yogurt to improve calf health is a relatively new concept (Fouladgar et al., 2016). Additionally, while the majority of EU farms separate calves from their dam shortly after birth, there is a growing interest in extending cow-calf contact (Eriksson et al., 2022). These strategies also vary in terms of implementation costs. For instance, prolonged cow-calf contact may be fairly expansive due to substantial changes in labour inputs and buildings (Alvåsen et al., 2023), whereas probiotic supplementation might offer a more cost-effective approach to microbiome management with minimal changes needed in feeding practices (Cangiano et al., 2020). Thus, the implementation of these microbiome management strategies may have consequences not only for animals and farmers but also for consumers (e.g. increased cost of dairy products), which may be reflected in the acceptance level of microbiome management practices.

Material and methods

An online survey instrument was developed, tested and refined to collect data among a sample of citizens in four EU member states (Finland, France, Ireland and Poland). Data were collected in July 2023 by using a survey, which examined four innovative interventions affecting animal health and welfare that are studied by a European project HoloRuminant. The data were collected through an online panel by a market research company Taloustutkimus Ltd., which was connected to a network of online citizen panels in many countries (Moss et al. (2023) for an overview on market-research panels). It is highlighted that collecting data without access to a consumer panel presents significant challenges. Given a target of a maximum 2% error margin and 95% confidence level, our data collection was determined by two main factors: the length of the questionnaire and the available budget. Given these constraints, we negotiated with the market research company to obtain the largest sample possible (as representative as possible in relation to demographic variables) given our budget and questionnaire. However, due to budgetary and contextual limitations, we were unable to fully ensure the randomness of the sample.

The survey was developed in English, translated into Finnish, French and Polish and back-translated into English to ensure consistency between different language versions. The survey was available to the respondents in these four languages. Data collection was compliant with applicable laws, and followed the International Code of Marketing and Social Research Practice (ICC/ESOMAR, 2016) and ISO 20252 guidelines (International Organization for Standardization, 2019). The ICC/ESOMAR is a benchmark in the market research industry, setting the standards for ethical and professional conduct for the global community involved in data and research. Before starting the data collection, the questionnaire was tested in a small number of persons and refined based on their feedback. Finally, potential respondents in

the citizen panel received an email that invited them to respond to the survey. While respondents were not directly paid for their participation, they received 'points' for completing the survey. Once a respondent accumulated enough points from various surveys, they could redeem them for vouchers or gift cards. The value of these rewards varied by country but remained small, typically less than one euro per respondent per survey. While we do not know the exact value of the rewards, in our opinion, they were modest and unlikely to substantially influence participation. Data collection was continued in each country until the target sample size was achieved. A privacy notice was presented, and an informed consent was required before the respondent was able to answer the survey.

The sample of respondents (N = 3 220, at least 800 respondents per country) was representative of gender, age and region of residency of the adult population (18–65 years) in each country. In each country, the respondents of the online survey were recruited from a large internet panel which is expected to produce a representative sample of the population of each country in terms of different socio-demographic indicators (age, education, language, professional status, household characteristics). The invitations were sent to the members of the panel by email, and responses were collected until 800 responses per country were reached. The representativeness of sample in each country in relation to gender, age and region of residency of adult population was ensured by using quotas that corresponded to each groups' distribution of citizens in the country (Moss et al., 2023). Based on the sample size calculation, the targeted overall sample size had less than a 2% error margin and a 95% confidence level. At the level of individual country, the error margin was between 3.6 and 5% depending on the question.

At this point, we offer three cautions to be taken into account when interpreting the results. First, the representativeness of sample for variables other than those mentioned above was not ensured during data collection. Retrospectively, some overrepresentation of university-educated people in the data was detected. Moreover, a rank test was used to check that respondents' attitudes towards the four studied interventions were not biased, ensuring that, for example, the most negative views were not accumulated earlier than the positive ones. Second, information about the overall response rate was not available. However, the total sample size was predetermined when the order was placed with the market research company, so the response rate does not reflect the level of active participation in the survey. Third, caution is needed as internet panel surveys might exclude segments like those with limited internet access or low digital literacy. A random sampling approach would have been preferable as it would have given every individual in the target population an equal chance of being selected, reducing the risk of self-selection bias. The key differences between our sample and a true random sample lie in the method of participant selection and potential biases introduced by using an online panel, such as the overrepresentation of digitally active or university-educated individuals. Random sampling would have provided a more accurate representation of the broader population by including individuals less likely to participate in online panels. However, in studies like ours, which assess public preferences and perceptions of farming practices, using online panels is common. This approach is often chosen due to the challenges in accessing the respondents, higher costs, and longer timeframes associated with conducting true random sampling. Online panels offer a practical, cost-effective solution that still allows researchers to gather data on key demographic variables such as age, gender, and region.

The survey design comprised three distinct sections. The first section aimed to evaluate the microbiome interventions, the second to assess associated attitudinal variables and the third to provide basic socio-demographic information. The survey was

completed by 3 220 respondents. Before answering to the survey questions, the participants were required to provide an informed consent via an online form.

In the first section of the survey, participants were asked to indicate their level of acceptance of four interventions on a standardised Likert scale ranging from 1 to 5, with 1 indicating "strongly agree" and 5 indicating "strongly disagree". There was also an option for responders who were unsure could choose to answer "I do not know". A Likert scale is a prevalent psychometric tool often employed in surveys, especially within educational and social sciences, designed to quantify an individual's level of agreement or disagreement with a specific statement (Joshi et al. (2015) for more details). The interventions and their descriptions are presented in Table 1.

In order to test the impact of people's knowledge on decisions about livestock production practices, 50% of the samples in each country were randomly selected to receive additional information (additional to information presented in Table 1) about possible impact of the intervention on calf health and welfare, the quality of milk and meat products, environmental effects, effect on production and costs of milk and dairy products for citizens (for details, please see the supplementary material). This division allowed us to analyse whether more informed persons made different choices compared to those with limited information. However, the sampling method used does not allow us to assess whether the responses are unbiased.

The survey's next section focused on attitudinal variables with the goal of evaluating respondents' perspectives on various dimensions. Attitudinal variables were grouped into seven topics: (1) familiarity with farming and microbiome, (2) food safety, (3) environmental awareness, (4) animal welfare, (5) costs considerations, (6) cultural perspective of consuming dairy products and (7) general concerns related to dairy production. Familiarity with the farming and microbiome summarises the information related to farm visits, understanding microbiota's role, and awareness of food

Table 1

Description of interventions presented to commercial consumer panels in four EU countries (Finland, France, Ireland and Poland).

Intervention	Description
Using colostrum	Colostrum is the first milk produced by a lactating mammal. It contains high levels of antibodies and nutrients that are important for the health and development of newborn animals, including calves. Some research suggests that colostrum can also be used as an additional treatment for certain diseases in calves, such as diarrhoea and respiratory infections.
Providing mix probiotics powder	Probiotics are live microorganisms that can have beneficial effects on the health of animals. Providing probiotics to calves in the form of a powder mixed with their milk can improve calves' digestion, support immune function, and prevent disease in calves.
Adding probiotics as yogurt or kefir	Providing probiotics to calves by adding yogurt or kefir (fermented milk prepared by the farmer) to calves' milk can enhance the health of animals. Yogurt and kefir can improve digestion, support immune function, and prevent disease in calves. Adding yogurt or kefir to calf's milk could be a less expensive alternative when compared to using commercially produced probiotics.
Prolonged cow-calf contact	Keeping calves with their mothers or with nurse cows until they are 3 months old rather than separating them shortly after birth, which is a common practice in some farming systems, can enhance the health and welfare of both the calf and the mother. This practice allows the calf to receive important nutrients and immunity-boosting substances from its mother's milk.

Table 2
Statements that were considered as part of respondents' attitude factors in this study.

Attitudes statements	Factors
I have visited a farm and seen first-hand how cattle are raised.	Familiarity with farming and microbiome
I understand the role of microbiota in human health and well-being.	
I understand the benefits and challenges associated with the food production and sustainability in the livestock sector.	Food safety
It is important for me to consume food products that are safe for me.	
I take the time to read the labels and packaging information (e.g. allergens) to ensure food I purchase is safe to consume.	
I believe that food producers have an ethical responsibility to provide safe food products to consumers.	Environmental awareness
I consider the environmental impact of a product before making a purchase	
I frequently recycle and make an effort to reduce my waste	
I frequently buy products that are labelled as antibiotic-free	
I try to reduce my carbon footprint by walking, biking, or taking public transit when possible	Animal welfare
I actively seek out information about animal welfare standards of companies before purchasing animal-derived products.	
I am willing to pay more for products that are produced using high animal welfare practices.	Conscientious consumption preferences
I support animal welfare organizations and donate to their causes.	
I prioritize buying organic food, even if it is more expensive.	
I am willing to pay more for products that are sustainably sourced and produced.	
I am willing to pay more for food produced using high animal welfare standards.	
I am willing to pay a premium price for food products that are guaranteed to be free from harmful contaminants and residues.	
I feel that consuming dairy products is necessary for balanced nutrition and healthy life.	Cultural perspective of consuming dairy products
I feel that it is important to purchase dairy products to support the dairy industry and local farmers.	
Consuming dairy products is a traditional and cultural practice that should be continued.	

production dynamics. The factor related to food safety indicated whether citizens prioritise their own safety by reading labels carefully and expecting food producers to act responsibly. Environmental awareness factor represented environmentally conscious behaviours and a commitment to sustainable practices. Another factor reflected a commitment to animal welfare, as indicated by participants' preferences for seeking information before purchasing, willingness to pay for ethical products, and supporting related organisations. A factor of conscientious consumption preferences reflected participant's willingness to prioritise ethical and quality food choices, even if it involves higher costs, encompassing preferences for organic, sustainably sourced, high animal welfare, and contaminant-free products. The cultural perspective of consuming dairy products was represented by various aspects of dairy consumption, including its perceived role in nutrition, support for local industries, and its cultural significance. Finally, general concerns related to dairy production represented potential concerns, such as antimicrobial resistance and climate change. To derive a quantitative measure of the attitudinal variables, a five-point Likert scale from 'strongly disagree' to 'strongly agree' was used. A list of 34 statements covering a range of attitudes was given to the respondents. Furthermore, to ensure a comprehensive understanding of our respondents, socio-economic information was also collected. This included a range of demographic data that provided insights into the social and economic contexts that might influence participant's perceptions and attitudes. A copy of survey questions is in the supplementary material (Section 1).

Data analyses

Statistical models were used to explain the association between acceptance of an intervention and different factors. To reduce the number of statements and to improve the discriminatory power of the resulting models, a principal component analysis (PCA) on 34 attitudinal variables was performed first. PCA results were used to reveal that the underlying structure of the attitudinal variables can be largely explained by six independent components: familiarity with farming systems and microbiome, food safety, environmental awareness, animal welfare, cost-conscious preferences, and social norms. Only the statements with a factor loading (mag-

nitude of the correlation between the attitudinal variables and the identified components) above 0.4 were retained for the analysis (Maskey et al., 2018) (Table 2). Each component was quantified by summing the score points of the corresponding items to obtain six continuous variables. For example, we have three statements that were loaded on the 'Food safety' component. Then, for Person A, who scored 4 for the first statement, 5 for the second statement, and 3 for the third statement, we quantify the "Food safety" component for that Person A by summing the scores of these three statements: $4 + 5 + 3 = 12$. This process was repeated for each respondent across the six components, resulting in six new interval-scale variables that summarise the original attitudinal data in a more compact form. Hence, the result was an index that was measured by using a linear scale. Detailed results of the PCA are shown in the supplementary material (Section 2).

Next, an Ordinary Least Squares (OLS) regression model was used to identify the socio-economic factors and respondents' attitudes that underlie the variation in the acceptance of interventions. The regression procedure was expressed by the following model:

$$Y_i = \beta_0 + \beta_1 A_i + \beta_2 S_i + \beta_3 D_i + \epsilon_i \quad (1)$$

where Y_i represents the outcome variable or response variable for the i -th intervention, β_0 is an intercept, representing the expected value of Y_i when all other predictor variables were held constant, $\beta_1 A_i$ represents the effect of attitudinal variables (A_i) on Y_i . The estimated parameter β_1 is associated with the attitudinal variables, indicating how a unit change in A_i affects Y_i . The parameter β_2 quantifies the effects of the socio-economic variables on Y_i , while β_3 captures the effect of dummy variables (D_i) on Y_i . These dummy variables can represent categorical distinctions such as country of residence, consumption habits, or level of information provision (binary variable). ϵ_i stands for the error term, representing the unobserved factors, random noise, and measurement errors that contribute to the variability in Y_i that is not explained by the predictor variables in the model. The model (1) has been estimated in four specifications, each of which has a different outcome variable (intervention), but independent variables are the same. We present SEs corrected for heteroscedasticity. The SEs are robust, ensuring reliable statistical inference and providing valid results even when

the error distribution deviates from normality (White, 1980). Although we found non-normality in the residuals (Supplementary Figure S1), it is important to note that the normality of errors is not a requirement for OLS estimators to remain unbiased (Gelman and Hill, 2006; Wooldridge, 2002). We used the method proposed by Weisberg and Cook (1982) to detect potential influential data points (e.g. observations with Cook’s distance > 0.5), but none of the observations exceeded this threshold. Table 3 contains summary information on the variables used in the analysis.

To validate the stability of our findings, we further explored alternative models, such as non-linear probability models, including ordinal probit models. Following Angrist and Pischke (2009), we favour the linear probability model as our principal approach due to its advantages in the straightforward interpretation of the coefficients and the challenges presented by alternative models (Breen et al., 2018).

Results

Sample socio-demographics characteristics

In Table 4, a comprehensive breakdown of socio-demographic characteristics across the four surveyed European countries, Finland, France, Ireland, and Poland, is presented. Gender distribution was balanced in Finland, France and Poland. In contrast, 59.8% of respondents in the sample of Ireland were women. Education levels differed among the countries. In Finland and Ireland, the majority of respondents had a university education (52.6 and 58.1%, respectively). In contrast, a substantial percentage of respondents in Poland had a secondary education (43%). Poland had the highest percentage of respondents with income under €10 000 and the lowest percentage with income of at least €150 000. While 52.9% of respondents in Poland were from households with an income of a maximum €20 000 per year, 36.6% of respondents’ households in France, 63.0% in Finland and 58.7% in Ireland had an income of more than €40 000 per year. Residential areas also varied across countries. The majority of respondents in Ireland and Finland resided in towns or suburbs, and in Poland in city centres, towns or suburbs. In France, the respondents were quite evenly distributed across the three types of residential areas.

Table 3
Descriptive statistics for the variables used in the analysis of respondents’ views.

Variables	Unit	Pooled sample		France		Finland		Ireland		Poland	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dependent variables											
Using Colostrum	(Scale 1–5)	3.89	1.43	3.68	1.45	4.39	1.16	3.75	1.46	3.72	1.50
Probiotics as a powder	(Scale 1–5)	3.56	1.41	3.38	1.43	3.81	1.28	3.56	1.41	3.50	1.48
Probiotics as yoghurt or kefir	(Scale 1–5)	3.48	1.48	3.30	1.49	3.77	1.38	3.52	1.43	3.34	1.58
Keeping calves with their mothers	(Scale 1–5)	4.08	1.36	3.94	1.41	4.38	1.10	4.09	1.31	3.89	1.52
Independent variables											
Familiarity with farming systems and microbiome	(Scale 1–15)	11.38	2.56	10.95	2.60	12.63	2.09	10.85	2.61	11.06	2.50
Food safety	(Scale 1–15)	12.55	1.93	12.30	2.11	12.70	1.69	12.67	1.91	12.53	1.96
Environmental awareness	(Scale 1–15)	15.17	3.04	15.31	3.12	15.14	3.19	14.85	2.89	15.39	2.92
Animal welfare	(Scale 1–15)	9.87	2.92	10.14	3.00	8.83	2.92	10.50	2.71	10.01	2.76
Cost consideration	(Scale 1–20)	13.81	3.63	13.99	3.87	13.53	3.54	13.69	3.59	14.03	3.48
Cultural views on dairy consumption	(Scale 1–15)	11.33	2.86	11.70	2.49	10.19	3.68	11.72	2.43	11.73	2.29
Age	Years	41.65	13.08	41.34	13.05	43.42	13.52	41.03	12.63	40.80	12.95
Female	Dummy	0.53	0.50	0.52	0.50	0.51	0.50	0.60	0.49	0.51	0.50
Education	Categories	4.16	0.94	4.17	0.90	4.23	0.92	4.31	0.89	3.92	1.02
Income	Categories	3.54	1.71	3.29	1.48	4.17	1.76	4.07	1.69	2.62	1.39
Meat consumption	Dummy	0.89	0.31	0.91	0.29	0.85	0.36	0.88	0.32	0.94	0.24
Dairy consumption	Dummy	0.90	0.30	0.90	0.30	0.92	0.28	0.86	0.35	0.94	0.25
Residence area	Dummy	0.25	0.43	0.32	0.47	0.19	0.39	0.29	0.45	0.21	0.41
Information provision	Dummy	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Number of observations		3 220		803		813		801		803	

Across all four countries, 86.9% of respondents consumed dairy products. Notably, the country with the highest rate of dairy consumption was Poland (93.5%), while Ireland registered the lowest (86.1%). Turning to meat consumption, again Poland stands out with the highest proportion (93.9%), and Finland recorded the lowest (84.6%). The data further underscore the diversity in parental status among surveyed populations. Finland reported the lowest percentages (13.8%) and Ireland and Poland the highest percentage of respondents with children.

Acceptance of strategies and the role of socio-demographic profile

The overall sample’s response to the different measures under study is presented in Fig. 1. A majority of respondents (76%) considered that using colostrum to treat calves’ diseases was acceptable. Keeping calves with their mothers for an extended period was even more widely accepted measure among respondents, with almost 79% of respondents noting to agree or strongly agree with the statement. More than half of respondents agreed or strongly agreed that providing probiotics to calves either in the form of powder or through yoghurt or kefir prepared on the farm was acceptable.

The role of attitudinal variables

Table 5 presents information on the relationship between interventions under study and potential factors affecting their acceptance. The coefficient of the independent variables represents the estimated change in the interventions’ acceptance for a one-unit increase in that independent variable, holding all other variables constant. A positive (negative) coefficient indicates that an increase in the corresponding variable is associated with an increase (a decrease) in the interventions’ acceptance. The R-squared values were between 0.101 and 0.186. However, in the social sciences, encountering low R-squared values in regression analyses, especially within cross-sectional studies, is not uncommon (page 39, Wooldridge, 2013) but makes predicting future outcomes problematic (page 201, Wooldridge, 2013).

Individuals more familiar with farming systems and microbiome were more susceptible to accept all four interventions. Likewise, there was a strong correlation between participants’

Table 4
Socio-demographic characteristics of respondents across the four surveyed European countries—Finland, France, Ireland, and Poland.

Variable	Item	Finland		France		Ireland		Poland	
		N	%	n	%	n	%	n	%
Gender	Male	399	49.1%	387	48.2%	321	40.1%	390	48.6%
	Female	408	50.2%	414	51.6%	479	59.8%	413	51.4%
Education	prefers not to say	6	0.7%	2	0.2%	1	0.1%	0	0.0%
	Less than primary education	0	0.0%	7	0.9%	2	0.2%	4	0.5%
	Primary education	31	3.8%	14	1.7%	9	1.1%	26	3.2%
	Secondary education	179	22.0%	187	23.3%	190	23.7%	345	43.0%
	Vocational education	175	21.5%	224	27.9%	135	16.9%	80	10.0%
	University education	428	52.6%	371	46.2%	465	58.1%	348	43.3%
Area of Residence	City centre	179	22.0%	286	35.6%	162	20.2%	321	40.0%
	Town or suburb	478	58.8%	258	32.1%	409	51.1%	315	39.2%
	Rural area	156	19.2%	259	32.3%	230	28.7%	167	20.8%
Income	€0–€10 000	57	7.0%	87	10.8%	45	5.6%	146	18.2%
	€10 001 – €20 000	89	10.9%	128	15.9%	79	9.9%	279	34.7%
	€20 001 – €40 000	155	19.1%	294	36.6%	207	25.8%	253	31.5%
	€40 001 – €60 000	184	22.6%	169	21.0%	179	22.3%	68	8.5%
	€60 001 – €80 000	128	15.7%	61	7.6%	126	15.7%	20	2.5%
	€80 001 – €100 000	104	12.8%	27	3.4%	89	11.1%	10	1.2%
	€100 001 – €150 000	80	9.8%	25	3.1%	49	6.1%	11	1.4%
	€150 001 or more	16	2.0%	12	1.5%	27	3.4%	16	2.0%
Dairy consumption	No	69	8.5%	79	9.8%	111	13.9%	52	6.5%
	Yes	744	91.5%	724	90.2%	690	86.1%	751	93.5%
Meat consumption	No	125	15.4%	73	9.1%	95	11.9%	49	6.1%
	Yes	688	84.6%	730	90.9%	706	88.1%	754	93.9%
Children	No	701	86.2%	559	69.6%	530	66.2%	518	64.5%
	Yes	112	13.8%	244	30.4%	271	33.8%	285	35.5%
Number of observations		813		803		801		803	

perceptions of food safety and how well these interventions are received. Moreover, participants who place a greater value on the cultural aspect of consuming dairy products are more likely to support the use of practices such as using colostrum, providing mixed probiotics powder, and incorporating probiotics such as yogurt or kefir in calf management. However, this group was less receptive to the idea of prolonged cow-calf contact. Interestingly, our findings show that respondents who placed a higher priority on animal welfare expressed less acceptance and value for the use of colostrum in the treatment of calves' illnesses. Quality-conscious respondents were more likely to support keeping calves with their mothers and to accept the use of colostrum as a treatment for diseases in calves.

Instead of focusing solely on statistical significance, it is relevant to examine also whether the magnitude of the estimated coefficients includes any values that could be considered practically significant. The only variable that had no statistically significant association with the acceptance of the four interventions was environmental awareness. The estimated coefficients for this variable ranged from an increase of 0.002 in the acceptance of providing mixed probiotics powder to an increase of 0.015 in the acceptance of adding probiotics as yogurt or kefir, per one-unit change in the environmental awareness of respondents. These values can all be considered practically insignificant, as they are the lowest among the magnitudes of the coefficients of the attitude variables. Furthermore, when comparing the magnitude of the coefficients that were statistically significant and those that were not for the same variable, we observed substantial differences. For most of the variables, the change for a coefficient that is statistically significant was at least twice as large as that of a non-significant. For instance, the association between education and the acceptance of using colostrum had a magnitude of 0.018, while the lowest statistically significant coefficient for the same association was 0.040 for the acceptance of prolonged cow-calf contact. These differences indicate that statistically significant variables had stronger and larger effects compared to non-significant ones. However, as indicated

by the low R-square-values, the predictions of outcomes will be imprecise.

The role of socio-economic characteristics and consumption habits

Younger participants were less likely than older to be in favour of keeping calves longer with their mothers, even though younger respondents were more likely to accept the use of probiotics as powder. Three of our interventions were found to be positively and statistically significantly and substantially associated with educational status. According to our analyses, longer cow-calf contact and a higher acceptance of using colostrum were positively correlated with female gender. The results also indicate that the acceptance of using colostrum to treat diseases in calves is statistically significantly associated (positively) with income levels.

The results also offered insights into the associations between consumption habits, represented by dummy variables (they take the value of 1 if the consumer consumes meat or dairy products, and 0 otherwise) for meat and dairy products and their acceptance of diverse livestock interventions, while dairy consumers are more likely to accept only the intervention that involves the use of yoghurt of kefir in calves' diet. We also controlled for country differences in our analysis by using dummy variables, since the survey was carried out in four different countries. We added three dummy variables for Finland, Ireland, and Poland, while France was the reference category. These dummy variables helped us account for possible variations in respondents' attitudes and preferences among the surveyed countries. Considering the mean parameter estimates of country dummies and their SEs suggests that there are differences in the acceptance of various livestock interventions between the countries. Food safety and gender both were considered to have a substantial effect on the acceptance of prolonged cow-calf contact. Meat consumption variable showed a greater impact on the acceptance of using colostrum and adding probiotics as yogurt or kefir compared to its effect on the acceptance of two other interventions. Detailed results by countries

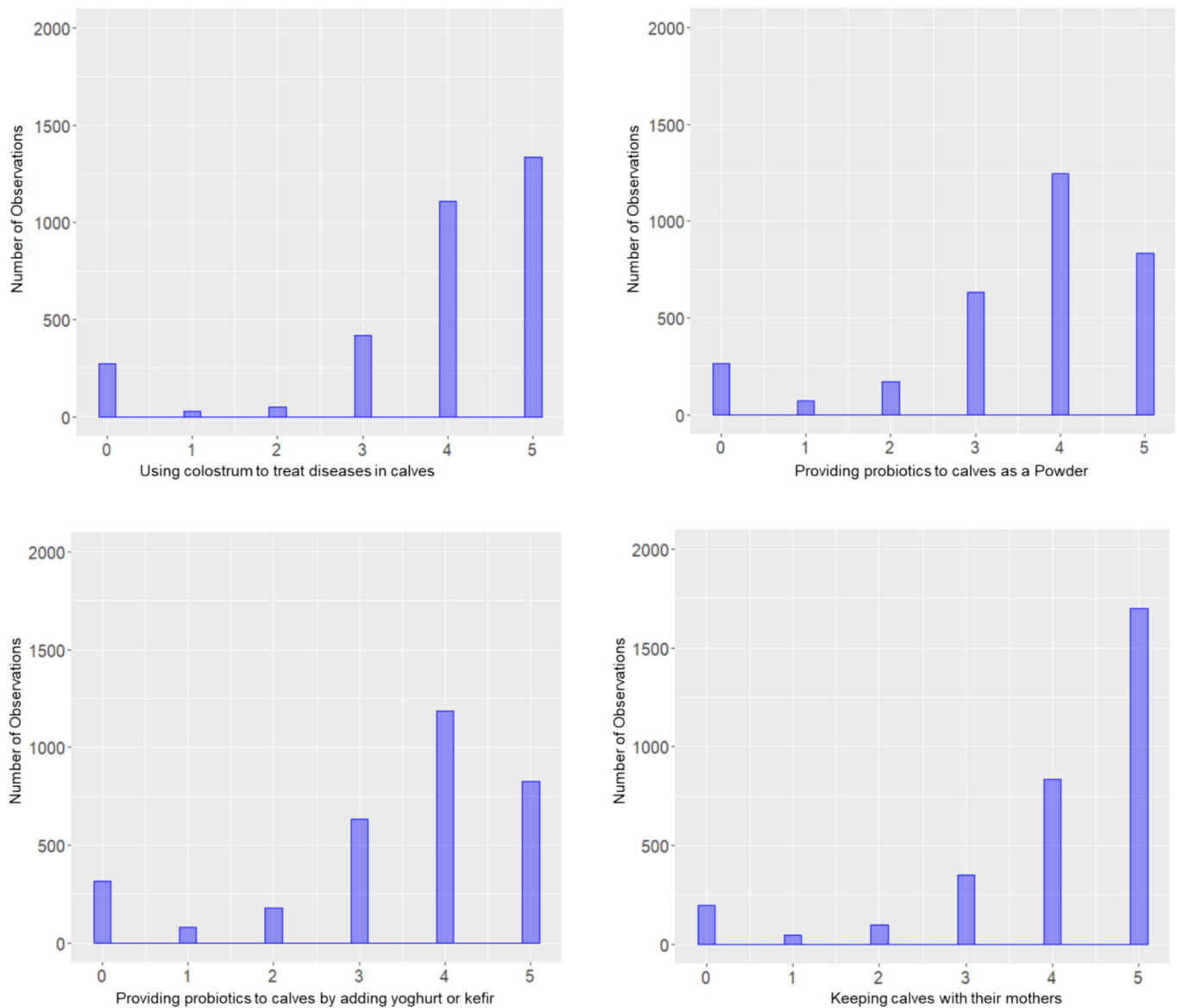


Fig. 1. Respondents' acceptance of using colostrum, providing mix probiotics powder, probiotics as yogurt or kefir, and prolonged cow-calf contact, measured using a 5-point Likert scale, ranging from 1 for strongly disagree to 5 for strongly agree, and 0 denoting 'I do not know'.

are shown in the supplementary material ([Supplementary Tables S1–S4](#)).

The role of additional information

To learn more about the role of knowledge and information in shaping responses, we implemented a deliberate strategy in which our sample was separated into two distinct groups. While the first group received concise and brief information about the interventions, the second group was provided with more comprehensive details (see the supplementary material). Results indicated that across all of our models, the provision of information was associated with a decrease in citizens' acceptance of proposed interventions. This means that citizens who received more information exhibited statistically significantly lower levels of acceptance compared to those who received less information. The magnitude of effect of additional information was the largest for the acceptance of prolonged cow-calf contact, while it was the smallest for the acceptance of using colostrum. Nonetheless, the magnitude of

the coefficient for additional information indicates that the association between the level of information and these dependent variables was still greater compared to most other independent variables. However, the sampling method used does not allow us to determine whether the responses are unbiased.

As a robustness check, we opted for an ordinal probit model over a linear one to analyse the models presented in [Table 5](#). Results are shown in [Supplementary Table S5](#). We found that the direction and statistical significance of the results align perfectly with those from the OLS regression previously presented. Moreover, the magnitude of the coefficients derived from the probit model was quite comparable to those from the OLS regression.

Discussion

This study aimed to consult a commercial consumer panel on four microbiome management measures in dairy calves and gained better knowledge on people's acceptance of various livestock measures. Our results indicate that among tested strategies, prolonged

Table 5

Estimated parameters of the regression analysis (Pooled model) used to identify respondents' attitudes and the socio-economic factors that underlie the variation in the acceptance of interventions.

Variable	Using Colostrum	Providing mix probiotics powder	Adding probiotics as yogurt or kefir	Prolonged cow-calf contact
Familiarity with farming systems and microbiome	0.061*** (0.008)	0.084*** (0.009)	0.061*** (0.009)	0.023*** (0.008)
Food safety	0.057*** (0.010)	0.048*** (0.012)	0.028** (0.012)	0.101*** (0.012)
Environmental awareness	0.011 (0.007)	0.002 (0.009)	0.015 (0.009)	0.010 (0.008)
Animal welfare	-0.026*** (0.009)	-0.013 (0.010)	-0.014 (0.011)	-0.011 (0.009)
Conscientious consumption preferences	0.014** (0.007)	0.009 (0.008)	0.013 (0.009)	0.020*** (0.007)
Cultural view on dairy consumption	0.042*** (0.006)	0.036*** (0.008)	0.051*** (0.008)	-0.015** (0.006)
Age	0.000 (0.001)	-0.004*** (0.001)	-0.002 (0.001)	0.004*** (0.001)
Gender	0.055* (0.029)	0.034 (0.035)	-0.034 (0.036)	0.134*** (0.032)
Education	0.018 (0.016)	0.049** (0.019)	0.058*** (0.020)	0.040** (0.017)
Income	0.019** (0.009)	-0.009 (0.012)	-0.013 (0.013)	-0.003 (0.010)
Meat consumption	0.112** (0.056)	-0.010 (0.065)	0.135** (0.067)	0.019 (0.054)
Dairy consumption	-0.006 (0.058)	0.102 (0.069)	0.132* (0.070)	0.061 (0.056)
Residence area	0.025 (0.033)	0.007 (0.040)	-0.070* (0.041)	-0.091** (0.038)
Level of information	-0.066** (0.028)	-0.150*** (0.034)	-0.084** (0.035)	-0.262*** (0.031)
Finland	0.465*** (0.047)	0.246*** (0.057)	0.320*** (0.057)	0.164*** (0.051)
Ireland	0.087* (0.045)	0.218*** (0.051)	0.202*** (0.051)	0.073 (0.048)
Poland	0.123*** (0.042)	0.212*** (0.050)	0.112** (0.052)	0.041 (0.046)
Intercept	1.831*** (0.141)	1.663*** (0.173)	1.519*** (0.172)	2.257*** (0.164)
F-test	43.85	23.61	19.23	29.08
Probability of F-test	0.000	0.000	0.000	0.000
R-squared	0.186	0.116	0.101	0.133
Number of observations	2 939	2 951	2 896	3 018

Note: We present coefficient estimates (SE) from an OLS regression with heteroscedasticity robust standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

cow-calf contact was the most acceptable measure in all countries (79% of responders agreed or strongly agreed). However, different perceptions on attitudinal values and socio-economic background influenced the level of acceptance. Furthermore, additional information provided to the respondent decreased the acceptance of measures. Regarding general acceptance of measures, previous studies also indicated that cow-calf contact is favoured by the public (Naspetti et al., 2021).

The role of attitudinal variables on strategy acceptance

Drawing from our findings, it was observed that respondents who exhibit a higher degree of familiarity with farming systems and microbiome were inclined to show greater acceptance of the four interventions in terms of magnitude of effect. This means that persons who have a better understanding of farming systems are more likely to embrace and accept a wide range of interventions related to farming practices. This finding is consistent with several other studies as documented by Clark et al. (2016). Similarly, we also observed that the favourable reception of the four interventions was strongly associated with improvements in participants' perceptions of food safety. This is compatible with the argument claiming that farming practices that are based on the principles

of naturalness and humane treatment lower health risks and increase the quality of animal products (Vaarst and Alrøe, 2012). Exploring the relationship between food safety concerns and consumer perception is especially important as studies show that consumers' concerns about the safety of food products derived from livestock are growing, and food retailers are actively looking for ways to reduce their liability (Ruegg, 2003).

The findings drawn from the observed data trends among respondents show that those consuming dairy products are more likely to accept using colostrum, providing a mix probiotics powder and probiotics as yogurt or kefir in calf management. This finding may reflect a growing consumer trend towards health consciousness and preference for natural products. Indeed, studies have shown a rising consumer interest in probiotics and products characterised by attributes such as 'animal welfare' (Alonso et al., 2020; Pimentel et al., 2021).

Interestingly, we found that participants who place a greater value on the cultural aspect of consuming dairy products were less likely to accept prolonged cow-calf contact. This finding may appear counterintuitive at first glance because one would expect the public to oppose early cow-calf separation. However, on commercial dairy farms in Europe, calves are typically separated from their mothers within a few hours after birth (Stěhulová et al.,

2008). Thus, one possible explanation for this finding is that social norms are often related to conservative and traditional farming practices, which in this case involve early separation of calves from their mothers, and therefore keeping calves with their mothers may deviate from these established norms.

Surprisingly, our results showed that respondents who were more concerned about animal welfare showed a lower acceptance for using colostrum to treat diseases in calves. The negative perception towards the use of colostrum to treat ill calves might be an indication that there is a knowledge gap among consumers regarding the functional benefits of colostrum as a natural remedy for calf diseases. Although there are no existing studies specifically addressing public acceptance of colostrum use in calf treatment, we reference research indicating diverse levels of awareness among pregnant women about colostrum's nutritional benefits (Reddy et al., 2015). This disparity suggests the importance of targeted educational initiatives to fill such knowledge gaps.

We also observed that respondents who prioritise quality food over cost were more likely to approve the use of colostrum to treat diseases in calves and were also in favour of keeping calves with their mothers. These persons may be willing to pay a premium for animal products that are produced in a humane and sustainable way, and even if the mentioned interventions involve additional costs (Cantor et al., 2021; Hötzel et al., 2017), they perceive them as healthier and more human than conventional alternatives. This also highlights the new consumer priorities towards more ethical consumption (Hölker et al., 2019). Finally, we found that the studied interventions were not related to respondents' environmental awareness. This result was not surprising because the four intervention measures were focused on animal health and welfare rather than the environment.

The role of socio-economic characteristics

Numerous studies have investigated the influence of the public's age on animal welfare concerns. Most of these studies have reported a negative association between the public's concern for animals and age (Clark et al., 2016; Knight et al., 2004; Serpell, 2004; Vanhonacker et al., 2010). This is consistent, at least partially, with one of our findings, since we observed that younger respondents were more willing to accept the use of probiotics as a powder. However, we also found that older participants tended to be more supportive of keeping calves with their mothers than young participants. These results may seem to be surprising, but they are not implausible. For instance, Boogaard et al. (2011) found that older Dutch citizens were more satisfied with contemporary management practices such as keeping calves with their mothers.

The level of education is another factor that can influence the public acceptance of more welfare-friendly practices (Ellis et al., 2009; Toma et al., 2012, 2011). Respondents who are more educated may have a better knowledge of the potential benefits of modern farming practices and, hence, are more likely to support measures that are healthier and more humane as a means of addressing sustainability challenges. Consistently, the level of education was found to have a positive and statistically significant effect on the acceptance of three of the studied interventions. Women are often thought to be more compassionate, as evidenced by the social roles they prefer to fill (Kendall et al., 2006), and this relates to their being more driven by welfare concerns, evaluating the issue more emotionally than men, and appearing to empathise with animals more (Graça et al., 2018). Our study indicated that being a female was positively associated with an increased acceptance of using colostrum and prolonged cow-calf contact. This result was also supported in previous studies (Paul and Podberscek, 2000; Sirovica et al., 2022). The findings also suggest

that income levels have a statistically significant impact only on the acceptance of using colostrum to treat diseases in calves.

The role of information in evaluating alternative livestock practices

The idea of exposing individuals to scientific information (such as contemporary animal welfare practices or new technology) is linked to the accessibility of scientific knowledge on the subject and an individual's ability to understand it (Schultz, 2002; Ziman, 1991). For instance, it is suggested that the lack of awareness about the causes and consequences of animal welfare issues underlies the unwillingness to support alternative and sustainable practices (Schröder and McEachern, 2004; Verbeke, 2009). This approach is rooted in the belief that addressing the knowledge gap, as discussed by Ingram (2008) and Šūmane et al. (2018), can reconcile public perceptions with the realities of agricultural practices, thereby promoting sustainable farming through a well-informed public discourse. Both studies emphasise the importance of narrowing this gap, which includes reconciling differences between agricultural professionals and the general public and melding both formal and informal knowledge sources. This effort aims to challenge mainstream narratives and enrich public discourse with authentic insights into farming, thereby correcting misconceptions and encouraging a well-informed view on sustainable practices. However, this idealistic view is contrasted by our findings, which indicate that increased information provision may paradoxically lead to reduced public acceptance of alternative management systems.

Contrary to the "information deficit-approach", suggesting that a better knowledge within the public about farming activities will increase the acceptance of alternative management systems (Brown, 2009; Sturgis and Allum, 2004), our findings align with previous studies showing that, while such strategies may increase the transparency of animal production, they have been found to be ineffective in increasing the acceptance for alternative management systems (Montossi et al., 2013). Furthermore, other research has shown that when people are given more information about particular issues, it might cause the reverse reaction, with people becoming even more critical towards these issues (Kellstedt et al., 2008; Schultz et al., 2016). The reasons could be different frames of reference used by specialists and the general public when interpreting this information, as well as diverging values among the individuals (Busch and Spiller, 2018). The public may also get confused when they are provided with more detailed information, which may contain both negative and positive aspects of farming. While it is essential to communicate coherent and fact-based messages to the public (Clark et al., 2019; Niemi et al., 2020), the current animal welfare labelling schemes often prioritise validating only a limited and easily understandable welfare attributes to the public (Stygar et al., 2022).

While our initial analysis highlighted how the amount of information influences public perception, integrating the concept of message framing, as discussed by Dearing and Lapinski (2020), adds a critical layer of understanding. For instance, they argue that reframing messages to highlight community health benefits rather than direct climate impacts can alter public receptivity towards new policies or technologies. This insight, combined with Busch and Spiller's (2018) findings, underscores that both the volume and presentation of information are essential in shaping public attitudes and willingness to support new agricultural practices.

The magnitude of effect

The magnitude of effect sizes in this study highlights the importance and relevance of different variables in specific contexts. Understanding these nuances is crucial for stakeholders who aim

to apply these findings to problem-solving strategies effectively. Food safety, being the attitude variable with the highest magnitude in association with the acceptance of prolonged cow-calf contact, underscores the critical role that health and safety perceptions play in consumer acceptance. Policymakers can leverage these insights to develop regulations and standards that ensure and communicate the safety of prolonged cow-calf contact, thereby enhancing public acceptance of these practices. The high magnitude of the positive association between being female and the acceptance of prolonged cow-calf contact suggests that gender-specific attitudes influence acceptance rates. Marketing professionals can design tailored communication strategies that effectively resonate with female consumers. Based on the finding that there is a strong association between meat and dairy consumption and the acceptance of using colostrum and adding probiotics as yogurt or kefir, food producers can develop and market products that align with the dietary preferences of meat and dairy consumers, emphasising the complementary health benefits of colostrum and probiotics. However, as indicated by the low R-square-values, the predictions of outcomes will be imprecise. The substantial negative association of additional information with the acceptance of prolonged cow-calf contact, compared to the other interventions, highlights the need for a strategic overhaul of communication approaches. This negative perception emerged after providing additional information, even though the practice was initially the most accepted one. Additional research is needed to further understand the specific reasons behind the negative perceptions and to identify the key areas of concern and confusion that consumers have about this practice.

Implications and study limitations

Our results suggest that the provision of information has a negative impact on the public acceptance of four animal welfare-related measures. This implies that policy makers and industry must consider tailoring information campaigns to ensure that the public is not overwhelmed with data that may hinder their acceptance of sustainable farming practices (Chong and Druckman, 2007). Furthermore, the disparities in perception across Europe suggest that future policies should be more contextualised for different regions than they have been in the past. Recognising the influence of age and gender, educational efforts can be targeted to specific demographic groups. For instance, older citizens and women may be more receptive to messages promoting the keeping of cows and calves together. Although this research has made the best use of the available data, it is acknowledged that the analysis relies on a cross-sectional dataset. In future research, using panel data would enable a more robust analysis, particularly in addressing time-invariant unobservable heterogeneity. For instance, it would be of interest to explore how cultural values influence the reception of alternative management practices by following a sample of citizens for an extended period. We also acknowledge that our study design might not have fully accounted for the nuanced ways in which different types of information impact public acceptance of studied interventions. Hence, another future avenue for research is to employ a factorial design to systematically vary the initial definitions of targeted practices and the subsequent information layers to better understand their separate and combined effects on public acceptance. Additionally, it would be beneficial to incorporate a qualitative approach to more accurately capture the nuanced effects of information provision on public acceptance of studied interventions. Utilising qualitative methods such as interviews, focus group discussions, or content analysis could provide deeper insights into the complexities of public perception and acceptance. In this context, another valuable direction for future

research would be to conduct an in-depth study on the criteria and processes used in selecting information for public dissemination. This study should explore how different types of information are prioritised, the role of media and governmental agencies in this selection, and the impact of these decisions on public perception and behaviour. Finally, an interesting direction for future research would be to compare our findings to those from developing countries.

Conclusion

In conclusion, using colostrum to treat diseases in calves and keeping calves with their mothers for an extended period are interventions that are widely accepted by a European commercial consumer panel. Acceptance is more common among respondents who are familiar with farming systems and microbiome, and place a greater emphasis on food safety. Our findings highlight the importance of taking into account age and gender when aiming at understanding the public's preferences to support sustainable farming practices. The results suggest that providing additional information about farming practices does not necessarily increase the acceptance of these practices. Hence, care should be taken to design messaging that is understandable to the laymen, fact-based and coherent across communication channels.

Supplementary material

Supplementary material to this article can be found online at <https://doi.org/10.1016/j.animal.2024.101380>.

Ethics approval

An informed consent was obtained at the time of original data collection. The data were anonymised, and the research team did not have access to personal data of respondents. According to the guidelines (TENK, 2019), an ethical review (e.g., considering potential risks and harm that may be caused to research participants, their families and the researchers themselves due to the research or its results) by the Ethics Committee for Human Sciences (University of Turku, 2023) before data collection was not required for this survey, because the research design did not contain elements requiring ethical review (TENK, 2019, p. 61).

Data and model availability statement

The data were not deposited in an official repository, but they are available from the authors upon request.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) did not use any AI and AI-assisted technologies.

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Declaration of interest

None.

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