



Sensory analysis and hedonic evaluation of fermented plant-based products similar to yogurt

Not imitating, but emancipating

Karolin Höhl, Jana Dreyer

Abstract

This non-representative, preliminary market study examined four fermented vegan products and a dairy yogurt using comparative product tests with an explorative approach. Vegan products are positioning themselves on the market as “alternatives” to or “substitutes” for traditional yogurts. Qualitative profiles were used to analyze whether these claims are accurate based on sensory characteristics, or whether the products belong to a separate product group that are useful not so much as imitations, but rather as beneficial additions to the diet in their own right.

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Introduction

Recent sales figures for Germany indicate that the market potential of vegan products fermented using lactic acid cultures (hereinafter referred to as “...-gurts”) is increasing [1]. Between 2020 and 2022, sales increased by 12%; the sales volume of “...-gurts” in the “plain” flavor category rose from 11 million (2018) to 19 million kilograms (2020) [2]. Annual sales growth of 7.45% is forecast for Germany until 2029 [3]. The group of products falling into the category of “...-gurts” and other vegan products can no longer be described as niche products [4]. The new Food Based Dietary Guidelines for Germany make this clear. The new guidelines include “plant-based milk alternatives” in both the text and the images [5]. Although this group of products is relatively new

compared to traditional dairy products, it has already become an integral part of German food culture.

The impression that vegan “...-gurts” create, their creative product names (used to distinguish them from the legally protected designation of “yogurt”) and the various ways they can be used in the kitchen indicate that they are designed to imitate the traditional fermented products made from cow’s milk or cream known as yogurt under the German Milk Products Ordinance (*Milcherzeugnisverordnung*) ([6], Annex 1, II). For example, an established fermented soy product is currently marketed on the manufacturer’s website under the product category name “Soy yogurt alternatives”.

Manufacturers of “-gurts” are aiming for the best possible imitation of animal-based yogurts, particularly with regard to the sensory properties [7]. The guidelines of the German Food Code Commission (*Deutsche Lebensmittelbuchkommission*, LMBK, [8], p. 3) also refer to this fact: “(...) vegan and vegetarian foods that are similar to foods of animal origin, that are advertised as such and whose designation, product name or presentation is based on the customary designations of foods made with animal ingredients of animal origin (...)”. The guidelines state that “sufficient sensory similarity” – in particular with regard to the appearance and mouthfeel of vegan products – can justify product names that are borrowed from animal products, such as “...-schnittel” or “...-goulash” used together with the prefix “vegan” ([8], p. 7, 2.1). However, according to a ruling of the Court of Justice of the European Union, purely plant-based products such as the product group of “...-gurts” that is being analyzed in this study cannot be marketed under names such as milk or yogurt ([9], paragraph 8, sentence 2a). According to



the ruling, this still applies even if the product name includes a clarification indicating its plant-based origin. However, the word ending “-gurt” is not legally protected, so there are many examples of it being used on the German market: e.g., *Sojaghurt* (“soy-gurt”), *Naturghurt* (“plainingurt”), *Lughurt* (“lupingurt”).

The imitation of organoleptic, cooking and marketing properties of yogurts has also led to the establishment of terms such as “plant-based alternatives” (cf. [4, 5, 10]) or “plant-based substitute products” in scientific publications (cf. e.g., [11, 12]). The communication surrounding “...-gurts”, which presents them as alternatives to or substitutes for animal products, also leads consumers to have certain expectations about the products’ sensory properties, with these expectations being based on yogurt as the “gold standard”. Since the nutritional values of foods influence organoleptics, it is necessary to establish whether vegan “...-gurts” can actually act as alternatives to or substitutes for traditional yogurt on a sensory level. Lichtenstein, Bergmann and Brandt [13] previously demonstrated how diverse vegan products similar to yogurt or milk are in terms of ingredients and nutritional profiles. However, since it is impossible to systematically infer sensory characteristics merely by analyzing nutritional profiles, the descriptive market study by Lichtenstein, Bergmann and Brandt [13] was supplemented by sensory analyses of selected “...-gurts”. This article presents and discusses the results. This is a non-representative, preliminary market analysis using a comparative product test with an explorative approach. The sensory characteristics of four “...-gurts” made from different raw materials and one yogurt were recorded using analytical and hedonic test methods.

Methodology

Study question

The study analyzes how untrained testers rate various sensory characteristics of fermented vegan products (“...-gurts”) and yogurt. Paper testing forms [14] were used to determine whether and how products with different main components (soy, coconut, lupin, oats and cow’s milk) differ organoleptically. The key question is whether the terms “alternative” or “substitute” adequately reflect how testers rate the products based on their sensory characteristics.

Study design

The study design was based on a prior in-house tasting and a pre-test.

In-house tasting

In summer 2022, three employees of the Dr. Rainer Wild Foundation initially carried out an in-house tasting to select a range of products to represent the range of products with various different main components available on the market (various retail and manufacturer brands, discount and organic products). The tasters described the sensory attributes (appearance, aroma, mouthfeel and taste) of selected fermented products based on soy (n = 6), oat (n = 4), coconut (n = 6), lupin (n = 1) and cashew (n = 1) as well as six yogurts with different levels of fat content (1.5%, 3.5%, 4%

and 10%) in two sessions of 1.5 hours each. Subsequently, one product per main component (N = 5) was selected in a step-by-step process based on an open discussion of the subjective judgments. Exclusion criteria included “non-typical” sensory characteristics for the general product group of “fermented products”, e.g., oat flakes present in the product, flavored products and sensory “outliers” with strongly deviating acidity or sweetness intensity as well as off flavors, e.g., in the case of the fermented cashew product, which was not included in the study.

Pre-test

The next step was a pre-test in which six students from the Heidelberg University of Education (PH HD) evaluated the product selection, the questionnaire on sociodemographic characteristics, purchasing and consumption behavior and the paper testing forms (♦ Table 1). This resulted in the following modifications to the study: layout of the questionnaire, order in which the tests were carried out and changes to the scales for test no. 5 on the intensity assessment of product characteristics (change from linear scales to just-about-right scales). This made it possible to evaluate the product characteristics as “just right” [15].

Study

Study population: recruitment and training

The sensory analysis tastings were carried out anonymously on the premises of the Heidelberg University of Education in January 2023. 26 untrained sensory testers (= “N”) were recruited via analog and digital announcements. At the start of the study, the participants were fully informed about the voluntary nature of their participation, about data protection arrangements, and that they were responsible for their own well-being during participation (e.g., with regard to allergies or veganism).

Data collection and evaluation

The collected data was encoded and transferred to Excel once the study was complete. The quantitative analysis was carried out using Excel. Qualitative analysis of the contents of the free text field made it possible to build a qualitative profile of the products through categorization [16, 17] and typologization [18].



Fig. 1: Products tasted

Products tested

A total of five different products (♦ Figure 1) were tasted “blind” in six different test procedures, i.e., the participants had no knowledge of which specific product they were testing.

Sensory tests

The test procedures are shown in ♦ Table 1. Each paper test form was labeled with a three-digit letter code to allow anonymous evaluation. The blind samples were assigned random three-digit numbers. The samples were presented to the participants in a randomized order.

Results

Sociodemographic characteristics

♦ Table 2 shows some of the participants’ key characteristics in tabular form.

Two participants described their diet as vegan, seven described it as vegetarian, nine as flexitarian and eight stated that they ate a mixed diet.

Results of the sensory tests

Matching test

All participants correctly identified the coconut product. Yogurt was also correctly identified by all (except the two vegans who did not taste it). The fermented oat product was mistaken for soy or lupin by three people each, which means it had an error rate of 23%. The fermented soy product, on the other hand, was incorrectly matched at a rate of 38.5%: three people matched it to oats and 7 people to lupin. As expected, this produced a reversed result for the lupin product: three incorrect matches to oats and seven incorrect matches to soy.

Preference and acceptance

In test no. 3, yogurt and the coconut product received the best ratings with an average score of 3.8 each (out of a possible 0 to 5 stars). The fermented soy product came in second with 2.8 stars. Lupin (2.2 stars) and oats (2.0) were less popular.

The acceptance test (test no. 6a) was supplemented with a question about the intention to consume the five products on offer

No.	Test	Description	Variables I. qualitative II. quantitative
1	Simple descriptive test ^a [19]	Appearance, smell, consistency/mouthfeel, taste	I
2	Matching test [20]	Assignment of samples to a main ingredient (yogurt, oats, soy, lupin, coconut)	II
3	Preference test [21]	Product popularity based on a 5-point hedonic scale	II
4	Ranking test [20]	Ranking of the samples according to creaminess and intensity of sweetness and sourness	II
5	Assessment of the intensity of product characteristics using the just-about-right scale (JAR) [21]	Assessment of whether a product characteristic is “much too weak”, “too weak”, “just right”, “too strong” or “much too strong” using a 5-point JAR scale a) appearance/mouthfeel: runny – thick b) smell/taste: weak – intense	II
6	Acceptance test [22]	a) Testing using a 5-point category scale b) Open question about reasons	a) II b) I

Table 1: Overview of the sensory test procedures carried out in the order in which they were carried out in the study

^a This test is not covered in the present publication.

Age distribution	n
19–24	6
25–29	13
30–39	3
40 and over	4
Gender	n
Female	24
Male	1
Non-binary/intersex	1
Current occupational status	n
Studying	21
Employed part-time	1
Employed full-time	4
Area of specialism	n
Teaching profession	13
Special education	9
not specified	4

Table 2: Overview of the sociodemographic data of the study participants (N = 26)

using a 5-point scale: “Would you consume the product?”. The results are shown in ♦ Figure 2.

Combining the consumption intentions “definitely” or “probably” confirms that yogurt and coconut products are preferred over the other products. Despite its ranking third in the previously expressed preference ranking, the majority (approx. 65%) of the participants said they would “definitely not” or “probably not” consume the soy product. In the case of the oat product, the participants were indifferent in terms of their intention to consume it, with 35% stating that they “might” consume the product, 38% expressing a negative inclination (“definitely/probably not”) and 27% remaining open (“definitely/probably consume”).

The participants gave reasons for their answers regarding their intention to consume the products, added descriptive attributes of the products to the free text field and declared whether and how they would use the respective product (test no. 6b). The qualitative profiles and the typology of the products are listed in ♦ Table 3. The results are presented using anchor examples.

Ranking test

The products varied in terms of their sweetness, acidity and creaminess. For example, yogurt had the weakest sweetness and the strongest acidity. Its creaminess ranked behind that

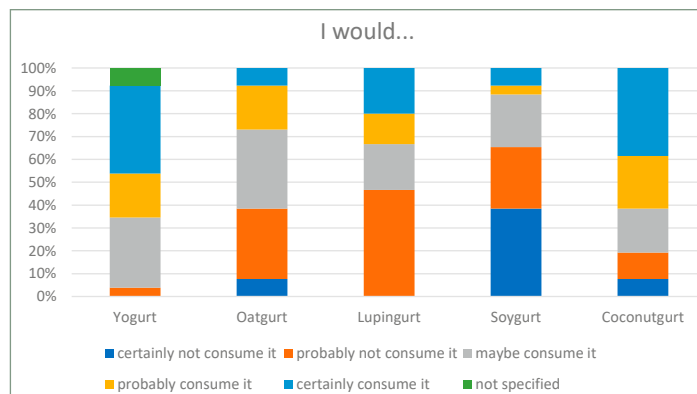


Fig. 2: Intention to consume based on the question “Would you consume the product?” (N = 26)

of the lupin product. On average, the participants perceived the oat product as having the strongest sweetness, but also rated it as slightly creamy and slightly sour. The lupin product was also perceived as very sweet which, similar to the oat product, could be explained by the nutritional profile, as these two products have the highest carbohydrate content: in the case of the oat product this comes from the raw material oats, while in the case of the lupin product it comes from ingredients such as maltodextrin, modified starch and inverted sugar syrup.

Intensity ratings using just-about-right scales

As with the qualitative profile results, the participants rated the five products very differently in terms of the sensory attributes “appearance”, “smell”, “mouthfeel” and “taste”.

One clear example of this is the lupin product. The majority of the participants rated the appearance (n = 25) and mouthfeel (n = 23) of the product as “just right”. However, there was great variation in ratings of smell and taste. The aroma was too weak or much too weak for some (n = 8), while others found it too intense or much too intense (n = 7). In terms of taste, the majority (n = 20) rated it as “too intense” or “much too intense” (♦ Figure 3).

The majority rated yogurt as “just right” across all characteristics. Nine people each found the mouthfeel and appearance “too runny” or “much too runny”, and the taste “too intense or much too intense”. One striking result is that the majority of participants felt that the “mouthfeel” characteristic was “just right” for all of the products except the coconut product. The mouthfeel of the coconut product was rated as too thick or much too thick by 16 testers.

Summary and discussion

Without making any claim as to the generalizability of the results, this exploratory study shows that untrained testers evaluate the fermented, animal and vegan “...-gurts” in a very differentiated and comprehensive manner. In hedonic terms, yogurt and coconut yogurt were the preferred and most reliably recognized products. Nevertheless, the testers were able to assess the individual



	Typologization	Impression of taste	Consistency and appearance	Possible uses
Cow's milk	<p>"The familiar all-rounder"</p> <p>This typologization is based on the positive impressions of taste described and the wide range of possible uses mentioned.</p>	<p>In terms of impressions of taste, it is clear that the participants were familiar with cow's milk yogurt. Comments such as "tastes like yogurt" and "just as you would probably imagine yogurt to taste", as well as the many evaluations stating that it has a familiar taste show that yogurt made from cow's milk is an established product. The evaluations range from positive descriptions ("I like it", "I like the taste") to neutral/indifferent and negative descriptions ("I don't like the aftertaste...").</p>	<p>In terms of consistency, runniness is a frequently mentioned aspect. Descriptions such as "even though it is runny, the consistency is... pleasant" and "a little too runny" make it clear that individual preferences dominate here.</p>	<p>The participants said that cow's milk yogurt can be used in a variety of ways in the everyday diet ("versatile") and give examples of this: "in desserts...", "with muesli or fruit", "in tzatziki or salad".</p>
Oat	<p>"The sweet addition"</p> <p>This typologization is based on the described/dominant taste impressions and the fact that it is explicitly named as a possible ingredient ("for baking...", "not on its own, but as an ingredient...") in the context of everyday use.</p>	<p>The descriptions of taste impressions were dominated by the characteristic of sweetness, which was associated with both positive and negative impressions. This is evident in the descriptions, for example "slight sweetness in the finish", "seems naturally sweet..." and "I really like the taste... not too much sweetness and not too little". The negative taste impressions outweigh the positive ones. Aspects influencing this included sweetness and other taste sensations that can be classified as unpleasant ("unpleasant taste of bread...", "yuck!").</p>	<p>Descriptions of consistency (in terms of how runny the product was) and appearance (in terms of the color) tended towards the negative: "a bit too runny", "...not a good mouthfeel", "not a very appealing color".</p>	<p>In terms of everyday use, the participants viewed this product as more of a baking ingredient, or as something to combine with muesli or have as a dessert. Some participants completely ruled out using it: "I wouldn't use it", "I can't think of a recipe I would use it in", "I wouldn't want to... use it".</p>
Coconut	<p>"The strong individualist"</p> <p>This typologization is based on the described intense and distinct taste of coconut and the intensity of the consistency (thickness).</p>	<p>The descriptions of taste impressions were dominated by the product's intrinsic coconut flavor. The ratings for this were both positive ("I like the coconut flavor", "...delicious coconut flavor, ...") and negative ("very strong coconut flavor, too intense for me", "artificial note of coconut ..."). The participants also rated intensity in terms of taste: "I particularly like the intense taste", "intense intrinsic flavor".</p>	<p>When describing the consistency and mouthfeel, the participants explicitly emphasized the thickness of the product. In some cases this led to an increase in the rating ("it's thick, I like it"), while in others it led to a decrease ("relatively thick, but unfortunately not creamy"). In terms of consistency and color, the participants also drew comparisons with other dairy products such as quark, crème fraîche and mascarpone. They found the color appealing: "cool color", "good color".</p>	<p>Some ideas for everyday use were mentioned, especially for cases where this particular profile is explicitly desired ("in oriental dishes") or for desserts ("not for savory dishes") or in combination ("with muesli", "in smoothies...").</p>
Soy	<p>"The ambivalent one"</p> <p>This typologization is based on the contrasts between the descriptions of everyday use and the conflicting taste impressions ranging from bitterness to acidity.</p>	<p>Qualitative descriptions of taste impressions tended towards the negative. The participants' descriptions included comments such as "strange and peculiar taste..." and "taste takes some getting used to, very peculiar". The bitterness of the product was also a factor: "...really bitter", "...bitter taste". For sourness, there were neutral/indifferent ratings and positive ratings ("a little sour, but not too sour...", "interesting sour taste").</p>	<p>For consistency, the product was described with positive comments such as "nice and creamy", "good consistency" and "nice mouthfeel". Some participants also found the visually appealing: "looks great visually", "the appearance/look of it is particularly good". The product was also marked down for its color: "the color is too yellow for me", "too yellow".</p>	<p>Some participants clearly ruled out using it in their everyday diets: "I couldn't eat it on its own", "I wouldn't use the product", "I wouldn't buy it or use it". Other participants viewed it as an ingredient ("in a recipe...", "as a partial ingredient"). There were two interesting opposite rankings that drew comparisons with yogurt: "best alternative to cow's milk yogurt", "not very reminiscent of yogurt".</p>
Lupin	<p>"The niche product"</p> <p>This typologization as a niche product is based on the ratings, which tended towards the negative, and on the fact that the product received a failing grade across almost all sensory dimensions.</p>	<p>Negative ratings dominate the descriptions of taste impressions. They mention the bitterness ("much too bitter/tart") and the artificial and sour taste ("tastes artificial", "too sour"). Some participants also described unpleasant taste characteristics: "an unpleasant sour-sweet aftertaste", "unpleasant aftertaste". However, few participants appreciated the sour taste: "a good mix of sweet and sour", "tastes good as it is slightly sweet and slightly sour at the same time".</p>	<p>When describing the consistency, the participants gave positive evaluations: "the consistency is very good", "perfect in terms of consistency".</p>	<p>In terms of inclusion in the everyday diet, the participants clearly rejected the product, particularly because of its taste: "unfortunately I don't like the taste of the product at all", "the product isn't to my taste", "I can't imagine any recipe where I would use it at all".</p>

Table 3: Qualitative profiles of the products

characteristics of all of the products independently from the overall impression. In fact, the majority found the look and mouthfeel of the oat, soy and lupin yogurts to be “just right”. A different picture emerges for the attributes taste and smell – here again yogurt and coconut yogurt score well ahead of the other products. Oat, soy and lupin yogurt were judged to be “too intense” or “much too intense” in terms of taste and “too weak” or “much too weak” in terms of aroma. Using the qualitative profiles in particular, the study was able to show the key sensory differences that characterize the products and the wide range of technical culinary uses that were predicted (♦ Table 3), even if the product itself was rejected in its “pure” form, as was the case with the lupin product, for example.

For Germany, the German Food Code Commission guidelines point out potential organoleptic differences in the context of the different composition of vegan foods [18], p. 5). However, the guidelines also state that the vegan foods are (or should be) similar in terms of “typical sensory characteristics” to the “referenced foods” of animal origin. It could not be confirmed that this is the case for all characteristics of the products selected in the present study, which is in line with the results of Pandey et al. [4]. At the same time, sensory characteristics – and in particular taste [4] as well as appearance and mouthfeel [23] – are strong and significant predictors of an intention to consume vegan “...-gurts”.

However, a Finnish-US study by Greis et al. [24] showed that consumers have different expectations of dairy products than of plant-based (vegan) fermented products. The exact same 50:50 mix of dairy products with vegan “...-gurts” was rated better when labeled “vegan” than when labeled “dairy product”. For other vegan products (including cookies, sausages and cheese), consumers found the label “plant-based” more appealing than “vegan” [25]. Labeling and claims about special product characteristics therefore appear to have a positive influence on consumer acceptance of the vegan product group, including “...-gurts”, regardless of sensory deviations from traditional yogurt [4].

According to one study, the fermentation process itself improves the overall sensory perception of plant-based products [4] and focusing on creaminess and texture during product development appears to be key to improving

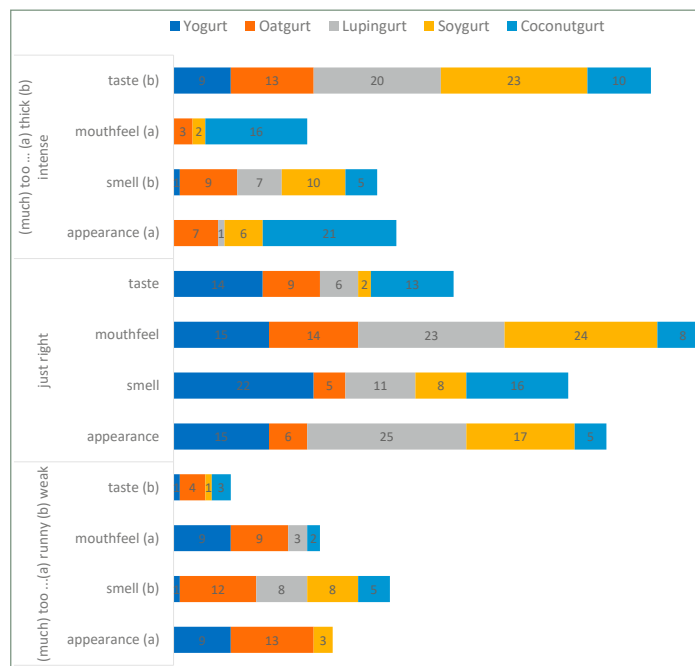


Fig. 3: Evaluation of product characteristics using the 5-point just-about-right scale
 Absolute frequencies (N = 26), the scale points “much too runny/weak” + “too runny/weak” and “much too thick/intense” + “too thick/intense” have been combined for visual clarity.

evaluations of mouthfeel [24, 26, 27]. Being as similar as possible to dairy products increases the overall popularity of vegan “...-gurts” [24], whereas a “bean-like taste” and other off flavors make them less popular [26].

Limitations

Based on the number of testers and the number of products, this was a non-representative, preliminary market study conducted using an exploratory approach. The untrained testers varied in terms of their dietary patterns and their consumption of vegan products. For the two vegans who participated, the testing setup was different because the dairy product was omitted.

The testing conditions were not standardized in terms of testing location, light and temperature conditions, as is standard for sensory analyses (e.g., simple descriptive tests). However, the methodology used in this study was based on the German Agricultural Society (*Deutsche Landwirtschafts-Gesellschaft*, DLG) expert opinion published by Schneider-Häder and Derndorfer [19], which also allows the use of untrained testers and specifies a minimum number of three testers.

The five products selected were very heterogeneous in terms of their production processes and compositions (organic/conventional, name brand/own brand, ingredients and nutritional values). However, in the in-house tasting selection process, attention was paid to distinctive off-flavors or sensory characteristics atypical for the “plainingurt” product group, as described above.

The study was conducted two years ago, which means that it is possible that recipes and therefore also sensory characteristics have



changed since the study was conducted or that the products are no longer available on the market. Nevertheless, the results leave open the possibility of analyzing the sensory properties of other vegan “...-gurts” and changing the positioning of the products on the market by highlighting distinctive unique selling points.

Outlook

Future studies on vegan “...-gurts” should validate the results presented here using a larger number of products ($n \geq 8$ per raw material), a larger panel and, if necessary, trained testers. Future studies should also investigate whether the differences described here are typical for each main ingredient or whether brand-specific positioning also contributes to the differences. Quick sensory methods (such as “SORTING”, “projective mapping” or “Napping”[®]) could also be used for this purpose (cf. [19]). In addition to “blind tastings”, future studies should also analyze whether and if so, how providing clear information on the sensory quality of the products leads to changes in judgments.

The need for comprehensible positioning of vegan products in general is also addressed in the German Food Code Commission guidelines for vegan and vegetarian foods with similarities to foods of animal origin, which are currently under legal review. In these guidelines, the terms “sufficient and extensive similarity” that have already been used to date are to be made more tangible by means of a supplementary definition: “Sufficient similarity means a clearly perceptible similarity, which must be present as a minimum requirement to justify referencing terms that normally refer to foods of animal origin, whereas extensive sensory similarity means an almost complete similarity.” [28]. For “...-gurts” as a product group, “sufficient similarity” can likely be assumed based on the results shown here – at least for certain attributes, such as appearance. However, it is necessary to analyze to what extent consumers share this assessment and for which sensory attributes they expect sufficient or extensive similarity is expected and for which sensory attributes they will tolerate larger deviations from the minimum requirements, or which other motives for consumption the products must satisfy in order to override the effects of greater sensory deviations (e.g., animal welfare, more sustainable nutrition, etc.).

It appears likely that more differentiated market positioning combined with emotional appeal and references to key aspects of consumer concepts of sustainability [cf. 23] could help to establish the product group among different target groups. Freeing vegan “...-gurts” from the constraints of comparisons with conventional yogurts and communicating their expanded potential uses in the kitchen and the wide range of ways they can be used in everyday diets could also be a catalyst for the market penetration of vegan “...-gurts”. Nevertheless, manufacturers should continue to optimize the organoleptic characteristics of vegan “...-gurts” in line with consumer expectations [4, 23], provide specific recommendations for their use and highlight additional benefits. One innovative approach could be to mix dairy yogurts with vegan “...-gurts” [23].

Adequate communication strategies to steer currently established dietary patterns in a more sustainable direction using a wider variety of animal, plant-based and vegan products – or a mixture of these – will need to take into account the question of whether terms such as “alternatives” and “substitutes” trigger appropriate expectations among consumers. This is because expectations that are not met due to previous experiences with dairy products lead to negative emotional activation (e.g., disappointment), damage to the image of vegan products and ultimately to a lack of repeat purchases (cf. [29, 30]).

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Disclosures on Conflicts of Interest and the use of AI

The authors declare that there is no conflict of interest and that no AI applications were used in the preparation of the manuscript.

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