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Consumers' categorizations of dairy products and plant-based milk, yogurt, and cheese alternatives

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ABSTRACT

Plant-based dairy alternatives have many benefits in terms of sustainability, animal welfare, and health, but they can only be successful in the market if consumers perceive them as suitable substitutes for conventional dairy. Consumers' expectations for new products are strongly influenced by the food categories into which they place these products. The present study aims to reveal consumers' categorizations of plant-based dairy products to gain insights into their potential as dairy substitutes. In a free sorting task, 100 participants from the German-speaking part of Switzerland sorted a variety of plant-based and conventional animal-based dairy products into groups, indicating their spontaneous similarity perceptions. Additionally, we assessed the participants' characteristics and attitudes toward plant-based dairy products to test potential differences in categorization strategies among consumer groups. Multidimensional scaling and cluster analysis showed that consumers' mental representations of plant-based dairy and conventional animal-based dairy were clearly separated across a wide range of product types. This pattern was even observed among consumers who ate less meat, had higher exposure to vegan dietary styles, and had less negative attitudes toward dairy alternatives. The results suggest that taxonomic distinctions based on plant or animal origin dominate consumers' perceptions and are likely to hinder the substitution of dairy with plant-based dairy. Nevertheless, they also imply that plant-based products that manage to emphasize shared goals and functional properties akin to conventional dairy products are more likely to form a common goal–derived category in consumers' minds and thus have better prospects as substitutes.

1. Introduction

Moving diets away from animal-based foods is desirable for a more sustainable food system (Aiking & De Boer, 2020). In recent years, alternatives to conventional animal-based products have emerged as a significant trend in the food market. Meat alternatives in particular have attracted much attention, and consumers' acceptance of them has been studied extensively in recent years (Hartmann & Siegrist, 2017; Hoek, Luning, et al., 2011; Michel et al., 2021; Onwezen et al., 2021; Slade, 2018). In contrast, much less is known about consumers' perceptions of dairy alternatives. Dairy products can have a large negative impact on the environment, and most plant-based dairy alternatives have a lower environmental impact than their conventional counterparts on various indicators (Carlsson Kanyama et al., 2021). When it comes to animal welfare, dairy production is criticized because milk produced economically most often requires the early separation of calves from their mother cows and a high intensity of reproduction (Kolbe, 2018). Plant-based dairy products circumvent this animal welfare issue.

Plant-based milk alternatives based on grains, pulses, nuts, or seeds have been on the market for several decades and are regularly consumed by many people. In Switzerland, plant-based milk alternatives constituted a market share of 11% of the overall milk market in 2021 (Federal Office for Agriculture, 2022). In contrast, other dairy alternatives, such as plant-based cheese and yogurt, occupy smaller niches. Plant-based cheese, for instance, achieved a market share of only 0.7% in Switzerland in 2021 (Federal Office for Agriculture, 2022). While plant-based cheese and yogurt initially showed impressive growth rates (Good Food Institute, 2021), data from the US show that their sales in units have decreased over the last couple of years (Good Food Institute, 2024). Understanding consumers' perceptions of plant-based dairy products is crucial to further improving the acceptance and success of these products. The present study investigates consumers' similarity perceptions of a wide range of plant-based and animal-based dairy products using a free sorting task to identify plant-based dairy products

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that are more likely to be used as substitutes.

1.1. Advantages of plant-based dairy products

Dairy production is associated with negative environmental consequences and public health risks (Üçtuğ, 2019; Woolhouse et al., 2015). Milk is the commodity with the second-largest greenhouse gas emissions within the livestock sector (Gerber et al., 2013). Studies using life cycle assessments have shown that even the most environmentally friendly animal-based products often have the highest greenhouse gas emissions and use more land than any plant-based food products (Poore & Nemecek, 2019). In addition, the widespread use of antimicrobials in livestock farming poses a risk to public health by facilitating the emergence of antimicrobial resistance (Woolhouse et al., 2015). Large-scale livestock farming also increases the risks of zoonoses by increasing animal-human contact (Rohr et al., 2019), as was recently seen in the rapid spread of H5N1 viruses among dairy herds in the US (Ly, 2024).

Moving diets toward more plant-based food can substantially mitigate climate change and the loss of biodiversity (Kozicka et al., 2023). A recent review found that producing plant-based milk releases only a fraction of CO2 equivalents and requires significantly less land than animal-based milk (Silva & Smetana, 2022). For other indicators, the environmental benefits of plant-based milk depend on the plants used as ingredients. Plant-based milk made out of rice, oat, or soy usually requires less water, but the production of plant-based milk made out of almond requires even more water than cow milk (Silva & Smetana, 2022). Similarly, plant-based fat spreads were found to have lower climate, land, and water impacts than butter (Liao et al., 2020). There is little published work comparing the environmental impact of plant-based and animal-based variants of other dairy products, such as cheese or yogurt. The few studies suggest that both plant-based yogurt and plant-based cheese are associated with fewer greenhouse gas emissions and smaller land use (Carlsson Kanyama et al., 2021). However, it is important to mention that the environmental benefits of plant-based products are often diminished to some extent if grams of protein is used as a unit of measurement instead of grams of product (Nijdam et al., 2012).

The reviewed studies suggest that overall, plant-based dairy alternatives are more environmentally friendly than animal-based dairy (Carlsson Kanyama et al., 2021; Silva & Smetana, 2022). However, dairy is also an important source of micro- and macro nutrients in many people's diets (Beal et al., 2023). Several studies have found that plant-based milk alternatives do not reach the protein content (except for soy-based drinks) or the level of highly bioavailable vitamins and minerals of bovine milk (Burton-Pimentel & Walther, 2023; Chalupa-Krebzdak et al., 2018; Scholz-Ahrens et al., 2020). Similar results have been found for plant-based yogurt and cheese alternatives (Clegg et al., 2021). In contrast, plant-based milk often provides nutritional advantages in terms of higher fiber content and lower levels of saturated fat (Lee et al., 2023). However, more research on the long-term health effects of plant-based dairy is needed.

1.2. Why similarity perceptions matter

Past studies have found tastiness and healthiness considerations to be the most important reasons for consuming cow's milk and plant-based milk alternatives, while animal welfare and sustainability values have been found to drive consumption less frequently (Haas et al., 2019; McCarthy et al., 2017). A large survey study in Switzerland replicated these findings, showing that animal welfare and the environment were mentioned in less than 10% of cases as reasons for the consumption of plant-based milk alternatives (Ammann et al., 2023). Factors preventing consumers from using plant-based dairy alternatives are low perceived naturalness (Martinez-Padilla et al., 2023), lack of interest, bad taste (Ammann et al., 2023), and the overall good image of conventional dairy products (Haas et al., 2019). Additionally, consumers seem to underestimate the health and sustainability benefits of plant-based dairy products (Giacone et al., 2024). These studies suggest that for most consumers, the advantages of environmental friendliness and animal welfare offered by plant-based dairy products will not be compelling enough on their own to regularly adopt them as substitutes for traditional dairy. Other studies have shown that plant-based alternatives that are perceived as similar to their animal-based counterparts (Michel et al., 2021) and that belong to the same mental categories (Hoek, Van Boekel, et al., 2011) are more likely to be used as substitutes.

Dairy products form a substantial food category containing many different product types, and plant-based alternatives currently exist for almost all of these product types. Plant-based alternatives perceived as distinct from their conventional counterparts are less likely to be seen as suitable substitutes and are more likely to be affected by consumers' negative attitudes toward plant-based products as a whole. Therefore, it is of great relevance to explore how consumers perceive the similarity between plant-based and conventional dairy products across different product types within the dairy category. A fruitful way to investigate what types of conventional and plant-based dairy products are viewed as similar by consumers is to study how consumers mentally structure and categorize these products (Valentin et al., 2018).

1.3. Categorization strategies for conventional and plant-based products

Consumers categorize products to efficiently evaluate and interact with the abundance of products in their environment, and in this way, product categorization influences consumers' expectations and decision-making (Loken et al., 2008). Past studies have identified different categorization strategies for objects in the food domain. Felcher et al. (2001) differentiated between taxonomic and goal-derived categorizations of food items, corresponding to Ross and Murphy's (1999) distinction between taxonomic and script-based categorizations. Taxonomic categories are formed based on the intrinsic properties and physical attributes that food items share (Ross & Murphy, 1999). In contrast, script-based categories are formed based on shared consumption situations or activities (Ross & Murphy, 1999), and goal-derived categories are formed based on the shared consumption goals that the products fulfill (Felcher et al., 2001). Script-based and goal-derived categorization strategies are conceptually very similar; hereinafter, the distinction between taxonomic and goal-derived categorizations is used as a framework. The perceived similarity of two products based on taxonomic or goal-derived features determines whether they are seen as part of the same food category (Felcher et al., 2001). At the same time, membership in a category influences what consumers can expect from a product, especially in the case of new products (Felcher et al., 2001; Loken et al., 2008). Both taxonomic and goal-derived categorization strategies are used by consumers in everyday life to draw inferences about products (Ross & Murphy, 1999). However, whereas taxonomic categorizations are stable and independent of context, goal-derived categories are activated only in specific contexts that emphasize the shared goals of products (Felcher et al., 2001).

While, to the best of our knowledge, no study has investigated this specifically for dairy and plant-based dairy products, a handful of studies have explored the mental representations of meat and meat alternatives (Hoek, Van Boekel, et al., 2011) and of protein-rich food in general (Chollet et al., 2022; Van der Meer et al., 2023) using sorting tasks. Sorting tasks are efficient methods for revealing mental structures and obtaining similarity measurements between products (Valentin et al., 2018). They require little effort and enable the simultaneous investigation of many products (Valentin et al., 2018). Hoek, Luning, et al. (2011) found that across many meat and meat alternative products, consumers apply a taxonomical strategy and separate products based on their animal or plant origin, except for highly processed products, for which more co-categorizations of meat and meat alternatives were observed. Another study found that the strong distinction of products based on origin only diffuses for ready-to-eat dishes that share

a clear function (Chollet et al., 2022). Van der Meer et al. (2023) included in their sorting task study not only meat and meat alternatives but also dairy products, dairy alternatives, and some nonprotein foods to set a diverse stage for products in which categorization can occur. Meat and meat alternatives were strictly separated by all participants, showing the importance of protein origin. Dairy and dairy alternatives were, however, separated only by vegetarians and vegans, but for omnivores and flexitarians, they formed a common product category (Van der Meer et al., 2023). The study of Van der Meer et al. (2023) shows how consumers categorize products when they have no limited consideration set in mind but rather the full diversity of products in a grocery shop. However we do not know whether consumers still co-categorize plant-based and animal-based dairy products when they are presented with products within the dairy category and thus do not consider the full variety of products in a grocery shop. For these situations, it is necessary to investigate consumers' mental categories of products within the (plant-based) dairy domain.

1.4. Aims of this study

This study aims to better understand how consumers perceive plant-based dairy alternatives in relation to conventional dairy products using a free sorting task design in the German-speaking part of Switzerland. Patterns in consumers' categorizations can reveal which alternative products are perceived as similar to their conventional counterparts and when substitution is more likely. We complement the results of Van der Meer et al. (2023) by zooming into the dairy category, having presented participants with 50 plant-based and animal-based dairy products. In this way, we aim to get a more detailed and accentuated picture of consumers' representations of plant-based dairy products in relation to conventional ones. Additionally, we are interested in whether consumers with more positive attitudes or more frequent exposure to plant-based dairy products show different categorization patterns compared to other consumers. For this, we use several indicators, such as consumers' attitudes toward dairy alternatives and exposure to vegan lifestyles, to form subsamples and compare them using the INDSCAL (Carroll & Chang, 1970) procedure.

2. Methods

2.1. Study participants

The data for this study were collected in May and June 2023. Participants were recruited using the research group's own panel of people in the greater Zurich area (a German-speaking part of Switzerland) interested in participating in consumer research. The participants were invited to come to the university for the study and were compensated with CHF 20 for their participation. To be included in this study, participants had to be 18 years or older, have very good written and spoken German language skills, and consume meat and dairy products. Of the 104 invited participants, four gave false information about their dietary styles during the screening process and later had to be excluded from the data analysis because they did not meet the dietary requirements. Of the remaining 100 participants, 44 were men and 56 were women. Fifty-eight participants self-identified as omnivores and 42 as flexitarians. The mean age of the sample was 41 years ($SD = 17$). The study sample showed a higher educational background than the general population. Most participants had a university degree ($n = 44$) or had acquired the qualification for university entrance ($n = 25$), while one participant had only finished compulsory school, 13 had a vocational degree at the upper secondary level, and 17 participants had a higher vocational education. Six participants stated that they were lactose intolerant.

2.2. Selection of products

A search of the online product assortments of major supermarkets in Switzerland was conducted to identify available dairy product alternatives. This long list of products was then shortened based on the relative amount of shelf space that this category of products was assigned in a typical supermarket. Products with a very small shelf space were not included in this study. For broad product categories, flavor and ingredient variations were added. Namely, for milk alternatives, the main ingredient (e.g., soy, oat, rice, or almond) was specified, and for yogurt and yogurt alternatives, the flavor (e.g., plain or fruit) was specified. For each dairy alternative, one or more conventional counterparts were added to the list. For some conventional dairy products, variations in fat content (e.g., full-cream milk and reduced-fat milk) and lactose-free versions were introduced to the list to represent the product range in supermarkets. The final list consisted of 50 products, 22 of which were plant-based dairy alternatives and 28 were conventional dairy products. Studies have shown that participants can easily sort 40 to 60 objects in a free sorting task (Blanchard & Banerji, 2016). The names of the 50 food products were printed on a laminated card (size A7) for this task. The names were as long as necessary but as short as possible so that the participants could clearly identify the products. The plant-based nature of the dairy alternatives was specified at the end of the product names to avoid sorting being done purely based on the visual similarities of the product names. A list of the product names used in German and their English translations can be found in the Appendix (Table A1). To avoid brand names, packaging, or other external information influencing sorting behavior, no pictures or other information about the products were added to the cards.

2.3. Procedure

This study took place in a neutral room furnished only with tables and chairs. After arrival, each participant received an information sheet and a consent form, which they read and signed before continuing with the study. The study itself consisted of two parts. In the first part, the participants completed the free sorting task; in the second part, a questionnaire was completed. It took the participants, on average, 40 min to complete both tasks.

2.3.1. Free sorting task

In the first step, the participants familiarized themselves with the 50 products written on cards for a few minutes. The card deck was shuffled beforehand to avoid sequence effects. In the next step, the participants were asked to sort the products into groups. No criteria for sorting were prespecified, and the participants could generate as many groups as they wanted, although more than one and fewer than 50 groups were required. When the participants were satisfied with their sorting, a picture of the card sorting was taken by the experimenter for later coding. Meanwhile, the participants continued with the questionnaire.

2.3.2. Questionnaire

The questionnaire was completed on a tablet computer. First, the participants' sociodemographic variables were assessed—namely, their gender, age, educational background, lactose intolerance, self-identified dietary style, and exposure to vegetarian and vegan diets in their social environment. Exposure to vegetarian and vegan diets was measured with one item each on a seven-point Likert scale (1 = do not agree at all, 7 = completely agree): "Vegetarian/Vegan diets are widespread in my

close social environment." In the second part, participants' attitudes about dairy alternatives were measured using a 10-item *dairy alternative rejection* scale (response format: 1 = do not agree at all, 7 = completely agree). This scale was based on the meat alternative rejection scale, which previously showed good psychometric properties (Wassmann et al., 2023). Example items of the dairy alternative rejection scale included the following: "Plant-based dairy alternatives will never be able to adequately replace the taste of dairy" and "Plant-based dairy alternatives are only a temporary trend."

2.4. Multidimensional scaling and cluster analysis

The main interest of this study was to quantify and interpret the proximity between the products in a sorting task as a measure of consumers' similarity perceptions. In all approaches to analyzing sorting data, the individual sorting data of participants first needs to be aggregated by counting the number of times product pairs are sorted into the same group. This results in a product × product co-occurrence matrix that can be analyzed using multidimensional scaling or cluster analysis (Coxon, 1999). Both approaches were applied in this study using IBM SPSS (version 28.0.1.1) and R (version 4.3.1) statistical software.

2.4.1. Multidimensional scaling

The basic idea of multidimensional scaling (MDS) is to represent proximity data as distances in a multidimensional space to make them accessible to the eye of the researcher (Borg et al., 2018). For the present study, the proximity data came from the co-occurrence matrices of products sorted together by participants in a free sorting task. The MDS procedure was used to transform these co-occurrence matrices into a relatively simple spatial map that maintains the proximity information as well as possible by placing similar objects closer together and dissimilar objects further apart (Jaworska & Chupetlovska-Anastasova, 2009). Depending on the data, more or fewer spatial dimensions are needed to sufficiently represent the proximity of the objects under investigation.

We used individual difference scaling (INDSCAL; Carroll & Chang, 1970) to take potential differences between subgroups of consumers into account. The INDSCAL procedure models individual differences in the proximity data by transforming an overall group MDS space with dimension weights (compressing and stretching of dimensions) into individual MDS spaces. In this study, we compared the MDS spaces of omnivores and flexitarians, participants with high versus low exposure to vegan diets, and participants with high versus low values on the dairy alternative rejection scale.

The large number of different (alternative) dairy products used in this study allowed us to investigate for which product types a separation of conventional dairy products and dairy product alternatives occurred. To do this, we focused on how the MDS space could be partitioned into different facets and whether certain types of products ended up in certain regions of the MDS space. The facet approach does not require an interpretation of the dimensions spanning the MDS space (Borg et al., 2018; Borg & Groenen, 2005). However, we also interpreted the dimensions of the MDS space to gain further insights into the participants' sorting behavior.

2.4.2. Cluster analysis

Cluster analysis is another method often used to analyze sorting data (Coxon, 1999). In hierarchical cluster analysis, objects are grouped together stepwise, first by fusing objects that are most like each other into clusters and then by grouping similar clusters together into bigger clusters until a single cluster remains that contains all objects. As with MDS, the aggregated co-occurrence matrix of the sorting data can be used as an input for a hierarchical cluster analysis. In this study, hierarchical cluster analysis using squared Euclidean distances and average linkages was used to verify the facets found in the MDS solution.

3. Results

In the free sorting task, participants were asked to generate groups from the 50 (plant-based) dairy products presented to them. On average, they sorted the products into 9.1 groups ($SD = 4.1$, min. = 2, max. = 20). The sorting data were coded into a co-occurrence matrix for each participant. These matrices were then aggregated into a 50 × 50 dissimilarity matrix containing for each product pair the number of participants who did not group the two products into the same group (the higher the number, the greater the dissimilarity between the products). The dissimilarity matrix was then analyzed using MDS. The ordinal PROXSCAL procedure resulted in stress-1 values of .38, .0.19, .12, .08, .07, and .07, with the greatest decrease going from a one-to a two-dimensional solution. For solutions with more than four dimensions, stress-1 no longer decreased substantially. While rules of thumb for evaluating stress values can be found in the literature, stress should never be evaluated blindly, because it is only a technical index (Borg et al., 2018). Stress automatically increases with a higher number of objects and a lower dimensionality of the MDS solution. A good way to incorporate these factors into the evaluation is to compare the stress value with the stress values that can be expected when scaling random data (Borg et al., 2018). A two-dimensional ordinal MDS solution on 50 objects leads, on average, to a stress-1 value of .37 when using random data (Borg et al., 2018). Given its high interpretability and sufficiently low stress value compared to random data, a two-dimensional solution was chosen as a good representation of the data.

3.1. MDS map and cluster analysis

Overall, the MDS solution in Fig. 1 shows a clear distinction between conventional animal-based products and plant-based alternatives. The MDS map can be partitioned unambiguously into an animal-based region and a plant-based region. Only margarine and the mix of milk and oat drink are located between these regions. Among the animal- and the plant-based products, the different cheese types form a further distinct region. In particular, animal-based cheese types are clearly separated from other dairy products. The MDS map also shows separate regions for lactose-free dairy products and for plant-based drinks. In general, plant-based products form a more homogenous group than conventional animal-based products. The first dimension of the MDS space distinguishes between animal- and plant-based products. The majority of the products are located on one of the two ends of this dimension, showing that the participants had a clear separation of animal- and plant-based dairy products in their minds. The second dimension shows a more gradual differentiation of products based on their consistency. While more solid cheeses are located at one end of the second dimension, liquid drinks can be found at the other end, with semisolid or creamy products in between.

The cluster analysis is visualized with dotted circles in Fig. 1. The two methods complement each other. While MDS is best suited to representing the overall pattern of similarities, cluster analysis is better able to differentiate clusters of products that have close proximities to each other. The cluster analysis confirmed the MDS solution for most parts. Nonetheless, some differences could be observed between the two methods. The cluster analysis suggests a higher similarity between milk-based and plant-based drinks than the MDS solution. Plant-based drinks

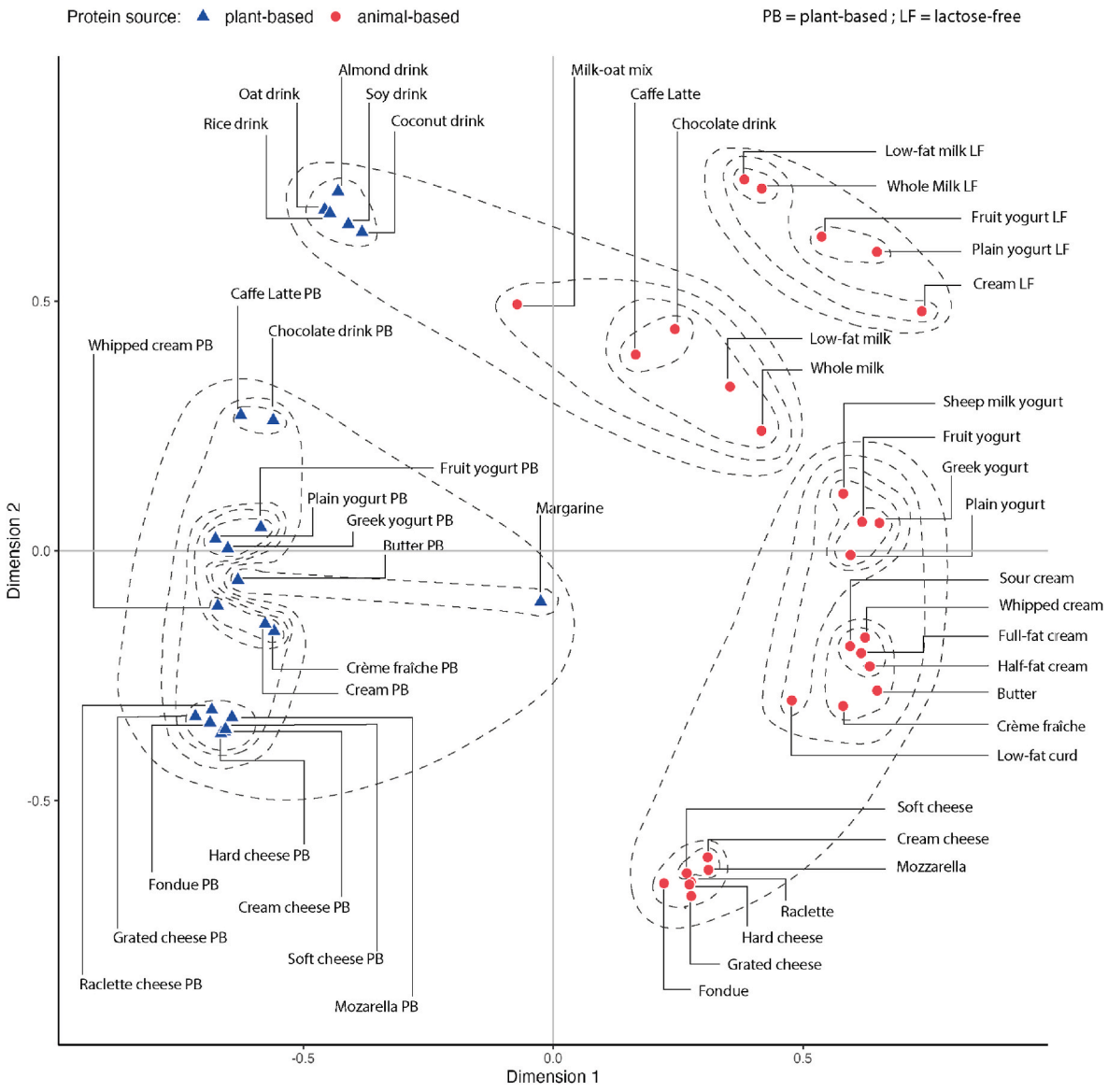

Fig. 1. Two-Dimensional MDS Solution for the Sorting Task Data of the Full Sample
Note. The locations of the products show the results of two-dimensional ordinal multidimensional scaling computed using the PROXSCAL procedure. The dotted circles show the results of a hierarchical cluster analysis computed using Euclidean distances and average linkages. Extreme low and high levels of clustering are not shown in this plot (for all details, see the dendrogram in Figure A1 in the Appendix).

form a common cluster with milk-based drinks before they form a cluster with other plant-based products. However, this conjunction of plant-based drinks and milk-based drinks occurs only at a high level of the cluster hierarchy (see the dendrogram in Figure A1 in the Appendix).

3.2. Consumer groups and invariance in sorting patterns

To test whether the MDS solution differs between different subsamples of participants, the INDSCAL procedure (Carroll & Chang, 1970) was applied. Subsamples were compared based on dietary style (omnivores vs. flexitarians), exposure to vegan diets, and dairy alternative rejection.

Participants' exposure to vegan diets showed a skewed distribution, with most participants having little or no exposure to vegan dietary styles in their close social environments. To have large enough sample sizes and still be able to differentiate well between the two subgroups, participants with values equal to or lower than 2 (very low and low exposure) were compared with participants with values above 2

Table 1
Dimension weights in the INDSCAL analysis.

Criteria	Mean (*SD*)	Cut-off	Subsamples	INDSCAL weights	
				Dim. 1	Dim. 2
Diet	–	–	Omnivore (n = 58)	.500	.465
	–		Flexitarian (n = 42)	.506	.464
Exposure to vegan diets	2.2 (1.3)	2.0	Low (n = 75)	.505	.467
			High (n = 25)	.484	.474
Dairy alternative rejection	2.7 (0.8)	2.65	Low (n = 50)	.503	.466
			High (n = 50)	.505	.462

Note. For dairy alternative rejection, the median was used to split the sample into subsamples. For exposure to vegan diets, a scale value of 2 was used to split the sample into subsamples.

(medium to high exposure) on a scale of 1–7.

The dairy alternative rejection scale showed good reliability (Cronbach's alpha = .72). A median split was used to compare participants with high and low dairy alternative rejections in the INDSCAL procedure.

The INDSCAL analysis shows that none of the subsamples differed in their weighting of the two dimensions in the MDS solution (see Table 1). How closely participants placed products in the sorting task therefore did not depend on their dietary style, their exposure to vegan dietary styles, or their rejection of dairy alternatives.

4. Discussion

By analyzing the proximities from a free sorting task, the present study shows that consumers clearly separate mental representations for animal- and plant-based dairy across all tested types of products. This implies that the taxonomical distinction of products based on animal or plant origin dominates consumers' similarity perceptions. In contrast, the shared functional properties of products seem to be less influential. This pattern was also observed among participants with a flexitarian dietary style, high exposure to vegan dietary styles in their social environment, and less negative attitudes toward dairy alternatives. Whether a product is animal- or plant-based seems to define category boundaries, even for people who are in general more open to plant-based dairy products. The strong overall tendency to separate animal- and plant-based dairy products in our study complements the findings of Van der Meer et al. (2023). They found that animal- and plant-based dairy products formed a common group for omnivore and flexitarian participants when confronted with a variety of products that could be found in grocery shops. While Van der Meer et al. (2023) were interested in how consumers group different protein-rich foods in the context of grocery shop products, we wanted to find out which specific dairy alternatives are already perceived as similar to their animal-based counterparts and for which dairy alternatives a stronger mental separation could be observed. Depending on the range of objects that form the context of similarity ratings, different characteristics become salient and diagnostic for similarity judgements (Tversky, 1977). By excluding meat, meat alternatives, and other food products, such as fruits, from the sorting task in the present study, there was less perceived similarity between animal- and plant-based dairy products than in the study by Van der Meer et al. (2023). Restricting the context in this way enabled the present study to focus on differences in perceived similarities across different product types within the (plant-based) dairy domain. At the same time, the selected products provided a realistic representation of the potential options available to consumers when purchasing (plant--based) dairy products. Taken together, the results of the study of Van der Meer et al. (2023) and the current study suggest that consumers are likely to consider plant-based dairy alternatives as a substitute for dairy products when they are merely looking for protein-rich food but that they will be much less likely to consider a plant-based dairy alternative when they are looking for a specific dairy product.

That plant-based dairy products are predominantly categorized by consumers based on their plant-based nature and not on their shared functions with other conventional dairy products has important implications. Expectations of new products are strongly influenced by how consumers categorize them (Loken et al., 2008). If consumers do not perceive plant-based alternatives as members of the same food category as their conventional counterparts, substitution is less likely. The dominance of the plant-based origin in the participants' mental categories of products also suggests that consumers' attitudes toward new plant-based dairy products will be strongly guided by their already existing general attitudes toward plant-based alternatives. The INDSCAL analysis implies that this is not only the case for consumers with negative attitudes toward plant-based dairy but also for consumers with more positive attitudes. Both consumer groups showed the same taxonomical categorization strategy based on the plant or animal origin of the products. This aligns with findings from other studies showing that a large portion of consumers do not distinguish between different categories of plant-based foods in terms of their willingness to consume them (Cardello et al., 2022) and that negative attitudes toward meat alternatives negatively affect consumers' acceptance of all types of meat alternatives (Etter et al., 2024). Convincing consumers, who are unsure about plant-based products, of new plant-based dairy products is challenging under these conditions.

Previous studies have found that taxonomic separation based on animal or plant origin is less pronounced among highly processed products (Hoek, Van Boekel, et al., 2011). Such a pattern could not be observed in the present study. Milk and plant-based drinks are arguably less processed than yogurts or cheeses, but they still showed higher similarities in the MDS solution and the cluster analysis. It could be that it is not the degree of processing itself that facilitates a common representation of products but the salience of shared functional properties (Chollet et al., 2022). The more processed food products are, the more specific their use case typically is. Other studies have shown that the application of familiar flavor profiles to unfamiliar foods can improve consumers' willingness to try new products (Pliner & Stallberg-White, 2000). In the present study, however, this effect did not cause equally flavored plant- and animal-based dairy products to be grouped together more often. Even though familiar flavor profiles did not influence participants' similarity perceptions, future studies should investigate whether they influence consumers' willingness to try plant-based dairy alternatives.

Nevertheless, a few exceptions to the strong taxonomical separation of animal- and plant-based dairy were found in the present study. The MDS analysis showed margarine to be located between plant-based and animal-based products. Margarine is a well-established butter alternative with which consumers have been familiar for decades (Morris & Vaisey-Genser, 2003). Consumers, therefore, have had many opportunities to experience, directly or indirectly, the functional characteristics of margarine and the situations in which and the goals for which it can be used. It is therefore likely that a goal-derived categorization (Felcher et al., 2001) of margarine as a butter-like spread and cooking ingredient counterbalanced its taxonomic categorization as a plant-based product. Similar can be said for plant-based drinks. While the separation based on animal and plant origin was also apparent for plant-based drinks, the cluster analysis showed that such drinks form a common cluster with milk-based drinks before they form a cluster with other plant-based products. As with margarine, plant-based drinks are frequently consumed products. For example, many coffee shops offer their customers plant-based drinks as an equivalent alternative to milk. Such experiences of shared functional properties and goals of the products might facilitate the representation of plant- and animal-based products in a common category.

Plant-based alternatives for other products, such as cheeses and yogurts, are newer on the market, and consumers are less familiar with them. A common representation, therefore, has not had much time to evolve. However, this is unlikely to be the only reason why the taxonomic distinction between plant- and animal-based products is even stronger for these product types. It is very challenging to imitate the sensory qualities of cheese with plant-based ingredients (Grossmann & McClements, 2021), and sensory studies have shown that consumers often do not like the flavor or texture of plant-based cheeses on the

market and that they name sensory properties as their main concern (Falkeisen et al., 2022). In addition, cheese production is an important cultural tradition and even a source of identity in Switzerland. And while both plant-based and animal-based cheeses are processed products, studies have shown that traditional production techniques are perceived as more natural by consumers (Etale & Siegrist, 2021). Even with increased exposure, it might be difficult for plant-based cheese to be considered an equal alternative to traditional cheese. Plant-based yogurts also have difficulty meeting consumers' sensory requirements (Jaeger et al., 2023). However, we assume that, at least in Switzerland, the production of yogurt is not seen as a cultural heritage as much as the cheese-making tradition. While for both, cheese and yogurt, consumers strictly separate plant-based alternatives from their animal-based counterparts, compared to plant- and animal-based cheese, it might be easier for consumers to perceive plant- and animal-based yogurts as belonging to the same category in the future.

One product in the sorting task consisted of a blend of cow's milk and oat drink. Not surprisingly, the participants struggled to categorize this product, and it landed in the MDS solution between the plant-based drinks and the milk-based drinks. Consumer studies in the meat alternative domain have found positive attitudes toward such blended or hybrid products and have identified them as promising low-threshold products into less meat-heavy diets (Grasso & Goksen, 2023). Hybrid products, however, are not yet widely available, and it is difficult to predict their success.

One way to promote consumers' similarity perceptions of plant- and animal-based dairy products and increase the likelihood of substitution is to demonstrate the shared goals and functional properties of these products. This way, new common goal-derived categories could be formed in consumers' minds, which would facilitate the substitution of conventional dairy products in people's everyday diets. This strategy was suggested by Hoek, Luning, et al. (2011) more than 10 years ago in the context of meat alternatives. While this seems to have worked for margarine and plant-based drinks, good sensory properties are nonetheless necessary for any plant-based product to be successful on the market (Siegrist et al., 2024).

4.1. Strengths and limitations

The free sorting task design used in the present study allowed for the exploration of consumers' mental representations of a wide range of plant-based dairy alternatives. The strength of this approach is that consumers' spontaneous similarity perceptions can be assessed without questions predefined by the researcher influencing or restricting the participants' responses. In addition, we used a large number of plant- and animal-based dairy products (50 in total), providing detailed insights into consumers' perceptions of specific products. While we focused on omnivore and flexitarian consumers, we were still able to assess potential differences in consumers' sorting behavior by differentiating consumers based on their exposure to vegan dietary styles and their attitudes toward dairy alternatives. To avoid nonrelevant characteristics, such as packaging, influencing the sorting, only descriptive product names were presented to the participants. This increases the generalizability of the results but might decrease external validity. In real-life shopping situations, the appearance and the products' brands also influence consumers' perceptions and, potentially, their mental representations. Since this was the first study to focus only on dairy and dairy alternatives, finding general patterns in mental representations based on consumers' expectations was prioritized. However, future studies should also investigate how different packaging of products influences their categorization.

For the same reasoning, no specific context of the sorting task was specified. We were interested in the participants' spontaneous similarity perceptions and categorization strategies. Past research has shown that taxonomic categorization strategies tend to be more influential when no context is specified (Felcher et al., 2001). Future studies should therefore also investigate how mental representations of products change in different contexts and the contexts in which consumers perceive more similarity between plant- and animal-based dairy products.

Dairy products have different dietary and cultural relevance in different countries. In Switzerland, dairy products, especially cheese, are highly valued and are part of the cultural heritage. Most European countries have similar dairy traditions (Kindstedt, 2012), but in other regions, especially in some Asian countries, dairy products are not an integral part of the diet (Wei & Wang, 2023). At the same time, markets in Asia are showing a growing interest in dairy products (Yang et al., 2023). Future studies should therefore explore whether rigid taxonomic distinctions based on animal or plant origin also exist in other cultures or if more flexible categorizations can be observed.

4.2. Conclusion

Using a free sorting task design, this study showed that consumers' mental representations of plant-based and conventional animal-based dairy products are clearly separated from each other across a wide range of product types. This pattern was observed even among consumers with higher exposure to vegan lifestyles, with less negative attitudes toward plant-based dairy alternatives, and who followed a flexitarian diet. The few products that deviated from this overall pattern (plant-based drinks, margarine) are well established and have over time enabled consumers to experience their shared functionality with conventional dairy products. This study also demonstrated that high levels of processing do not facilitate the co-categorization of plant- and animal-based dairy, contrary to earlier findings related to meat alternatives (Chollet et al., 2022; Hoek, Van Boekel, et al., 2011). The results also suggest that improving consumers' attitudes toward dairy alternatives and confronting them with vegan dietary styles alone will not change their mental representations. Instead, the sensory properties of dairy alternatives such as plant-based cheese and yogurt need to be improved, and their shared functionalities with animal-based dairy products need to be experienced by consumers for them to be seen as equivalent products from a common product category.

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Ethical statement

The participants received an information sheet explaining their rights during participation, the potential risks and benefits, the anonymity of the collected data, the funding of the study, and contact details for complaints. They then provided informed consent by signing a consent form. They were able to withdraw from the survey at any time without giving a reason. The study was approved by the ETH Zurich Ethics Commission on April 20, 2023 (proposal No. EK 2023-N-94).

CRediT authorship contribution statement

Bruno Etter: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Fabienne Michel:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization. **Michael Siegrist:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix

Table A1
List of Product Names Used in the Free Sorting Task.

German product name	English translation	Abbreviation for plots
Butter	Butter	Butter
Butter auf pflanzlicher Basis	Plant-based butter	Butter PB
Caffè Latte	Caffe latte	Caffe latte
Caffè Latte auf pflanzlicher Basis	Plant-based caffe latte	Caffe latte PB
Crème fraîche	Crème fraîche	Crème fraîche
Crème fraîche auf pflanzlicher Basis	Plant-based crème fraîche	Crème fraîche PB
Fondue	Fondue	Fondue
Fondue auf pflanzlicher Basis	Plant-based fondue	Fondue PB
Frischkäse	Cream cheese	Cream cheese
Frischkäse auf pflanzlicher Basis	Plant-based cream cheese	Cream cheese PB
Frucht-Joghurt	Fruit yogurt	Fruit yogurt
Frucht-Joghurt auf pflanzlicher Basis	Plant-based fruit yogurt	Fruit yogurt PB
Frucht-Joghurt laktosefrei	Fruit yogurt lactose free	Fruit yogurt LF
Griechisches Joghurt	Greek yogurt	Greek yogurt
Griechisches Joghurt auf pflanzlicher Basis	Plant-based Greek yogurt	Greek yogurt PB
Haferdrink	Oat drink	Oat drink
Halbrahm	Light cream	Light cream
Hartkäse	Hard cheese	Hard cheese
Hartkäse auf pflanzlicher Basis	Plant-based hard cheese	Hard cheese PB
Kokosnussdrink	Coconut drink	Coconut drink
Magerquark	Low-fat curd	Low-fat curd
Mandeldrink	Almond drink	Almond drink
Margarine	Margarine	Margarine
Milch Drink	Reduced-fat milk	Reduced-fat milk
Milch Drink laktosefrei	Reduced-fat milk lactose free	Reduced-fat milk LF
Mischgetränk Hafer und Milch	Mix of oat drink and milk	Milk-oat mix
Mozzarella	Mozzarella	Mozzarella
Mozzarella auf pflanzlicher Basis	Plant-based mozzarella	Mozzarella PB
Nature-Joghurt	Plain yogurt	Plain yogurt
Nature-Joghurt auf pflanzlicher Basis	Plant-based plain yogurt	Plain yogurt PB
Nature-Joghurt laktosefrei	Plain yogurt lactose free	Plain yogurt LF
Raclette Käse	Raclette cheese	Raclette
Raclette Käse auf pflanzlicher Basis	Plant-based raclette cheese	Raclette PB
Rahm auf pflanzlicher Basis	Plant-based cream	Cream PB
Rahm laktosefrei	Cream lactose free	Cream LF
Reibkäse	Grated cheese	Grated cheese
Reibkäse auf pflanzlicher Basis	Plant-based grated cheese	Grated cheese PB
Reisdrink	Rice drink	Rice drink
Saurer Halbrahm	Sour cream	Sour cream
Schafmilchjoghurt	Sheep's milk yogurt	Sheep milk yogurt
Schlagrahm	Whipped cream	Whipped cream
Schlagrahm auf pflanzlicher Basis	Plant-based whipped cream	Whipped cream PB
Schokoladen-Milch-Getränk	Chocolate milk drink	Chocolate drink
Schokoladen-Milch-Getränk auf pflanzlicher Basis	Plant-based chocolate milk drink	Chocolate drink PB
Sojadrink	Soy drink	Soy drink
Vollmilch	Whole milk	Whole milk
Vollmilch laktosefrei	Plant-based whole milk	Whole milk PB
Vollrahm	Heavy cream	Heavy cream
Weichkäse	Soft cheese	Soft cheese
Weichkäse auf pflanzlicher Basis	Plant-based soft cheese	Soft cheese PB

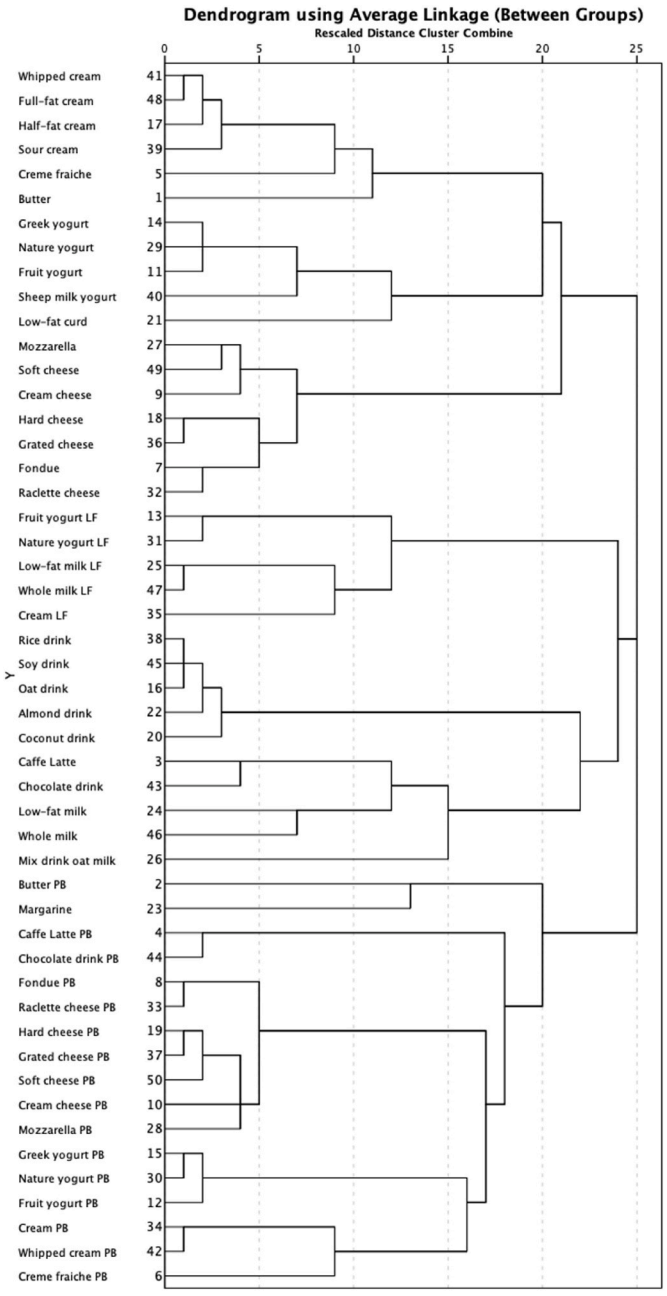

Figure A1 Dendrogram of Hierarchical Cluster Analysis of Sorting Data

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