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How do we feed our livestock? Knowledge, perceptions and informational needs of the public and farmers in Germany

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Little is known about knowledge and perceptions of the public and farmers on livestock feed. However, it is important to know their perspectives to find widely accepted and sustainable solutions in agriculture, which account for animal welfare, societal expectations, economy and the environment alike. Therefore, the objective of the present study was to assess knowledge, perceptions and informational needs regarding livestock feed among the general population and farmers. A German-wide online survey was conducted with n = 1000 participants from the general population (representative for age and gender) and n = 251 farmers. Differences in answers were compared between the general population and farmers as well as between subgroups of the general population. Results indicate that the public is correctly informed about some livestock feeds, although knowledge gaps and misconceptions became evident. The general population rated potatoes, fodder beets, kitchen waste and bread as common feedstuffs for pigs, which was rather a common practice in smallholder "backyard" pig husbandry several decades ago. Ratings of relevant aspects of feed differ between the two groups and partially depend on sociodemographic variables (i.e. gender, rural/urban upbringing, age) in the general population. Farmers were more likely to have heard and know the meaning of the term feed additives and are better informed about the functions that are fulfilled by feed additives. Farmers also expressed higher agreement for use of most alternative feeds than participants from the general population, although no differences of acceptance levels were found for algae, insects, animal by-products and fungi. In the group of the general population, 56% agree with the use of cereals and only 17% with the use of soy as livestock feed. When asked for the level of knowledge on livestock feed, 42% of participants from the general population indicate low or very low knowledge, whereas 97% of farmers judged the knowledge among the public to be low or very low. Both groups rate the need for information on controls of feed highest. Providing more information on livestock feed to the public seems necessary to improve knowledge, increase acceptance of alternative feeds and of sustainable solutions in agriculture.

KEYWORDS

feed, feed additives, alternative feed, perception, knowledge, survey study

1 Introduction

Livestock farming, and animal welfare in particular, have increasingly gained political and social importance, which is reinforced by the media and public discussions (Thompson et al., 2011; Spiller et al., 2012). Animal feeding is an important part in livestock farming and one of the major challenges facing agriculture today. The ongoing paradigm shift in Germany includes the question how to feed and nourish livestock in a way that takes into account animal welfare, consumer expectations on product quality and price, economical aspects for farmers alike and the environment. Climate change, global population growth and related food security as well as society's awareness of sustainability is putting additional pressure on agriculture. Consumers in Western societies not only expect healthy and safe food of high quality, but are also increasingly interested in the way food is produced (Altmann et al., 2022). In particular, the current system for livestock farming, which has partly developed into a highly mechanized and resource intensive sector, is in the spotlight of criticism (Krystallis et al., 2009; Christoph-Schulz et al., 2015; Brem, 2019). Additionally, several food safety incidents have damaged consumer trust in existing complex food supply chains in recent years. Well-known examples are several dioxin contamination incidents of foods of animal origin due to contaminated feed (Hoogenboom et al., 2020); or the misuse of fipronil as insecticide, which led to fipronil contamination of eggs in Europe and other countries in 2017 (Stafford et al., 2018). Against this backdrop, consumers generally expect more transparency in production, processing, trade and consumer protection. Even more, certain sectors of society expect to be provided with comprehensive, concrete and comprehensible information (Brem, 2019), which is why livestock nutrition has also moved to the forefront of public interest (Stranieri and Banterle, 2009). The role of livestock nutrition in developing foods that promote long-term human well-being has become increasingly important (Pinotti et al., 2014).

Food of animal origin contributes significantly to the supply of consumers with energy, protein and essential micronutrients (Beal et al., 2023). In addition, Europe is one of the leading feed compound producer worldwide (FEFAC, 2023). The increase in feed production is both the cause and the consequence of the intensification of livestock farming. As feed costs are a central economic factor for livestock farming (Schoof et al., 2020), a relatively high share of feed ingredients, in particular cereals and soybeans, are imported due to comparative cost advantages. This forms a field of conflict against the backdrop of climate change and society's expectation for resource-efficient production (Brem, 2019). Ultimately, the task of policy makers, science and agricultural practice is to discuss conditions and upcoming developments in society, economy, technology and environment. Answers and solutions must be found and general conditions must be designed in such a way that animal production processes are economically viable on the one hand and accepted by society on the other hand (Brem, 2019).

Against the backdrop of the paradigm shift that requires sustainable solutions, perception and knowledge of the public and farmers are of great importance. The question arises, what is known about the public's level of knowledge and expectations, as well as farmers' positions on livestock nutrition? First, there is little research on farmers' perceptions and knowledge of feed (Becker et al., 2018). Moreover, society's perceptions of contemporary agriculture have been investigated in several national and cross-national studies, however, mainly in relation to animal welfare (Christoph-Schulz et al., 2015). Only few studies address public perceptions of animal feed when purchasing livestock products. To date, most studies in this context refer to feed that is free of genetically modified organisms (GMOs) (Wägeli and Hamm, 2016).

However, differences in attitudes, perceptions and knowledge regarding animal feeding need to be taken into account in political decision making on agriculture developing an appropriate regulatory and market environment in order to achieve sustainability goals and meet society's expectations. Moreover, in order to counteract the threat of acceptance loss and thus the loss of the "license to produce", it is essential for farmers to know how the general population perceives livestock nutrition (Christoph-Schulz et al., 2018).

The objective of our study was to shed more light on knowledge, opinions, expectations and informational needs concerning livestock feed and feeding of the general population and farmers. To the best of our knowledge, this is the first study focused on general livestock feeding comparing the general population with farmers. A Germany-wide online survey was conducted with 1000 participants from the general population and 251 farmers to quantitatively capture the perception and knowledge regarding feeding and to examine to what extent they differ between the two groups. Furthermore, we have examined differences between genders, ages, and urban and rural populations in the group of the general population.

2 Methods and materials

2.1 Participants

Two groups of participants were included in the study. The first group consisted of n = 1000 participants from the general population, who did not work in agriculture, animal feed industry or associations from the agricultural sector. Participants had to be at least 18 years old to participate in the survey and were selected based on representative quota according to gender and age for the German population. To additionally compare results between urban and rural populations, participants were evenly distributed by place of residence (rather urban/rather rural).

The second group consisted of n = 251 farmers. All farmers included in the study had to be at least 18 years old and responsible or involved in selection and purchase of feed. Farmers were selected based on quota according to age and type of animal kept on the farm (cattle and other ruminants, pigs, poultry). For all type of animals, minimal numbers of animals that farmers had to keep were set.

Table 1 includes sociodemographic data of the two participant groups. Additional information on sociodemographic data of both

groups and details on the farms can be found in the online Supplementary Material (Supplementary Table S1–S3).

The market research institute Produkt + Markt GmbH was responsible for recruitment and data collection. All participants provided informed consent prior to study participation. The study was conducted in conformity with the Declaration of Helsinki. Ethical approval was not required for this study for the following reasons: the study did not involve deception, any risks, interventions or experimental manipulations. No vulnerable persons participated in the study and no medical data or sensitive information was collected. Therefore, no ethical approval was obtained for this study.

2.2 Study design

The survey was conducted as an online self-completion questionnaire and ran between 30th August and 13th September 2022. Participants were recruited via an existing online panel. Both questions and response categories were developed based on results from focus group discussions that preceded this study (further information on the focus group discussions can be found in the Supplementary Information SI1). Questionnaires for the general population and farmers were in large parts identical. However, some questions differed for the two groups since varying information needed to be obtained or questions seemed not suitable for both groups. Responses to all questions were voluntary and participants were always given the opportunity to choose the response category "don`t know/no answer".

The online survey was structured as follows: First, participants answered sociodemographic questions that were required for quota control and to screen participants for inclusion criteria (general population: gender, work area, place of residence, region; farmers: gender, age, conventional/organic farm type, type and number of farm animals, involvement in selection and purchase of feed).

The next questionnaire block included questions on knowledge of feeds. Participants from the general population were asked which feeds are fed to farm animals. Participants could choose from a list of potential feeds (including options that are forbidden under current regulations) for three different animal types (cattle, pigs, poultry). In the next question, both groups were then asked to indicate the importance of different aspects with regard to feeding and nutrition of animals using a response scale of 1 (not at all important) to 5 (very important).

In the next block of questions, knowledge and perceptions of feed additives were assessed. Both groups were asked whether they had already heard about the term feed additives. All participants, irrespective of their knowledge of the term, could then indicate up to three functions that are fulfilled by additives in feed (open-ended question).

In the next block, participants were asked on their opinion to use various alternative feeds in the feeding of farm animals. Twelve feeds were presented and participants should indicate whether the respective feed should be used on a response scale from 1 (definitely not) to 3 (definitely yes).

The last block of questions dealt with the level of knowledge and informational needs of participants. Participants of the general population were asked to rate their level of knowledge of feeding and nutrition of farm animals using a response scale ranging from 1 (very low) to 5 (very high). Using the same response scale, farmers were asked to rate the level of knowledge of the public, i.e. persons without any close relation to agriculture. Last, participants from the public were asked to indicate their desire to learn more about different topics regarding the feeding and nutrition of farm animals on a response scale ranging from 1 (very low) to 3 (very high). Farmers were asked to rate the importance of communicating different topics to the public on a response scale ranging from 1 (not important) to 3 (important). The questionnaire comprised additional questions that are not included here since they are beyond the scope of the present paper. Results based on these additional questions will be published separately. The complete questionnaire can be found in the Supplementary Information.

To further characterize the sample, the survey ended with additional sociodemographic questions (general population: diet, size of household; farmers: agricultural professional degree, time in farming) and questions regarding the farm structure (region, size of agricultural land, types of feed).

TABLE 1 Sociodemographic characteristics of participants from the general population and farmers.

Variable	General Population (n = 1000)	Farmers (n = 251)
Gender (%)		
Male	50.30	90.04
Female	49.40	9.96
Diverse	0.30	0.00
Age (%)		
18 – 39 years	39.20	23.51
40 – 59 years	42.80	55.38
60 years and older	18.00	21.12
M (SD) [1]	46.82 (13.98)	49.10 (11.48)
Region (%) [2]		
Northern states	19.00	33.86
Western states	36.10	21.51
Eastern states	18.50	11.95
Southern states	26.40	32.67

[1] M = mean; SD = standard deviation.
[2] Northern states = Bremen, Hamburg, Mecklenburg Western Pomerania, Lower Saxony, Schleswig Holstein; Western states = Hesse, North Rhine-Westphalia, Rhineland Palatinate, Saarland; Eastern states = Berlin, Brandenburg, Saxony, Saxony-Anhalt, Thuringia; Southern states = Baden-Württemberg, Bavaria.

2.3 Data analysis

Data was screened for inconsistencies, implausibility and conspicuous response patterns (i.e. speeding or straight-lining). Data procession and analysis was conducted using RStudio (version 4.2.2; R Core Team, 2022). The significance level was set to $p < 0.05$. For descriptive analyses, means (M) were calculated for continuous data, medians (Mdn) for ordinal data and percentages for categorical data. Differences in answers between the general population and farmers were analyzed using Chi-squared (X^2) tests. Ordinal data was analyzed using Wilcoxon rank-sum tests (W). As measures for effect sizes, Cramer's V was calculated for categorical data and the rank-biserial correlation r for ordinal data using the package effect size (Ben-Shachar et al., 2020). Effect sizes were interpreted according to the guidelines of Cohen (Cohen, 1988) (see Supplementary Table S4 in the Supplementary Materials). For the general population, differences for gender and upbringing (rather rural/rather urban) were analyzed in addition. For assessing potential associations of answers with age, Kendall's τ was calculated. For the farmers, results of subgroups were only compared on a descriptive level due to small sample sizes.

Responses of the open-ended questions regarding the assumed functions of feed additives were coded as follows: in a first step, categories were derived from the legal text on additives for use in animal nutrition of the European Union (Article 5 of Regulation (EC) No. 1831/2003 of the European Parliament and of the Council) (Regulation 1831/2003). These categories included the following functions:

(1) favorable influence on the characteristic of feed (e.g. taste, preservability, optimization of the feed, increase of feed intake);
(2) favorable influence on the characteristic of animal products (e.g. colorant, higher quality of meet, size of the eggs);
(3) satisfaction of nutritional needs of animals (e.g. covering nutritional needs, improved amylolysis, improved phosphorus utilization);
(4) favorable influence on the performance of animals (e.g. promotion of growth, increase in performance and productivity, weight increase, strengthening);
(5) favorable influence on digestibility or utilization of feed (e.g. improved digestibility, improved tolerance, intestinal health, improved utilization of feed);
(6) favorable influence on animal welfare;
(7) favorable influence on the environmental consequences of animal production (e.g. reduced environmental impact, less emissions, less nitrogen/phosphorus excretion);
(8) cocciodiostatic effect (i.e. drugs that are used to prevent and treat coccidiosis, an intestinal disease caused by certain protozoa)

For answers that did not fall into these categories, further categories were created based on the answers. Responses could fall into more than one category.

3 Results

3.1 Knowledge of different feeds

Figure 1 shows the results of the question to the general population on which feeds are fed to farm animals. More than half of the participants thought that hormones and antibiotic growth promoters are fed to all types of farm animals (i.e. cattle, pigs, poultry). Similarly, between 25% and 48% of participants assumed that meat and bone meal as well as fishmeal are fed to farm animals. Regarding the feeding of cattle, grass and hay were indicated as feed by 84% and 80% of participants respectively. Furthermore, about three quarters of participants stated that concentrated feed (75%), potatoes (75%), fodder beet (73%) and kitchen waste or residues from food industry (71%) are fed to pigs.

3.2 Relevant aspects of feeding and nutrition of farm animals

Rating of relevant aspects of feeding and nutrition of farm animals was compared between the general population and farmers using Wilcoxon rank sum tests. Table 2 displays the comparison of the average ratings of relevant aspects of the two target groups and the results of the Wilcoxon rank sum tests. In general, most listed aspects were rated to have a rather high relevance for both groups. Participants from the general population rated controls of feed, safety of feed and species-appropriate feed as the three most important aspects. For farmers, quality of feed, feed that meets the nutritional needs, safety of feed and optimal growth of feed were rated as the aspects with the highest relevance. Significant differences were found for all aspects except for the origin of feed. Biological cultivation of feed and climate-neutral production of feed are rated as important by the general population, whereas these aspects are less relevant to the farmers.

Furthermore, the specific aspects controls of feed, safety of feed, climate-neutral production of feed, biological cultivation of feed and origin of feed were compared between women and men in the group of the general population (see Table 3 for detailed results). Significant differences between women and men were found for the aspects controls, safety, biological cultivation and origin. Women rated these aspects as more important than men, although effect sizes for all comparisons were small. No differences were found for the aspect climate-neutral production.

In addition, these aspects of feed were also compared between participants with a rather urban upbringing and participants with a rather rural upbringing (see Table 3 for detailed results). A significant difference was found for the aspect origin of feed, with participants with a rather rural upbringing rating the origin as more important compared to participants with a rather urban upbringing, although the effect size is only small. No differences between the two groups were found for the other aspects.

Moreover, correlations of the ratings of these aspects of feed and age of participants from the general population were calculated using Kendall's τ. The age of participants positively correlated with

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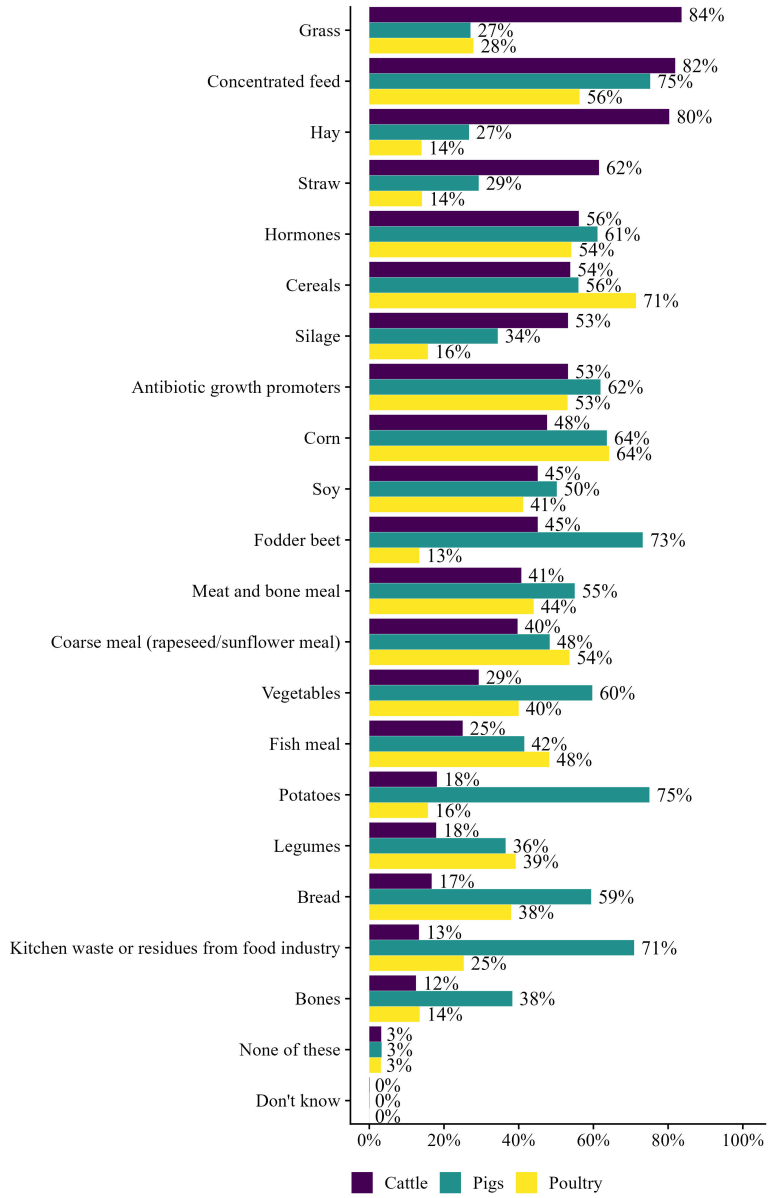

FIGURE 1
Feeds that are fed to cattle (purple), pigs (turquoise) and poultry (yellow) according to the general population (n = 1000). Answers represent the percentage of participants that indicated that the respective feed is fed to cattle, pigs or poultry.

ratings of safety ($\tau = 0.06$, $p = 0.01$) and origin ($\tau = 0.07$, $p = 0.005$). The older the participants were, the more important they rated the aspects safety and origin of feed. No significant correlations were found between age and the aspects controls of feed ($\tau = 0.04$, $p = 0.09$), climate-neutral production ($\tau = 0.02$, $p = 0.52$) and biological cultivation ($\tau = -0.02$, $p = 0.33$).

3.3 Knowledge and functions of feed additives

In the group of the general population, 20% of participants indicated that they have already heard the term feed additives and knew what was meant by it, whereas 48% of participants have heard the term, but did not know what was meant by it. In the group of the farmers, 68% knew the term and its meaning and 27% indicated that they have heard the term, but did not know what was meant by it (see Figure 2 for detailed results). Farmers were more likely to have heard and also know the meaning of the term compared to the general population ($X^2(1) = 222.77$, $p < 0.001$, $V = 0.42$). For the farmers, associations of knowledge of the term feed additives and different sociodemographic variables were examined (see Supplementary Table S5 in the Supplementary Materials for detailed results). No associations of knowledge with time in farming and size of agricultural land were observed. Regarding the agricultural professional degree, participants with agricultural studies and participants with no agricultural training seemed to more likely to have heard and also know the meaning of the term

feed additives. However, these results should be interpreted with caution due to the low sample sizes in some subgroups.

All participants, irrespective of their knowledge of the term, could then name up to three functions that are fulfilled by additives in feed. Figure 3 displays the results of the assumed functions that are fulfilled by feed additives. In the group of the general population, the most mentioned functions of feed additives were a favorable influence on the performance of animals (62%), the preservation of health/prevention of diseases (29%) and the satisfaction of nutritional needs (20%). Moreover, 14% of participants from the general population indicated that feed additives do not have any function or that they do not know the function or preferred to give no answer. In addition, 8% of participants mentioned that feed additives are used for the administration of antibiotics or medication. On the contrary, in the group of the farmers, the most mentioned functions of feed additives were a favorable influence on digestibility or utilization of feed (45%), a favorable influence on the characteristics of feed (41%) and the satisfaction of nutritional needs of the animals (39%).

3.4 Alternative feeds

Levels of agreement to use various alternative feeds in the feeding of farm animals were compared between the general population and farmers using X^2-tests. Table 4 displays the level of agreement on different alternative feeds of both groups and results of the respective X^2-tests. In general, farmers reported a higher level of agreement for most alternative feeds. Cereals had the highest level of agreement both among participants from the general population (56%) and farmers (97%). Significant differences between participants from the general population and farmers were found for all alternative feeds, except for algae, insects, fungi and animal by-products.

3.5 Level of knowledge

In the group of the general population, 42% of the participants assessed their level of knowledge on feeding and nutrition of farm animals to be low or very low and 48% as medium. On the contrary, 97% of the farmers judged the level of the general population to be low or very low (see Figure 4 for detailed results). Participants from the general population rated their knowledge on feeding and nutrition of farm animals significantly higher than farmers (general population: $M = 2.61$, $SD = 0.79$, $Mdn = 3$; farmers: $M = 1.41$, $SD = 0.65$, $Mdn = 1$; $W = 215897$, $p < 0.001$, $r = 0.74$).

In the group of the general population, no differences in level of knowledge were found between participants with rural ($M = 2.61$, $SD = 0.77$, $Mdn = 3$) and urban upbringing ($M = 2.65$, $SD = 0.82$, $Mdn = 3$; $W = 100596$, $p = 0.45$, $r = -0.03$). Similarly, no differences were observed between participants with different diets (vegan: $M = 2.82$, $SD = 0.88$, $Mdn = 3$; vegetarian: $M = 2.69$, $SD = 0.83$, $Mdn = 3$; mixed diet: $M = 2.60$, $SD = 0.79$, $Mdn = 3$; Kruskal-Wallis H test: $X^2(2) = 0.78$, $p = 0.68$).

3.6 Informational needs

The desire of the general population to learn more about different topics regarding the feeding and nutrition of farm animals was compared to the farmers' ratings of the importance to communicate these topics to the public using X^2-tests. Table 5 displays the ratings of both groups on the different topics and results of the respective X^2-tests. Controls of feed was rated as the topic with the highest informational need of both participants from the general population (54%) and farmers (61%).

4 Discussion

4.1 Knowledge of different feeds

The results indicate that the general population has correct knowledge about some feeds that are fed to different farm animals, e.g. in the case of poultry, which is mainly fed with cereals. However, the assumption of the general population that hormones and antibiotic growth promoters are still used in animal feed might either reflect a misconception due to a lack of information or a major concern of the public that hormones and antibiotic growth promoters might also arrive in animal products. In line with the latter point, results of the latest Eurobarometer on Food Safety in the EU revealed that antibiotic, hormone and steroid residues in meat are among the main concerns when it comes to food for 39% of respondents (European Food Safety Authority, 2022). However, hormones, antibiotic growth promoters as well as meat and bone meal are banned in the EU. (for a detailed description of the correspondent laws and regulations see Supplementary Information SI2).

Furthermore, the results show that the general public's knowledge of animal nutrition is partly outdated or corresponds to a romanticized view of agriculture. This is particularly evident in the case of pig feeding, where the general public has indicated feedstuffs such as potatoes, fodder beet, kitchen waste and bread as the usual diet. However, this reflects the small-scale "backyard" pig farming of several decades ago. As early as 2002, the European Union banned the feeding of food and kitchen waste because this has repeatedly led to outbreaks of animal diseases (Regulation 1774/2002). The same applies to the perception of cattle nutrition, which the public primarily associates with pasture and hay feeding. However, most cattle in Germany are fed silage, often all year round. Structural change in agriculture has led to a closure of many small farms on fewer and concentration of larger farms, resulting in an intensification of animal husbandry systems and a specialization of animal nutrition with regard to animal health and performance. Structural change has also widened the gap between agriculture and the consumer. One could conclude from this that knowledge about animal nutrition in Germany is often passed on from older generations to younger generations and that the media and advertising contribute to a romanticized perception (Krystallis et al., 2009).

TABLE 2 Comparisons of the ratings of relevant aspects of feed between the general population and farmers.

Aspect	General population			Farmers			Test statistic and p-value[4]	Effect size[5]
	n[1]	M (SD)[2]	Mdn[3]	n	M (SD)	Mdn		
Controls of feed	990	4.44 (0.71)	5	251	4.12 (0.78)	4	W = 154196, p < 0.001	r = 0.24
Safety of feed	984	4.36 (0.74)	4	251	4.53 (0.62)	5	W = 108619, p = 0.001	r = -0.12
Species-appropriate feed	988	4.35 (0.79)	5	251	4.11 (0.78)	4	W = 146936, p < 0.001	r = 0.19
Quality of feed	988	4.30 (0.75)	4	251	4.68 (0.48)	5	W = 89285, p < 0.001	r = -0.28
Feed that meets the nutritional needs	985	4.30 (0.74)	4	251	4.65 (0.53)	5	W = 91721, p < 0.001	r = -0.26
Ingredients of feed	982	4.28 (0.76)	4	251	4.43 (0.62)	4	W = 111860, p = 0.01	r = -0.09
Origin of feed	983	3.90 (0.94)	4	251	3.86 (0.90)	4	W = 127921, p = 0.34	r = 0.04
Climate-neutral production of feed	981	3.78 (0.97)	4	249	3.08 (0.92)	3	W = 170605, p < 0.001	r = 0.40
Biological cultivation of feed	979	3.74 (0.99)	4	248	2.25 (1.09)	2	W = 202787, p < 0.001	r = 0.67
Costs of feed	969	3.70 (0.92)	4	251	4.41 (0.65)	4	W = 68249, p < 0.001	r = -0.44
Optimal growth of animals by the feed	980	3.63 (1.01)	4	251	4.53 (0.59)	5	W = 58910, p < 0.001	r = -0.52
Availability of feed[6]	–	–	–	251	4.48 (0.56)	5	–	–

The response scale ranged from 1 (not at all important) to 5 (very important).
[1]Respective number of participants can differ between items since participants choosing the response option "no answer" were excluded from the analysis of the respective item.
[2]M = mean, SD = standard deviation.
[3]Mdn = Median.
[4]W = Wilcoxon rank-sum test.
[5]r = rank-biserial correlation.
[6]Aspect only included in item list for farmers.

4.2 Relevant aspects of feeding and nutrition of farm animals

The general population and farmers differ in what they consider as relevant with regard to feeds. For the general population, safety and control of feed seems to be of great importance, which most probably reflects their wish for safe and controlled food. For instance, the special Eurobarometer on food safety in the EU revealed that food safety is among the most important factors for Europeans when buying food items (European Food Safety Authority, 2022). In addition, species-appropriate feed and feed that meets the nutritional needs appear to be of relatively high importance for the general population. Both, the relevance of safety and animal welfare aspects might reflect the media focus on feed safety incidents (e.g., fipronil in egg) and animal welfare in the context of animal production, which certainly has a significant influence on the opinion formation among the public. Moreover, since feed also has an impact on the animal products, safe and controlled feed might therefore also be of importance to the public.

Besides safety of feed, farmers rate quality, feed that meets the nutritional needs of the animals and optimal growth of animals by the feed as most important aspects and thus aspects that are more focused on the welfare and needs of their animals. The public places a greater value on sustainability aspects, such as climate-neutral and biological cultivation of feed. Since farmers are primarily interested in securing their livelihoods, economic factors, such as costs of feed, optimal growth of animals by the feed and availability of feed play a greater role.

The importance of aspects was further dependent on sociodemographic characteristics (i.e. gender, upbringing, age) of the general population. A previous study showed that women and younger persons expressed higher concerns about animal welfare in U.S. food production (McKendree et al., 2014). An EU-wide survey revealed that women were more likely to be interested in the topic of food safety than men and older respondents rated food safety as important aspect when buying food (European Food Safety Authority, 2022). Similarly, women rated safety and controls of feed as more important compared to men in the present study. In addition, a higher age of respondents was associated with higher importance ratings of feed safety. This may indicate that major food incidents that occurred further in the past, such as BSE and the Belgian dioxin incident, were more perceived by the older population. Moreover, females were found to have a more positive attitude towards organic food compared to men (Lockie et al., 2004; Stobbelaar et al., 2007). In line with this, women also rated biological cultivation of feed as more important compared to men.

4.3 Knowledge and functions of feed additives

The general population is less informed about the existence and functions of feed additives compared to farmers, since the topic of livestock feed and also feed additives is rarely addressed in media. According to the general population, the main function of feed additives is the favorable influence on animal performance and the satisfaction of nutritional needs of animals. Most of the mentions do not correspond to official functions, which demonstrates the knowledge gaps or misunderstanding of feed additives in the

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TABLE 3 Comparisons of the ratings of a subset of relevant aspects of feed between both women and men as well as between participants with rather urban and rather rural upbringing from the general population.

Aspect	Group of comparison						Test statistic and *p*-value[4]	Effect size[5]
	Women			Men				
	n[1]	*M* (*SD*)[2]	*Mdn*[3]	*n*	*M* (*SD*)	*Mdn*		
Controls of feed	490	4.52 (0.66)	5	497	4.36 (0.74)	4	$W = 106921$, $p < 0.001$	$r = -0.12$
Safety of feed	485	4.43 (0.71)	5	496	4.29 (0.76)	4	$W = 108044$, $p = 0.002$	$r = -0.10$
Biological cultivation of feed	481	3.88 (0.94)	4	495	3.60 (1.03)	4	$W = 101527$, $p < 0.001$	$r = -0.15$
Origin of feed	486	4.04 (0.86)	4	494	3.77 (0.99)	4	$W = 102886$, $p < 0.001$	$r = -0.14$
Climate-neutral production of feed	483	3.85 (0.89)	4	495	3.72 (1.04)	4	$W = 113078$, $p = 0.12$	$r = -0.05$
	Rather urban upbringing			Rather rural upbringing				
	n	*M* (*SD*)	*Mdn*	*n*	*M* (*SD*)	*Mdn*		
Controls of feed	386	4.41 (0.74)	5	538	4.46 (0.69)	5	$W = 101416$, $p = 0.49$	$r = -0.02$
Safety of feed	386	4.33 (0.76)	4	532	4.36 (0.73)	4	$W = 100885$, $p = 0.62$	$r = -0.02$
Biological cultivation of feed	382	3.68 (1.00)	4	533	3.78 (0.99)	4	$W = 96775$, $p = 0.18$	$r = -0.05$
Origin of feed	384	3.78 (0.99)	4	534	4.00 (0.87)	4	$W = 91084$, $p = 0.002$	$r = -0.11$
Climate-neutral production of feed	384	3.82 (0.94)	4	533	3.76 (0.99)	4	$W = 104317$, $p = 0.59$	$r = 0.02$

The response scale ranged from 1 (not at all important) to 5 (very important).
[1]Respective number of participants can differ between items since participants choosing the response option "no answer" were excluded from the analysis of the respective item.
[2]*M* = mean, *SD* = standard deviation.
[3]*Mdn* = Median.
[4]*W* = Wilcoxon rank-sum test.
[5]*r* = rank-biserial correlation.

general population. The relative high mention of the factor performance could reflect the skepticism of the public that livestock is primarily about efficiency and less about animal welfare. The mention of the administration of antibiotics/medicines could also be seen in this context. In line with this, a previous German study with focus groups showed that participants from the general population criticized that concentrated feed is primarily fed to dairy cows to increase the milk yield (Christoph-Schulz et al., 2015). In this study, participants also expressed that concentrated feed contains additives such as vitamins and minerals, which were not perceived as generally negative. However, it was criticized that antibiotics and further medical products are added prophylactically to prevent infections and to enhance animal performance (Christoph-Schulz et al., 2015). Furthermore, the results show that farmers have a sound knowledge of feed additives, as their answers largely correspond to the functions listed in the legal text and are relatively homogeneously distributed.

There are knowledge gaps in both groups regarding the influence of feed additives on animal welfare. However, the fact that farmers did not mention these aspects could mean that, although they are not aware of this function, they still fulfill it by applying feed additives. Educating farmers in this regard could increase their awareness of their contribution to animal welfare and environmental protection and improve their image in society. This

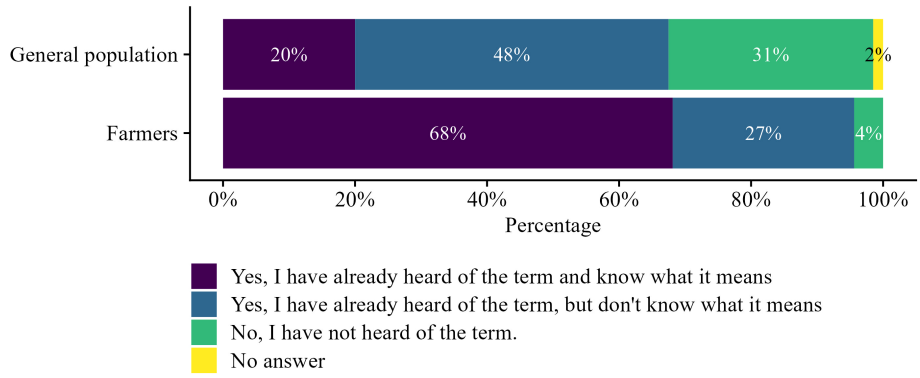

FIGURE 2
Knowledge of the term feed additives in the general population (n = 1000) and among farmers (n = 251).

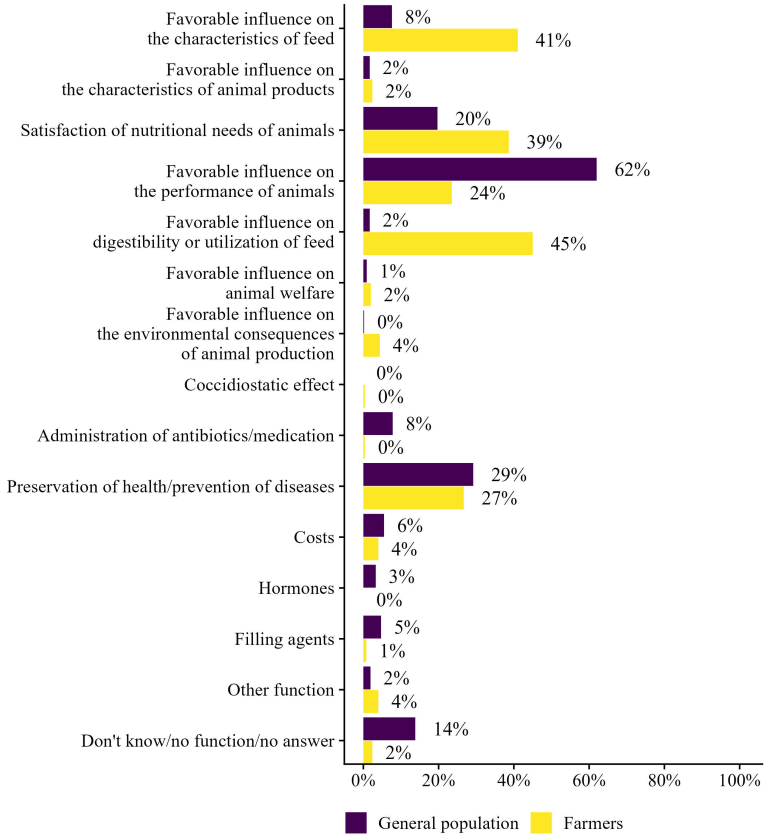

FIGURE 3
Assumed functions of feed additives according to the general population (purple, *n* = 1000) and farmers (yellow, *n* = 251). Answers represent the percentage of participants that named the respective function.

could be an opportunity to reduce the existing tensions between farmers and society in terms of different values through certain information campaigns or food labeling.

4.4 Alternative feeds

Only about half of the general population agree with the use of cereals as feed alternatives which actually is the main component in the compound feed industry in Germany (FEFAC, 2023), reflected also in the high acceptance of farmers. Furthermore, the same acceptance of soy is very low, which is however the second most important feed ingredient and the main source of protein in the feed industry with the highest import volume (FEFAC, 2023). The use of old bread and plant-based residues from food industry, on the other hand, enjoys higher acceptance among the general population. A possible explanation for this could be that these feeds are more familiar than soy, which is not traditionally grown and consumed in Germany. Moreover, the question of feed origin and the higher acceptance of regionality suggested by the answers could also play a role here, as could the lack of knowledge about the actual import of feed. In a study on local feed, it was found that relatively high share of German consumers did not know the details of feed imports for animal production in farming from which it was concluded that feed origin is currently not a well-communicated topic in food promotion (Profeta and Hamm, 2019a).

The general population and farmers are at about the same agreement level when it comes to the use of algae and insects as feed alternatives. These are referred to as novel feeds in literature and have received a lot of attention in the research in recent years as they represent a sustainable protein source to the resource-intensive soybean cultivation. Reasons given in the literature for relatively low acceptance of insects are disgust and lack of knowledge, with acceptance additionally dependent on sociodemographic factors (age, gender, nationality) (Naranjo-Guevara et al., 2021). In recent years, however, there has been a general increase in acceptance, especially young people and people with a higher environmental awareness seem to be much more open to the use of insects in food production. In general, the use of insects as feed is more widely accepted than as food (Naranjo-Guevara et al., 2021). However, despite the apparent increase in public interest in foods made with alternative proteins, the ultimate success of insect- or algae-based products depends on how consumers respond in the marketplace (Altmann et al., 2022). Studies show that there is often a discrepancy between values and behavior among consumers (Realini et al., 2013). Moreover, it is also important to provide the public with sufficient information on alternative feedstuff, since this might also help to increase their acceptance as previous studies have shown (Naranjo-Guevara et al., 2021; Altmann et al., 2022).

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TABLE 4 Comparison of levels of agreement to use various alternative feeds in the feeding of farm animals.

Alternative feed	General population (n = 1000)[1]	Farmers (n = 251)[1]	Test statistic and p-value[2]	Effect size[3]
Cereals	56%	97%	$X^2(1) = 147.24$, $p < 0.001$	$V = 0.34$
Old bread	37%	45%	$X^2(1) = 4.92$, $p = 0.03$	$V = 0.06$
Plant-based residues from food industry	27%	46%	$X^2(1) = 147.24$, $p < 0.001$	$V = 0.17$
Algae	25%	21%	$X^2(1) = 1.92$, $p = 0.17$	$V = 0.03$
Insects	22%	20%	$X^2(1) = 0.42$, $p = 0.52$	$V = 0.00$
Soy	17%	63%	$X^2(1) = 224.58$, $p < 0.001$	$V = 0.42$
Animal by-products	8%	10%	$X^2(1) = 2.21$, $p = 0.14$	$V = 0.03$
Yeasts	6%	37%	$X^2(1) = 180.22$, $p < 0.001$	$V = 0.38$
Fish meal	5%	19%	$X^2(1) = 49.17$, $p < 0.001$	$V = 0.20$
Meat and bone meal	5%	15%	$X^2(1) = 31.31$, $p < 0.001$	$V = 0.16$
Fungi	5%	7%	$X^2(1) = 2.49$, $p = 0.11$	$V = 0.03$
Bacteria	4%	18%	$X^2(1) = 64.65$, $p < 0.001$	$V = 0.23$

[1]Response frequency in percent for the response category "… should be used in the feeding of farm animals".
[2]X^2 = chi-squared test.
[3]V = Cramer's V.

Provision of information might thus also support the implementation of sustainable solutions in agriculture that are widely accepted by the public.

The very low acceptance among the general population and relatively low acceptance among farmers for bacteria and fungi could reflect knowledge gaps in both groups. However, on the side of the general population, bacteria and fungi have negative connotations and can be associated with disease. A large proportion of farmers do not seem to know that certain strains of bacteria and fungi are used as feed additives as probiotics to promote intestinal activity and thus animal health. With the help of probiotics, the nutrients in the diet are to be optimally utilized, thus indirectly achieving and securing high animal performance. It could be concluded that the use of bacteria and fungi is either not widespread in practice or is used unconsciously by the farmers. The situation is different, however, with yeasts, which are also a form of fungus, but seem to be better known and accepted by farmers. Yeast is a high-quality source of nutrients, and yeast cell wall components can improve animal health and growth performance (Shurson, 2018). Today, the use of live yeast cultures in the feeding of ruminants and horses is standard practice worldwide (Harris et al., 2017; Mohammed et al., 2018). In addition, yeast and yeast derivatives also have a medical importance and are considered a sustainable alternative to antibiotics especially in broiler

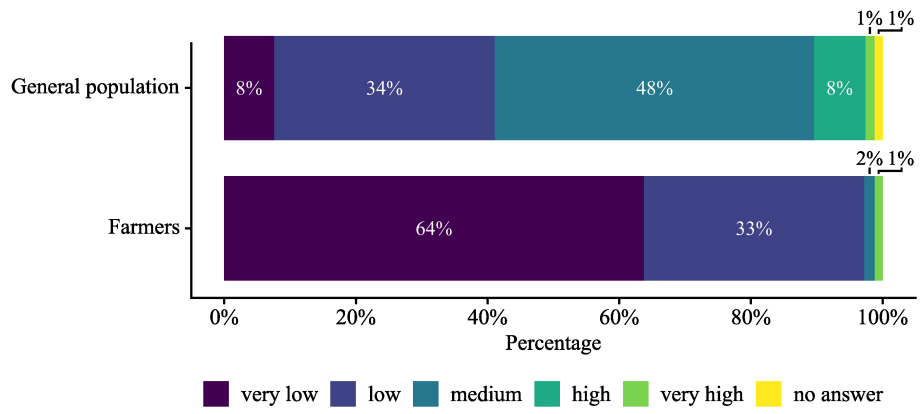

FIGURE 4
Level of knowledge on feeding and nutrition of the general population judged by participants from the general population (n = 1000) and farmers (n = 251).

TABLE 5 Comparison of ratings on the informational needs regarding the feeding and nutrition of farm animals.

Topic	General population (n = 1000)[1]	Farmers (n = 251)[2]	Test statistic and p-value[3]	Effect size[4]
Controls of feed	54%	61%	$X^2(1) = 3.81$, $p = 0.05$	$V = 0.05$
Guidelines for feed production	42%	36%	$X^2(1) = 2.94$, $p = 0.09$	$V = 0.04$
Influence of the animal feed on the animal product (meat, milk, egg)	42%	56%	$X^2(1) = 16.33$, $p < 0.001$	$V = 0.11$
Seal/label for animal products regarding the feed	40%	35%	$X^2(1) = 2.23$, $p < 0.14$	$V = 0.03$
Optimal composition of feed for different animals	34%	48%	$X^2(1) = 16.71$, $p < 0.001$	$V = 0.11$
Categories of feed used for different animals	30%	42%	$X^2(1) = 11.92$, $p < 0.001$	$V = 0.09$

[1]Response frequency in percent for the response category "very high" for the question "How high is your wish to learn more about the following topics?".
[2]Response frequency in percent for the response category "important" for the question "What do you think: which knowledge about feeds should be communicated to the general population? Please rate the importance of the following aspects."
[3]X^2 = chi-squared test.
[4]V = Cramer's V.

production, where antibiotic resistance is a worldwide problem (Bilal et al., 2023).

4.5 Level of knowledge

Considering the knowledge gaps, which were revealed by the previous results of the present study, the general population shows a realistic self-assessment of their level of knowledge. This is in contrast to another study, in which consumers misjudged their knowledge or overestimated their own knowledge in relation to the knowledge they were actually asked about feedstuffs (Christoph-Schulz et al., 2018). However, another focus group study in Germany with three groups of organic consumers also shows that consumer knowledge about feed and feeding is low (Wägeli and Hamm, 2016). Indeed, there are a number of studies that show that consumer knowledge of the animal production process is very basic (Naspetti et al., 2017), and therefore, this result is not particularly surprising.

The reasons for this can be multifaceted. For one thing, most animal products sold in Germany are not labeled with information about feed (Profeta and Hamm, 2019b). Furthermore, continuous changes taking place in the sector are often not reflected in the media and therefore not perceived by society (Altmann et al., 2022). However, a good level of consumer knowledge about feeding is important in order to avoid the threat of a loss of acceptance caused by the bad image of livestock farming (Christoph-Schulz et al., 2018). The fact that almost all farmers judged the level of the general population related to feeding to be low or very low may reflect the gap perceived by farmers as real between consumers and agriculture. Another disadvantage of lack of knowledge among consumers is the resulting lower acceptance of alternative feeds, such as insects and algae, whose use would make animal production systems more sustainable in terms of resource conservation (Naranjo-Guevara et al., 2021).

4.6 Informational needs

The need for information on controls is greatest among the public, since they also rate this aspect as most important aspect of feed (cf. Table 2). Controls of feed are also perceived by farmers as the most important topic to communicate. This demonstrates, on the one hand, a good understanding of farmers for the concerns of the public and, on the other hand, the awareness of the public for feed safety and quality, which should be ensured by the controls and which also were rated high in Table 2. It is well known that prominent feed safety issues have not only increased awareness in the general population of the importance of feed safety in producing safe food. They have also largely contributed to a general decline in public trust in food safety governance and therefore it is not surprising that the aspect of controls (Table 2) and consequently the need for information on controls and guidance for feed production was rated highest by the public. It confirms that consumers want to be sure that there is a traceable link between the feed industry and all regulations related to food safety and quality (Pinotti et al., 2014).

Furthermore, the result that the general population desires information about the influence of feed on the animal product

may also be directly linked to the already mentioned feed safety incidents. It could indicate that the public views feed as particularly susceptible to contamination, which in turn negatively affects the animal product. Another reason could be that the general population is interested in how quality parameters of the animal product may be influenced by the feed. The question arises as to how information related to feed about controls, guidelines and influence on the animal product can best be conveyed to the public.

One of the most important means to satisfy the public's need for information is food labeling. This is why literature on the economic aspects of labeling has strongly increased in the last two decades. While aspects such as nutrition and health, "free from," animal welfare, and sustainability of livestock systems have been commonly used already widely (Altmann et al., 2022), the aspect of feed is relatively new, which demonstrates that the general population is increasingly interested in information about animal nutrition (Stranieri and Banterle, 2009). In fact, it is assumed that mandatory labeling of feed ingredients (e.g. type of feed, origin of feed, nutrition, safety) used in animal production could provide the highest social benefit (Altmann et al., 2022).

5 Conclusion

The ongoing debate in Germany about animal welfare, which includes animal nutrition, has led to a paradigm shift in animal livestock. In contrast to animal welfare, the public's knowledge or perception of animal feed is relatively little researched. Against this background, we asked ourselves what level of knowledge the public and farmers in Germany have about animal nutrition. To the best of our knowledge, this is the first study comparing perceptions, knowledge and informational needs concerning livestock feed and feeding between the public and farmers. The study shows that the general population is informed to some degree about feed and feed additives. However, some misconceptions and knowledge gaps exist, such as the assumption that antibiotic growth promoters and hormones are added to livestock feed. The public expressed a relatively low level of agreement to use cereals and soy as feed, which are the most important feed ingredients. The general population and farmers differ in their level of knowledge of feed and feed additives as well as in their ratings of relevant aspects of feed. Farmers expressed a higher level of agreement for most alternative feeds. Our results indicate that better information of the public on livestock feed is necessary and also wished for by at least a part of the general population. While the topic of livestock husbandry has been increasingly brought into focus of public interest in the recent years and is also addressed in informational campaigns (e.g. label on livestock husbandry), information on livestock feed are still scarce and hard to find for consumers. This could be one reason why many assumptions of the public about feeding are "outdated" and partly refer to feeding practices from the 60-70s (such as potatoes, kitchen waste and bread as common feedstuffs for pigs). In this context, the study could confirm the existing gap between agriculture and the public, which can lead to a distorted view of husbandry conditions and thus to a poor image of livestock farming in society. It should therefore be an important task of politics and agriculture, as well as the upstream, downstream and adjacent sectors, to communicate transparently that livestock are generally fed according to their needs and that the safety of feed is assured by regular controls. The latter in particular seems to be of great importance to the general population. Provision of information might also help to increase acceptance of alternative feedstuff and thus to find sustainable solutions in agriculture that also find acceptance by the public.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study did not involve deception, any risks, interventions or experimental manipulations. No vulnerable persons participated in the study and no medical data or sensitive information was collected. Therefore, no ethical approval was obtained for this study. The study was conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MH: Conceptualization, Data curation, Formal analysis, Project administration, Visualization, Writing – original draft, Writing – review & editing. MZ: Formal analysis, Writing – original draft, Writing – review & editing. ML: Conceptualization, Supervision, Writing – review & editing. G-FB: Conceptualization, Supervision, Writing – review & editing. RP: Conceptualization, Supervision, Writing – review & editing. AM: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fanim.2024.1473036/full#supplementary-material

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