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Original article

Investigating the effect of sharing environmental information on consumer responses to conventional and hypothetical 'precision fermented' yoghurt

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Summary Precision fermented dairy (PFD) is a novel technology used to produce milk proteins that can be used to replicate conventional dairy (CD) products. With PFD products likely to be available soon in the United Kingdom, this study aimed to explore consumer acceptance of these products. Specifically, the effect of sharing information related to the process and environmental impact of PFD on overall liking and emotional response for yoghurts labelled as CD and PFD. Overall, all participants (n = 62) were willing to try the yoghurts labelled as PFD, and no significant difference in liking between yoghurts labelled as CD and PFD was found, indicating acceptance and trust. However, sharing information slightly increased liking for PFD yoghurt and evoked more positive emotions ('*understanding*', '*adventurous*' and '*enthusiastic*'). In contrast, information decreased liking for CD yoghurt and had minimal impact on the emotional response, but made participants feel slightly '*guilty*'. In particular, sharing information led high food-neophobic and food technology-neophobic individuals to be more '*understanding*' towards PFD in comparison to the low-neophobic groups. Findings suggest emotional responses can provide deeper insights beyond liking, which will benefit the food industry when reviewing consumer attitudes. The results show promise that consumers will accept PFD products when available, provided the novel technology can mimic the sensory properties of CD. Furthermore, when marketing products, sharing information may increase liking for sustainable products, but future studies would benefit from exploring the effect of different types of information on consumer acceptance.

Keywords Barriers, consumer acceptance, emotional response, information, liking, nutrition education, precision fermented dairy, yoghurts.

Introduction

Dairy remains a key commodity in many consumers' diets, being a good source of calcium and vitamin D. However, the consumption of dairy in EU diets is thought to contribute to as much as one-third of dietary greenhouse gas (GHG) emissions (Sandström *et al.*, 2018). Therefore, there are concerns over how to produce dairy in a sustainable way whilst meeting the nutritional needs and supply demands of future generations. Plant-based milk made from a variety of ingredients such as oats, soy, almond and rice offer viable, sustainable alternatives to conventional cow's milk, being lower in GHG emissions with less land and water use (Poore & Nemecek, 2018). However, these plant-based alternatives are not always nutritionally adequate, being higher in cholesterol and lower in protein (Collard & McCormick, 2021). Furthermore, the sensory properties and functionality of plant-based milk are very different from each other and sometimes give undesirable sensory characteristics such as beany flavours (e.g., in soy milk) (Sethi *et al.*, 2016).

One novel solution to produce dairy more sustainably, whilst addressing health needs and sensory appeal, comes from the development of dairy through a process called precision fermentation (also known as microbial fermentation). In its simplest terms, yeast cells are infused with cow DNA and processed in a

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bioreactor to produce milk which aims to have a similar composition and sensory profile to conventional dairy (CD) milk (Mouat & Prince, 2018). This novel food technology is thought to have the potential to be more sustainable in terms of lowering GHG emissions (Behm *et al*., 2022; Perfect Day, 2021) and improving production efficiency (Teng *et al*., 2021). Additionally, it has the possibility to modify the macro and micronutrient content to reflect optimised nutrition and taste (Mendly-Zambo *et al*., 2021). UK-based companies are currently developing precision fermented dairy (PFD) products, including Remilk and Better Dairy, whilst a more established American-based company (Perfect Day) launched a range of ice cream products made using PFD in 2019. It is therefore likely that the UK market will not have too long to wait before products become available. However, as products are manufactured using this emerging technology, the success of PFD very much depends on consumer acceptance (Lavilla & Gayán, 2018).

Understanding emotional responses to products can provide additional insights beyond consumer acceptance, for example, better prediction of food choices (Low *et al*., 2022). For example, sharing the sustainability benefits of products has been shown to elicit positive emotions and less guilt for more sustainable food products (Yang *et al*., 2020). Research has also found that the perceived benefits of a product, including environmental effects and consumer's food technology neophobia are highly influential in shaping attitudes towards precision fermentation technology (Banovic & Grunert, 2023). Therefore, exploring the effect of environmental information and individual differences in food technology neophobia on emotional responses will provide a richer overview, beyond liking, of consumer acceptance towards PFD products.

The provision of information (e.g., product composition, origin of ingredients, societal, personal benefits, quality and taste) alongside sensory evaluation is likely to increase consumer acceptance (Rolland *et al*., 2020; Bschaden *et al*., 2022; Grasso *et al*., 2022). However, whether environmental information alone increases acceptance in the context of PFD is yet to be explored. A previous study reviewing the effect of different information treatments (animal welfare, environmental concerns, GMO, farmer existence) found the animal welfare and environmental concern narratives to have higher willingness scores for precision fermented cheese, although the influence on consumer acceptance was deemed to be relatively small (Kossmann *et al*., 2023). Considering the potential for information and sensory appeal to shape consumer behaviour, sensorial studies are required for a deeper understanding of consumer acceptance and or rejection of PFD (Boukid *et al*., 2023).

A survey of British consumers found that 67.6% were willing to try precision fermented cheese (Zollman Thomas & Bryant, 2021), with only a minority willing to adopt it if it was priced comparatively with conventional dairy cheese (Slade & Zollman Thomas, 2023). However, a qualitative study amongst young British meat-eaters found participants to have positive feelings towards this novel technology (Ford *et al*., 2023a). Specifically, participants believed PFD would be beneficial for the environment and animal welfare, with the potential for optimised nutrition and curiosity around sensory appeal also acting as enablers (Ford *et al*., 2023a). In contrast, barriers are thought to relate to scepticism around its affordability, sensory appeal, safety, naturalness and contribution to climate change and health (Broad *et al*., 2022; Powell *et al*., 2023; Ford *et al*., 2023a). Overall, sensory appeal has always been identified as a key motive which links to repeated consumption/purchase (Zollman Thomas & Bryant, 2021; Powell *et al*., 2023; Ford *et al*., 2023a).

Due to products being unavailable on the market in most countries, previous studies have a lack of physical product exposure. Therefore, studies including PFD have either utilised focus groups (Broad *et al*., 2022; Ford *et al*., 2023a), questionnaire-based surveys (Zollman Thomas & Bryant, 2021; Banovic & Grunert, 2023; Crawshaw & Piazza, 2023; Kossmann *et al*., 2023; Slade & Zollman Thomas, 2023) or a mixture of quantitative and qualitative data (Powell *et al*., 2023). However, given that the technology aims to replicate and produce a similar sensory profile to CD, one approach could be to use CD labelled as PFD. Therefore, this study aims to address the gaps in research by conducting a sensory evaluation to understand the following research questions:

1 Are UK participants willing to try PFD?
2 Assuming the sensory properties are similar between PFD and CD, what are the differences in liking and emotional response between the same yoghurt when it is labelled as PFD or CD?
3 How does sharing information (environmental impact, PFD process) impact liking and emotional response to PFD and CD?
4 How do food neophobia and food technology neophobia influence liking and emotional response to PFD and CD?

Materials and methods

Participants

In total, 62 healthy adults (46F, 16 M) living in the United Kingdom, aged 20–62 (M = 28), from mixed ethnic backgrounds were recruited using convenience sampling, with the minimum sample size (n= > 40) achieved (Gacula & Rutenbeck, 2006). The majority

Table 1 Subject characteristics, results presented as *n* (%)

		Food Neophobia Group		Food Technology Neophobia Group	
Total (*n* = 62)		**Low (*n* = 32)**	**High (*n* = 29)**	**Low (*n* = 26)**	**High (*n* = 35)**
Gender					
Female	46 (74)	22 (48)	24 (52)	21 (46)	25 (54)
Male	16 (26)	10 (67)	5 (33)	5 (33)	10 (67)
Age					
20–29 years	47 (76)	24 (51)	23 (49)	17 (36)	30 (64)
30–62 years	15 (24)	8 (57)	6 (43)	9 (64)	5 (36)
Ethnicity					
African Caribbean	2 (3)	0	2 (100)	1 (50)	1 (50)
Asian	11 (18)	2 (18)	9 (82)	5 (45)	6 (55)
Mixed	2 (3)	0	2 (100)	1 (50)	1 (50)
White	47 (76)	30 (65)	16 (35)	19 (41)	27 (59)
Dietary preference					
Omnivore	49 (79)	24 (50)	24 (50)	17 (35)	31 (65)
Flexitarian	7 (11)	4 (57)	3 (43)	4 (57)	3 (43)
Pescatarian	3 (5)	2 (67)	1 (33)	3 (100)	0
Vegetarian	3 (5)	2 (67)	1 (33)	2 (67)	1 (33)

For the FN & FTN one person did not complete the data so total *n* = 61. Low FTN (score ≤45), high FTN (≥46), low FN (≤23) and high FN (≥24). The dietary preferences were classified as follows: Omnivore: I eat meat from animals, dairy products, seafood and fish, Flexitarian: I have a primarily vegetarian diet but occasionally eat meat, dairy, fish and seafood, Pescatarian: I don't eat meat from animals, but I do eat dairy products, seafood and fish, Vegetarian: I don't eat meat from animals, seafood and fish.

of participants self-identified as omnivores (79%) (Table 1) and were predominantly from a university cohort. Participants gave written informed consent to take part in the study and received a disturbance allowance at the end of the study. To reduce bias, the participant information sheet explained that the study was interested in understanding consumer acceptance of food produced using novel technologies and/or sustainably but did not explicitly mention PFD. Participants who smoked, were pregnant/breastfeeding, had any food allergies, were lactose intolerant, or had any anosmia/ageusia were screened out. This study was given a favourable opinion by the University of Nottingham School of Biosciences Ethics Committee (approval code: SBREC202223022FEO).

Products

A commercial dairy yoghurt (Activia strawberry yoghurt, no added sugar, 0% fat) was used during the tastings. This yoghurt was selected because it is reflective of one of the leading yoghurt brands commercially available in the United Kingdom, therefore very familiar to consumers, with strawberry being one of the most popular flavours around the world (Thompson *et al.*, 2007). The yoghurt samples were prepared at the start of each day and stored in a refrigerator (3 ± 2 °C) prior to the sessions. As PFD is not yet commercially available in the United Kingdom, the same CD yoghurt was used but labelled according to the experimental condition (PFD or CD). To conceal the brand and to ensure consistency, after thoroughly stirring the yoghurt, two tablespoons (~30 g) were decanted into clear and odour-free plastic pots and labelled with a three-digit randomised code (see Figure S1).

Overall liking and emotional response

Overall liking (OL) was rated on a labelled affective magnitude scale (LAM) (Schutz & Cardello, 2001). Emotional response was captured using the EsSense25 questionnaire (King & Meiselman, 2010; Nestrud *et al.*, 2016) through Check-all-that-apply (CATA). These emotions can be characterised into 16 positives (*active, adventurous, calm, enthusiastic, free, good, good-natured, happy, interested, joyful, loving, nostalgic, pleasant, satisfied, secure and warm*), 3 negatives (*bored, disgusted* and *worried*) and 6 unclassified (*aggressive, guilty, mild, tame, understanding* and *wild*) emotions (King & Meiselman, 2010). Subjects were asked to select all emotions that were elicited when consuming the samples and could choose not to select any emotions if they did not apply. Emotional terms were presented in a random order across participants, but the order was kept the same for each subject (King *et al.*, 2013).

Food technology and food neophobia status

Participants completed the food technology neophobia (FTN) scale consisting of 13 statements (Cox &

Evans, 2008) and the food neophobia (FN) scale consisting of 10 statements (Pliner & Hobden, 1992). All statements were measured using a 7-point Likert scale ranging from '*strongly disagree*' to '*strongly agree*' (Tables S1 and S2). To avoid priming, participant responses were captured prior to the tastings to obtain any fears or concerns participants may have about novel food technology. For both questionnaires, the scores for each statement were summed with consumers segmented based on the group median score following a previous study (Yang *et al.*, 2020). The following groups were classified: low FTN (score ≤45), high FTN (≥46), low FN (≤23) and high FN (≥24) (Table 1).

Experimental design

Participants attended two tasting sessions at the University of Nottingham's Sensory Science Centre. A summary of the session procedures is detailed in Fig. 1. Data was collected using Compusense Cloud (Compusense, Canada). Appropriate palate cleansers of water (Harrogate, England) and crackers (Matzo crackers, England) were provided during the one-minute break between samples. The data was collected across two separate sessions, as it was part of a larger project studying individual differences in taste preferences, personality and sustainable food attitudes.

In Session 1, participants were familiarised with the LAM scale and tasted the yoghurt labelled as CD with no other information provided (CD-Control). When tasting the yoghurt, participants were asked to taste two consistent teaspoons of yoghurt to rate emotional response, as there are 25 emotions to be evaluated and one further teaspoon to rate OL.

In Session 2, participants were first provided with definitions for CD and PFD (Table S3). Next, participants were asked if they were willing to try the yoghurt labelled as PFD (yes/no). If participants were willing, they tasted the PFD-labelled yoghurt (PFD-Control) using the same protocol as in Session 1. If participants were not willing, they were shown an image instead (Figure S1) and asked to imagine eating the sample before rating their expected OL and emotional responses.

Next, to assess the impact sharing environmental information had on the perception of the yoghurt, participants were shown a short (5 min) video as a group. Given the broad nature of sustainability within the food industry, the video focused on the GHG emissions of a range of food categories (meat, dairy, veg) based on Life Cycle Assessment analysis. It also included a comparison of the estimated climate impact of PFD to that of CD. See the Video S1 for a more detailed breakdown of the video content. After watching the video, participants were asked again if they were willing to try PFD (yes/no). Similar to the Control condition, participants then tasted (or viewed images) of the yoghurt labelled as CD (CD-information sharing) and PFD (PFD-information sharing) in a randomised, balanced order, before rating emotional responses and OL. At the end of Session 2, participants were informed that none of the samples were PFD for ethical considerations and transparency. In summary, only a definition was provided during the control condition, whilst the information sharing condition related to both definition and sharing information through video.

Data analysis

Data were analysed using XLSTAT (Addinsoft, 2023) with a 5% significance level. Analysis of variance (ANOVA) was carried out to examine differences in OL between the two yoghurts (CD and PFD). To

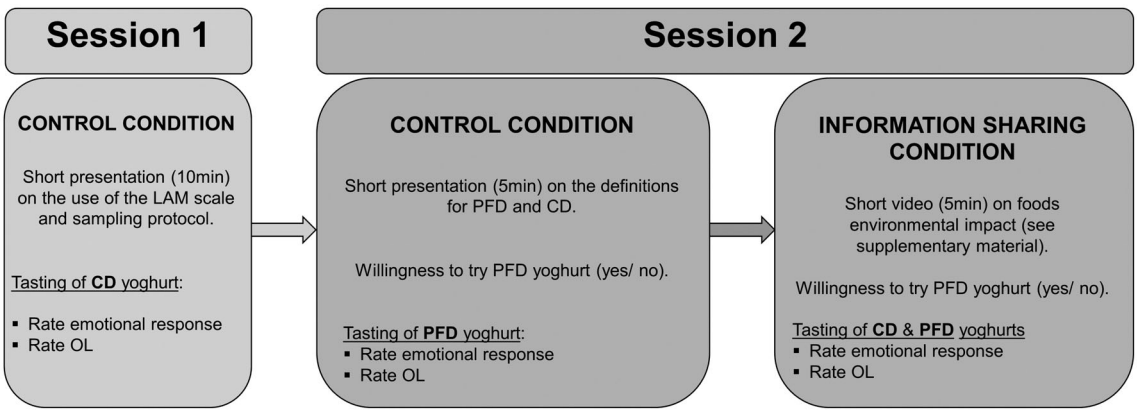

Figure 1 Flowchart of the study design procedure across the sessions. Please note that Session 1 CD yoghurt and the first part of Session 2 PFD yoghurt relate to the control condition (definition only).

understand significant changes in liking, post-hoc analysis was carried out using two-tailed paired sample t-tests on the two conditions (control and information sharing) for the two products (CD and PFD). Additional analyses were carried out across consumer segments (high neophobic, low neophobic) for both the FTN and FN groups. To understand how large the standardised mean differences were, effect size using Cohen's d_z was calculated and interpreted based on the following benchmarks: small (d = 0.2), medium (d = 0.5) and large (d = 0.8) (Lakens, 2013).

Contingency tables were used to tabulate the emotional response frequencies of the CATA data. To understand relationships between the products and emotional responses, correspondence analysis (CA) was conducted, and Cochran's Q test (with the Sheskin, 2011 procedure for multiple pairwise comparisons) was performed on each of the emotional terms to understand significant differences (5% level).

Results

Consumer willingness to try and acceptability of PFD

All participants (n = 62) were willing and consented to try the PFD yoghurt in both conditions (control and information sharing), which indicates high acceptability, curiosity and trust in this novel technology. In addition, PFD yoghurts were liked moderately (M = 71.62), which is not significantly different from CD (M = 73.05) (P = 0.24).

Comparing the impact of information on the liking of yoghurts labelled as 'conventional dairy' and 'precision fermented dairy'

When participants were given additional information through the video (environmental impact, PFD process), their liking for CD yoghurt decreased significantly (t(61) = 2.60, P = 0.031, d = 0.28), whereas PFD yoghurt's liking increased slightly (t(61) = −1.585, P = 0.085, d = −0.22) (Fig. 2). The trends observed indicate sharing this type of information impacts consumer acceptance slightly with a small effect size present (Lakens, 2013). See Figure S2 for the mean change in OL.

Comparing the impact of information on the emotional responses of yoghurts labelled as 'conventional dairy' and 'precision fermented dairy'

The CATA data relating to the 25 emotional terms were evaluated using Correspondence Analysis (CA), as presented in Fig. 3. The biplot explained 87.94% of the variance, with the first dimension (F1) accounting for 63.29% and the second dimension (F2) accounting

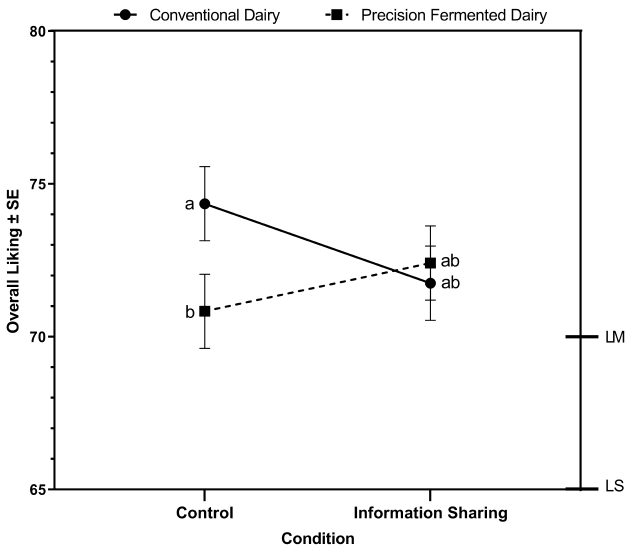

Figure 2 Mean overall Liking ± SE for the conventional dairy and precision fermented dairy yoghurt in the control (definition only) and information sharing (definition and video) conditions. LS, like slightly; LM, like moderately. Different letters denote significant difference ($P \leq 0.05$) based on Tukey Honest Significant Difference (HSD) multiple comparisons test.

for 24.65%. F1 captured the majority of the variance, with emotions ranging from positive (*nostalgic*) to negative (*disgusted*), whilst F2 represents '*worried*' to '*guilty*'.

The results of Cochran's Q test for each emotion revealed significant differences ($P < 0.05$) in frequencies amongst the four samples for five positive emotions (*adventurous*, *enthusiastic*, *free*, *interested* and n*ostalgic*) and one unclassified emotion (*understanding*). There were no significant differences for the negative emotions and the term '*aggressive*' was not selected by any participant (Table S4). In general, for each product, *'pleasant'* and *'good'* were the most frequently cited terms[1] (~72% and ~ 68%). The high frequency scores across products suggest an equally positive outlook.

The pooled data for the CD yoghurts was closely associated with positive terms and had higher citation frequency scores for the term '*nostalgic*' (~36%) compared to the PFD yoghurts (~16%). This suggests participants feel comfortable and familiar with the sensory characteristics of CD yoghurts. In contrast, the PFD yoghurts had significantly higher ($P < 0.0001$) frequency counts for the emotional terms,

[1]Frequently citied terms are calculated by the sum of the citation frequencies (%) for that emotional term, divided by the number of product categories (four).

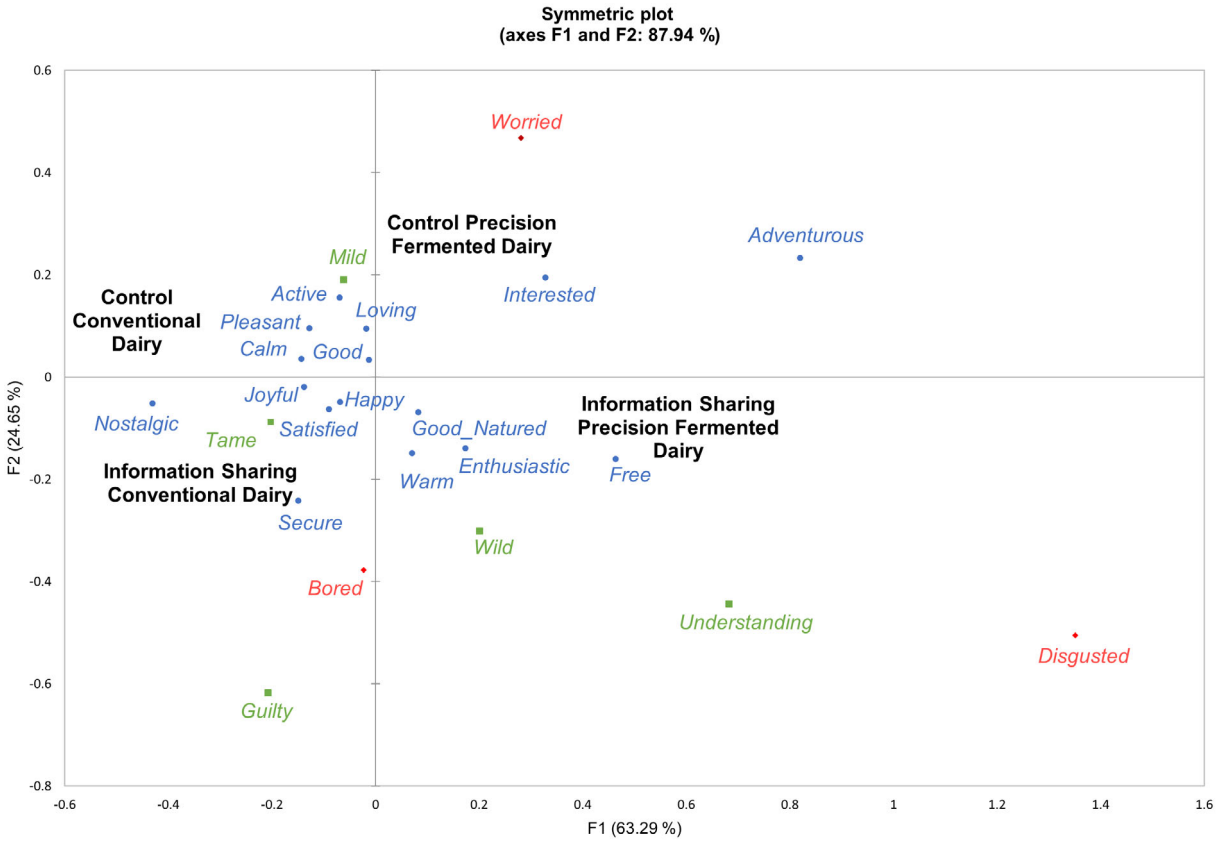

Figure 3 Correspondence analysis biplot of the frequency of use of the CATA emotional terms for the evaluation of two yoghurts (CD and PFD) under two conditions (control and information sharing). Please note the products are in bold and the emotional terms are in italics with red (diamond) = negative words, blue (circle) = positive words and green (square) = unclassified.

'*adventurous*' and '*interested*' (27.4% and 59.7%) compared to the CD yoghurts (~3.2% and ~ 23.4%).

As shown in Fig. 3, after sharing the information (environmental impact, PFD process), PFD yoghurt was associated with '*adventurous*' ($P < 0.0001$), '*enthusiastic*' ($P = 0.025$), '*free*' ($P = 0.008$) and '*understanding*' ($P < 0.0001$) significantly more compared to the Control condition. The data suggests that sharing information has evoked more positive emotions, helped to educate participants about PFD and made them feel more understanding, adventurous and enthusiastic about the product. Therefore, sharing information has a much higher effect on PFD yoghurt (i.e. a more sustainable product) than CD yoghurts. In contrast, for the CD yoghurts, sharing information had minimal impact on emotions, only making participants feel slightly '*guilty*' ($P = 0.063$). However, the changes in emotional responses are consistent with the small but potentially important differences observed for liking, which further justifies the decision to interpret these changes as significant, despite being marginal.

Comparing the impact of information on liking within the FN and FTN groups

Chi-square analysis found no associations between FN and FTN groups ($P > 0.05$), although some overlaps between the neophobic groups were present, with some participants considered high in both FN and FTN ($n = 14$, 23%), others low in both FN and FTN ($n = 12$, 20%) but the majority were mixed (i.e. high in one category and low in the other) ($n = 34$, 56%). Overall, there was no significant difference in liking between the two yoghurts (CD and PFD) for both the high and low FN and FTN groups ($P > 0.05$), respectively. Therefore, results indicate neophobia has little influence on OL. After the information was shared, both the FN and FTN groups showed a decrease in OL for CD yoghurt and a slight increase in OL for the PFD yoghurt (Figure S3a–d). The greatest mean decrease for the CD yoghurt was observed amongst the low FN group (Figure S3a. M = 4.34), which was significant ($P = 0.01$, $d = 0.48$), whilst the greatest mean increase

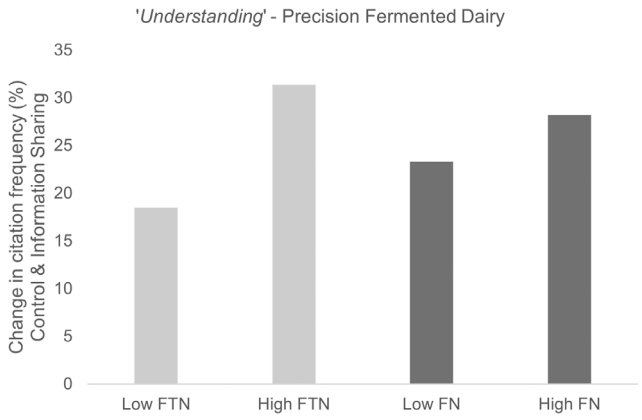

Figure 4 Change in citation frequency (%) between high and low FN and FTN groups for the emotional term '*Understanding*' before and after information for the PFD yoghurt.

for the PFD yoghurt was observed amongst the high FN group (Figure S3b. M = 2.54).

Comparing the impact of information on emotional response between FN and FTN groups

Reviewing the six significant emotions (*adventurous*, *enthusiastic*, *free*, *interested*, *nostalgic* and *understanding*) amongst the high and low FN and FTN groups provided further insights (Table S5). Results suggest that sharing information (environmental impact, PFD process) elicits different emotions, depending on the level (low, high) and type of neophobia (FN and FTN). For example, participants with high FN and FTN had a greater increase in citation frequency scores for the emotional term '*understanding*' (34.5% and 41.9%) between the control and information-sharing PFD conditions compared to low FN and FTN participants (28.1% and 20.0%). Overall, the increase in citation frequencies was greatest for the high FTN and FN groups, suggesting sharing information has more of an effect on highly neophobic individuals (Fig. 4). Potentially, these groups are likely to be more open to changing their behaviour as a consequence of interventions using information sharing.

Discussion and considerations

All participants were willing to try the PFD yoghurt, which supports findings from previous studies where consumers had a positive outlook towards this novel technology (Kossmann *et al.*, 2023; Ford *et al.*, 2023a). It also signifies an increase in acceptance compared to a previous survey amongst British consumers, where only an estimated two-thirds were willing to try precision fermented cheese (Zollman Thomas & Bryant, 2021). The higher acceptance observed in this study could relate to participant curiosity towards the taste of the product, which is a key driver (Ford *et al.*, 2023a). It could also relate to differing cohorts, as the majority of participants in our study were young and female, which is a demographic associated with a greater willingness to try protein alternatives (Ford *et al.*, 2023b). The past few years have also seen a boom in protein alternatives, which may have increased consumer awareness of the need for more sustainable products and/or normalised novel alternatives.

Additional factors likely to influence acceptance include the product type: for example, yoghurt may be more accepted in the context of PFD than cheese. As yoghurt undergoes a fermentation process, the method used for PFD may have seemed familiar, necessary and not risky. This may explain the little influence neophobia had on OL for the PFD yoghurt despite the mean average for FN being higher than other studies (Rabadán & Bernabéu, 2021). Previous research has found some consumers to be sceptical about the sensory appeal of PFD products (Ford *et al.*, 2023a), so any fears may have subsided once a familiar product was tasted. Indeed, familiarity is known to reduce neophobia (Pliner & Hobden, 1992). Furthermore, a study reviewing PFD cheese found consumers perceived it as being equally safe compared to CD cheese, which arguably strengthens consumer trust and decreases neophobia (Zollman Thomas & Bryant, 2021). In contrast, it has been widely found that neophobia has a negative influence on the acceptance of cultured meat (Bryant *et al.*, 2019; Wilks *et al.*, 2019; Hwang *et al.*, 2020). Therefore, it could be suggested that there will be fewer challenges regarding consumer acceptance towards PFD compared to some other novel technologies.

In general, participants moderately liked PFD yoghurts, which is similar in liking scores to CD yoghurts. Therefore, results show promise that consumers will accept PFD products when available, provided the assumption that precision fermented technology can mimic the sensory properties of CD. Following the provision of information (environmental impact, PFD process), the slight increase in liking and the positive emotions elicited for the PFD yoghurts compared to the decreased liking and somewhat '*guilty*' emotion for the CD yoghurts aligns with a previous study (Yang *et al.*, 2020). Furthermore, the additional insights gleaned from measuring emotional response agree with prior suggestions that it is a more discriminatory method compared to liking (Yang *et al.*, 2018). Additional studies have also found an increase in acceptance of sustainable products when information related to product composition was shared alongside a tasting (Bschaden *et al.*, 2022;

Grasso *et al.*, 2022). In the context of cultured meat, information relating to personal benefits, meat quality and taste increased acceptance more than societal/environmental benefits (Rolland *et al.*, 2020). Findings therefore suggest that the content of the information shared is also important, and in the case of PFD, alternative information may further increase acceptance.

In terms of the format and type of information shared, for ethical reasons, a definition of PFD was provided, which focused on the production method (Table S3). Considering the effect of framing when describing novel technologies, this may have influenced OL scores. For example, research has found that focusing on the technological nature of cultured meat creates more negative consumer attitudes (Bryant & Dillard, 2019). By contrast, comparing cultured meat to conventional meat and focusing on the sensory appeal creates more positive consumer attitudes such as more natural, tasteful and familiar (Fidder & Graça, 2023). In the context of precision fermentation technology, research has found using claims that are framed as 'natural' or 'naturally' enhances consumer attitudes, especially when they align with the beliefs of the consumer (Banovic & Grunert, 2023). In addition, the name used can also influence consumer acceptance, as shown in a study comparing the terms 'animal-free meat', 'cultured meat' and 'lab-grown meat' (Bryant & Barnett, 2019). Therefore, future study designs should consider how the novel technology is described and the name used. Currently, an alternative name used to describe and market products is 'animal-free' dairy (Broad *et al.*, 2022; Kossmann *et al.*, 2023; Slade & Zollman Thomas, 2023). The use of the word 'precision' in this study may therefore have elicited different connotations which further highlights the importance of semantics.

In contrast, during the information sharing condition, the explanation provided around the process of making PFD to some extent mirrored the definition provided during the control condition (see Video S1). Therefore, the level of information on this topic between conditions may not have changed much. Additionally, the video also contained information pertaining to the predicted environmental benefits of PFD, with the narration, '*Life cycle assessment analysis comparing conventional dairy production with large-scale precision fermented dairy, estimated a reduction in GHG emissions by 35%–65%*' (Mendly-Zambo *et al.*, 2021). As sustainability is a multifaceted subject, alternative product factors may resonate more with consumers, such as animal welfare and health benefits. Current literature highlights the significance of animal welfare in driving consumer acceptance of PFD (Powell *et al.*, 2023; Ford *et al.*, 2023a). Therefore, future studies would benefit from extending these findings to understand which type of information causes the greatest increase in OL for PFD. For example, messaging could pertain to improved food safety, being lactose free, having a similar functionality to dairy and reduced reliance on animals.

In relation to PFD cheese, previous research found different information treatments (animal welfare, environmental concerns, GMO and farmer existence) to have no significant influence on consumers' acceptance (Kossmann *et al.*, 2023). Reasons for the lack of overall influence could relate to the fact that the study did not include a sensory tasting and was amongst German consumers who had a lower willingness to try compared to previous studies. Considering the importance of sensory appeal in driving acceptance of PFD amongst UK consumers (Ford *et al.*, 2023a), future studies should review the influence of different types of information in a tasting context. It could be that certain PFD products exhibit greater barriers with regard to gaining consumer acceptance. For example, conventional cheese can exhibit a variety of flavour profiles, often influenced by the animal's diet; therefore, PFD cheese may face greater scepticism, especially around sensory expectations, compared to other PFD products.

In situations where information is lacking, to some extent consumer expectations and trust in products and food manufacturers becomes magnified. A recent study found lower levels of trust in relation to precision fermentation technology to be associated with higher levels of FTN (Banovic & Grunert, 2023). Therefore, sharing information should increase trust and reduce neophobia, especially considering neophobic individuals shifted their responses based on the information shared. As the emotional term '*understanding*' increased significantly in citation frequency amongst the high FTN and FN groups after sharing information (environmental benefits, PFD process), it supports the notion that these groups are particularly more susceptible to information. However, it is thought that although sharing information about the benefits of precision fermentation can improve consumer acceptance of this novel technology, it does not mitigate the effects of high-technology neophobia (Banovic & Grunert, 2023). Instead, the suggestion is to encourage consumers not to categorise it as a new technology.

Limitations and future directions

A notable limitation relates to the small and predominantly female sample size. This is especially apparent when comparing the neophobia groups; therefore, caution should be taken when drawing conclusions. However, including effect size within our calculations means that future studies will be able to estimate

population sizes, which will need to be larger in order to validate the findings. In relation to other novel technologies, such as cultured meat, previous research has found consumer willingness to try differs depending on nationality, age and gender (Ford *et al*., 2023b) as well as dietary preference and level of FTN (Krings *et al*., 2022). In addition, males and older participants have been found to have higher levels of FN (Siegrist *et al*., 2013). Future studies should therefore explore how different socio-demographic and socio-cultural factors influence consumer acceptance towards a range of PFD products, with a more nationally representative sample. In addition, attention should also be given to the segmentation tactics applied to group consumers based on FN and FTN scores which varies across studies. Although there are many ways to segment consumers based on FN scores (Choe & Cho, 2011), the following popular segmentation method has been previously applied and deemed appropriate to allow for comparisons to be made (Yang *et al*., 2020). Future research would benefit from a more standardised approach to allow for comparisons to be made across the literature (Rabadán & Bernabéu, 2021). In particular, the use of two groups (low vs high) for FN and FTN may mask differences that could be captured by more groups (i.e., low, standard and high).

Another limitation relates to PFD yoghurt not being commercially available. Consequently, the results were based on the hypothetical assumption that CD and PFD will deliver similar sensory experiences. The yoghurts would therefore have remained the same in physical appearance and taste during evaluation. Although this has its benefits, in that it controls for the influence of sensory differences, assessing actual PFD products in future studies will provide a more accurate assessment of OL and emotional response. It will also provide clarity regarding the influence of neophobia on OL for PFD products.

Lastly, all participants consented to try the PFD yoghurt, which meant it was not possible to determine the effect the video information may have had on changing non-consenters minds. The high consent could have been due to current knowledge regarding PFD, which was not captured, but should be a consideration in future studies. Another point worth considering is the level of trust the participants placed in the researchers which may have led people to feel more confident in trying the product. It is also worth noting that the changes in consumer liking were observed over a short period of time and repeated exposure to the video could lead to incremental shifts in liking. Current longitudinal studies show sustainable food behaviours, such as eating less meat, increased overtime but general knowledge, especially around foods environmental footprints did not (Siegrist *et al*., 2015). Additionally, a more recent longitudinal survey found exposure to information about animal farming to be associated with changes to animal product consumption, although the predictive ability was low for the period of 1 year (Bryant *et al*., 2023). Therefore, longitudinal studies that capture whether sustainable behavioural changes are made and maintained (i.e., the adoption of PFD) over the period of a few years in response to specific information interventions (i.e., the environmental impact of PFD vs CD) will provide valuable insights.

Conclusion

To the best of our knowledge, this is the first study to investigate the influence of sharing information (environmental impact, PFD process) on consumer acceptance towards yoghurts labelled as PFD and CD. In general, the yoghurts were equally liked, however, CD yoghurt was associated with the term '*nostalgic*' compared to '*adventurous*' and '*interested*' for the PFD yoghurt. Providing information increased consumer liking slightly for the PFD yoghurt and evoked more positive emotions with participants feeling more '*understanding*', '*adventurous*' and '*enthusiastic*'. In contrast, sharing information had minimal impact on CD yoghurt with participants indicating a slightly '*guilty*' emotion. Results therefore indicate a positive trend between sharing information and increasing acceptance whilst highlighting the importance of measuring emotional response for gaining a deeper insight beyond OL. All the participants were willing to try the PFD yoghurt, regardless of their level of FN and FTN. Findings therefore suggest high acceptance and trust with the potential for fewer barriers towards consumer acceptance compared to other novel food technologies (e.g., cell-based meat). Additionally, sharing information had varying effects on emotional responses in groups with different levels of neophobia, with high FTN and FN individuals more *'understanding'* towards PFD after information. Overall, these preliminary results offer insights that will aid the design of future research exploring sensory appeal and acceptance of PFD products in a larger sample size. Currently, the results provide support for high consumer acceptance of PFD, which could contribute to a more sustainable food future.

Acknowledgments

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethical guidelines

This study was approved by the University of Nottingham School of Biosciences Ethics committee (approval code: SBREC202223022FEO) [February 2023].

Peer review

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/ijfs.17228.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Image depicting presented yoghurt samples.

Figure S2. Effect of information (environmental, PFD process) on the mean change in overall liking ± SE for the conventional and precision fermented dairy yoghurt. (CD; M = 74.35, SD = 9.08 for control, M = 71.75, SD = 9.4 for informed; t (61) = 2.60, $P = 0.031$, $d = 0.28$). (PFD; M = 70.83, SD = 9.57 for control, M = 72.41, SD = 9.99 for informed; t (61) = −1.585, $P = 0.085$, $d = -0.22$).

Figure S3a–d. Effect of information (environmental, PFD process) on the mean change in overall liking ± SE for the conventional and precision fermented dairy yoghurt for the four consumer groups (low FTN = 26, High FTN = 35, Low FN = 32, High FN = 29).

Table S1. The Food Technology Neophobia Scale factors and statements.

Table S2. The Food Neophobia Scale statements.

Table S3. Definitions provided for Conventional Dairy and Precision Fermented Dairy.

Table S4. Results ($n = 62$) for the CATA emotional terms presented as citation frequencies (%) for the four yoghurt samples. The p-values are taken from Cochran's Q test with post hoc analysis based on the Sheskin procedure. Different letters within rows denote significant differences (5% level).

Table S5. Results for the four consumer groups (low FTN = 26, High FTN = 35, Low FN = 32, High FN = 29) for the CATA emotional terms presented as citation frequencies (%) for the four yoghurt samples. The P-values are taken from Cochran's Q test with post hoc analysis based on the Sheskin procedure. Different letters within rows denote significant differences (5% level).

Video S1. Video shown to participants during the information sharing condition relating to the environmental impact of food and the precision fermented dairy process.