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Plant-based alternatives vs dairy milk: Consumer segments and their sensory, emotional, cognitive and situational use responses to tasted products

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ABSTRACT

Plant-based alternatives to dairy milk are becoming more popular in many parts of the world. The present research explored this product category using a multi-variable research strategy where consumers from New Zealand (n = 345) tasted samples for degree of liking/disliking and described their perceived sensory, emotional/cognitive and situational use characteristics using check-all-that-apply (CATA) questions. A total of 10 products were included in the study, three of which were dairy-based (cow's milk, two at 3.4% fat and one at 0.1% fat), while the remaining seven products were a blend of three plant-based ingredients (coconut, rice and oats) or made from either soy, oat, rice or cashew nuts (including variations for sweetened/unsweetened products and reduced-fat products). Across all participants, the full-fat dairy milks were most liked, but heterogeneity was apparent, especially for the plant-based alternatives. Four consumer segments were identified that fell along a continuum from those people who exclusively liked full-fat dairy products (n = 107) to those who preferred a wide range of plant-based products (n = 111), with two smaller intermediary clusters, *Dairy and tri-blend Likers* (n = 55) and *Full-fat dairy / tri-blend / soy Likers* (n = 72). Each cluster had distinct and characterising sensory, emotional/cognitive and situational uses for the tested dairy and plant-based beverages, and penalty/lift analysis was used to determine how these positively or negatively impacted product liking. The penalty/lift analysis was supplemented with a test that for each CATA term (sensory, emotional/cognitive, situational use) enabled a comparison of the four clusters to understand for which of these the effect on liking scores was larger/smaller. Overall, the present research contributed new knowledge for plant-based beverages (which remain understudied relative to plant-based meat alternatives) by providing detailed product insights into a broad range of tasted samples, showing that complex consumer preference segmentation exists, driven by a combination of sensory, emotional/cognitive, and situational use perceptions.

1. Introduction

1.1. Plant-based alternatives to cow's milk

Over the past decade, research in agricultural food production has made it clear that many current food production systems are unsustainable (Godfray, et al., 2010, Godfray, 2019). This is due to a variety of factors, but especially the emission of greenhouse gases as a by-product of the production of foods derived from animal origins. Obtaining protein from animals is highly inefficient due to the extensive requirements for land, water, feed, housing and processing, and meat and dairy products have been identified as some of the most significant sources of greenhouse gases (Garnett, 2009; Nijdam, et al., 2012; Röös, et al., 2013; Oduro, et al., 2021). Despite their negative environmental impact, milk and other dairy products are consumed in large amounts in developed countries (Henchion, et al., 2021). In addition, the demand for milk in low- and middle-income countries is growing rapidly (Adesogan & Dahl, 2020), resulting in a global demand for milk that is

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projected to increase by 35% by 2030 (Adesogan & Dahl, 2020).

Due to the sustainability issues and health concerns related to animal fat intake, plant-based alternatives to dairy milk[1] are gaining market share relative to cow's milk in the United States, Europe, Australia, and New Zealand, and are forecasted to grow at a rate of 8–15% (Euvepro, 2019; Transparency Market Research, 2019; Munekata, et al., 2020; Stewart, et al., 2020). These alternative milk products are derived from a variety of plant sources, including seeds, nuts, legumes, cereal, and pseudo-cereal plants (Mäkinen, et al. 2016). Although meant to resemble animal milk in colour and mouthfeel, many plant-based alternatives have undesirable properties, such as beany and painty off-flavours (e.g., in soy milk) stemming from lipoxygenase activity (Kwok & Niranjan, 1995; Desai, et al. 2002; Makinen et al., 2006; Sethi, et al., 2016; Vanga & Raghavan, 2018) or a chalky mouthfeel due to large insoluble particles (Hinds, et al., 1997; Durand, et al., 2003; Aidoo, et al., 2010; Sakthi, et al., 2020), while still others have a visual appearance that is darker than cow's milk.

Among the various plant-based alternatives to cow's milk, soy milk is the most common, having been developed in Asia in the 1940′s and then marketed in the U.S. and Europe in the 1970s–1980s (Chen, 1989). Other plant sources often used in non-dairy milk products are almonds, oats, rice, coconut, wheat, maize, sorghum, and quinoa. Milk products and other beverages made from these plants are produced from water extraction of the ground plants or through fermentation. Although most plant sources offer high fibre and lower cholesterol as part of their nutritional and health-promoting profiles, most have very low protein content, except for soy (Mäkinen, et al., 2016; Jeske, et al., 2017; Collard & McCormick, 2021; Chalupa-Krebzdak, et al., 2018). This protein deficiency necessitates supplementation with vitamins, amino acids, and minerals (Sethi, et al., 2016; Silva, et al., 2020) and highlights the risk of replacing cow's milk with plant-based alternatives, especially for young children (Mäkinen, et al., 2016). Alternatively, blending of some plant-based milks, e.g., with soy, can reduce protein deficiency or compensate for potential flavour defects arising from any single plant source (Jeske, et al., 2018, Aidoo, et al., 2010; Oduro, et al., 2021).

In spite of the sensory and nutritional hurdles that plant-based products must overcome to compete as viable market alternatives to cow's milk, their environmental sustainability is a critical driver of their growing popularity. Other factors contributing to the growth of this market include the intolerance of many people to the lactose in cow's milk, dairy allergies, consumer concerns about hormones and antibiotics in cow's milk, the high cholesterol content of cow's milk, animal welfare concerns, increasing interest in vegetarian and vegan diets, and the potential health-benefits offered by a plant-based diet (Tangyu, et al., 2019).

1.2. Sensory properties and consumer acceptance of plant-based milk alternatives

With the wide array of plant-based milk alternatives currently on the market and the wide-ranging goals and motives of consumers for purchasing these products, which are both approach-oriented (more environmentally sustainable, healthier, improved animal welfare) and avoidance-oriented (lactose allergies, cholesterol, hormone, and antibiotic avoidance), understanding consumer perceptions, attitudes, and cognitions toward these products is critical to understanding the market for these products. In addition, emotions and intended situational uses for these products can add further insights about the underlying motives of consumers that may drive the choice and purchase of these products.

Although an increasing number of studies have addressed the sensory properties of plant-based food products, e.g., meat substitutes, far fewer have addressed plant-based milk alternatives. At the ingredient level, Vaikma, et al. (2021) found that the primary flavour attribute of plant-based milks was associated with its specific plant source. Thus, cereal-based products (oat, rice, buckwheat, quinoa) were found to have a cereal flavour; nut-based products (almond, coconut, hazelnut, cashew, Brazil nut) were characterised by nutty flavours, etc. Within these categories, specific products were identified as having other specific tastes, odours, and textures. Among these, oat-based milk alternatives had higher bitterness and aftertaste, buckwheat and quinoa had a sweet taste, while rice products were distinctive in having an astringent taste with a hay-like odour. Nut-based milk products were generally thicker in texture, with almond, cashew and Brazil nut products having a salty taste. Milk alternatives obtained from cashews and Brazil nuts were also distinctive in having umami notes. Soy-based products, on the other hand, were found to have metallic and astringent tastes, hay-like and earthy odours, and a reddish tint. Like soy, the hemp-based product in the above study was found to have an astringent taste and a hay-like odour (Vaikma, et al., 2021). Together, the flavours associated with plant origins and other non-dairy flavours are problematic, because the less that a milk alternative tastes like dairy milk, the lower is its acceptance (Diarra, et al., 2005; Sakthi, et al., 2020; Oduro, et al., 2021).

In a study focused specifically on rice-based milk alternatives, Pramudya, et al. (2019) used trained panellists to evaluate the sensory properties of these products and consumers to evaluate their acceptability. The sweetness levels of the rice-based products significantly affected consumer liking, with some products being rated as too sweet and some as not sweet enough. In addition, the mouthfeel of the products varied greatly and significantly impacted liking. All of the rice-based products were found to have "too little" thickness, and it was recommended that product developers and processors increase the thickness of these products to make them more acceptable to consumers (Pramudya, et al., 2019).

Consistent with the literature showing that most alternative protein foods have lower acceptance than their animal counterparts (Neff, et al. (2018); La Barbera et al. (2018); and reviews by Hartmann and Siegrist (2017) and Onwezen, et al. (2021)), studies of plant-based milk alternatives, like soy, have shown that most consumers (regardless of gender, ethnicity, or dairy tolerances) tend to like these plant-based alternatives less than dairy milk (Bus & Worsley, 2003a; Palacios, et al., 2009; McCarthy et al., 2017). To improve their sensory profile and acceptance, developers have tried blends of alternative protein milks or the addition of such ingredients as vanilla extract (Rincon et al., 2020).

1.3. The role of consumer expectations, attitudes, and values

Although the poor acceptance of many plant-based milk alternatives (relative to cow's milk) can be attributed to their inherent sensory properties, it has been argued that the expectations of the consumer also play an important role (Kempen, et al., 2017). Plant-based milk alternatives are often expected to taste like cow's milk, because cow's milk is the product for which they are positioned as the alternative (Aschemann-Witzel, et al., 2019; McClements & Grossmann, 2021). However, to the extent that their sensory profile does not closely mimic that of cow's milk, they run the risk of evoking sensory and/or hedonic disconfirmation, with highly negative effects on liking (see Cardello (2007) for a review of consumer expectations and their effects on food acceptance). In addition, although current plant-based milk alternatives have improved flavour profiles, they still suffer from the stigma of past, less appealing products in this category (Wansink, et al., 2005). This can lead to lowered expectations (Haas, et al., 2019), which can also produce reduced liking through the mechanism of cognitive assimilation (Cardello & Sawyer, 1992, Cardello, 1994, 2007; Kuenzel, et al., 2011; Piqueras-Fiszman & Spence, 2015).

Other factors related to the consumer's personal attitudes and values (e.g., regarding animal welfare) have been shown to play a role in the choice, acceptance and consumption of plant-based milk products (de Graaf, et al., 2016; McCarthy, et al., 2017; Haas, et al., 2019). So too,

[1] The milk of mammals, e.g., cows, goats, sheep, camels, water buffalo. Cow's milk is the most common dairy milk.

attitudes toward consuming a healthy or nutritious diet, free of animal fat, are important drivers of the choice and consumption of plant-based milks (Bus & Worsley, 2003a; 2003b; de Graaf et al., 2016; McCarthy, et al., 2017) and other plant-derived foods (Lea, et al., 2006; Vainio, et al., 2016, He, et al., 2020). Insofar as the above values of concern for animal welfare and a desire to eat healthy foods are core elements of vegetarian, flexitarian and vegan diets (Hoek, et al., 2004; Hamilton, 2006; Fox and Ward, 2008; Radnitz, et al., 2015; North, et al., 2021), adherents of these diets have a more positive image and preference for plant-based milk alternatives (Slade, 2018; Haas et al., 2019) and are primary consumers of these (Silva, et al., 2020) and other dairy alternatives (Rondoni, et al., 2021).

Among vegans, vegetarians and flexitarians, the consumption of plant-based products, including milk alternatives, becomes habitual and occurs in a wide range of use situations (Elzerman, et al., 2021), in the same way that drinking cow's milk becomes habitual (McCarthy, et al., 2017). This habitual behaviour reinforces the consumption of these products through increased familiarity, which has been shown to have a potent influence on the acceptance of most foods, especially those unfamiliar to the consumer (Rozin & Schiller, 1980; Birch, et al., 1987; Stein, et al., 2003; Jang & Kim, 2015; Giacalone, et al., 2015; Tan, et al., 2016; Jaeger, et al., 2020). Indeed, unfamiliarity with plant-based products has been found to be a primary reason for their non-consumption (Hoek, et al., 2011; Elzerman, et al., 2013; Apostolidis & McLeay, 2016), whereas familiarity has been found to increase consumption (Hoek, et al., 2011). In addition, repeated exposure to these products may further increase acceptance. For example, Russell and Delahunty (2004) found that five days of repeated exposure to rice milk increased consumption of this product, while Önning, et al. (1999) reported increased liking over a three-week period of exposure to oat milk.

1.4. The role of emotional, conceptual, and situational factors

The emotions evoked by a wide variety of beverages have been studied previously (van Zyl & Chaya, 2021). However, neither the emotions, conceptualisations, nor situational uses of plant-based milk alternatives have been studied extensively, despite several recent studies pointing to the potential importance of these factors. For example, Schouteten, et al. (2016) found plant- and insect-based burgers to have fewer positive emotional associations than traditional meat burgers. Similarly, Onwezen, et al. (2022) proposed that the experience of positive emotions may be among the most significant drivers of the intention to consume alternative protein products and may be key to increasing their acceptance. With regard to differences among individuals, Jaeger and Giacalone (2021) found that the emotional responses to plant-based and dairy milk products differed significantly between users and non-users of these products. They found that the majority of significant differences reflected more negative emotional responses to the plant-based products. Among non-users, Jaeger and Giacalone (2021) also found differences in cognitive associations to plant-based beverages, including the fact that plant-based beverages were viewed as "feminine" and oat milk was conceptualised as "boring," "irritating," "modern," "pretentious," and "unique," relative to cow's milk.

As for the role of situational appropriateness, it has been demonstrated for a wide range of food products that the appropriateness of their use in any situation varies both by product and by use situation (Schutz, 1994; Cardello & Schutz, 1996; Giacalone, 2019; Giacalone & Jaeger, 2019). For plant-based foods, Elzerman, et al. (2021) found that the appropriateness of both meat and plant-based alternatives varied by their intended use situation and that product use frequency significantly affected judged appropriateness. They found that the mean appropriateness rating across all use situations, which has been shown previously to be correlated with the liking of a product (Cardello & Schutz, 1996), was positively associated with meat substitute usage, i.e., the more often a respondent consumed meat substitutes, the higher was the product's judged appropriateness for use in a variety of situations. Jaeger and Giacalone (2021) extended these findings to several plant-based and other non-alcoholic beverages, showing that the appropriateness of plant-based (and non-plant) beverages differed by usage situation and between plant-based users and non-users. As one example, these researchers found that cow's milk and oat milk were rated most appropriate "for children" and "in cooking/baking" among plant-based beverage users but were rated much lower among non-users.

1.5. Aims of the research

Although many previous studies of plant-based milk alternatives have focused on a single product or a small group of response variables, the study by Jaeger and Giacalone (2021) was unique in its multi-response approach to a wide range of plant-based and other non-alcoholic beverages. However, this study used an online survey approach in which the stimuli were beverage names / descriptions. Whether the results of this study can be generalised to tasted beverages is unknown. What we do know is that studies using food names vs tasted products can produce different results, especially when it comes to the affective elements of product assessment. For example, Cardello and Maller (1982) demonstrated that the rated liking for food names is more extreme (liked foods are liked better and disliked foods are disliked more) than for tasted versions of the same products, possibly due to the fact that food names elicit a more idealised conceptualisation of a food product than does any physical version of that product. A similar phenomenon has been observed with emotional responses to food products and has been attributed to the same mechanism (Cardello, et al., 2012).

Furthermore, while several of the studies cited above investigated responses to plant-based products or milk alternatives among users and non-users of these products, none of these studies have attempted to characterise consumer segments based on their perceptions, emotions, conceptualisations, or situational uses for these products. Palacios, et al. (2009) segmented consumers based on their liking of a variety of lactose-free dairy milk and soy milk products, uncovering two consumer segments – cream seekers and sweet seekers. Van Loo, et al. (2017) segmented consumers based on their involvement in sustainable and healthy eating and found four different consumer segments with varying combinations of involvement in sustainable and healthy eating. Such involvement may well reflect itself in distinct segments of consumers who perceive, conceptualise, emote, or use plant-based milk alternatives differently. As such, it would be useful in the marketing of plant-based milk alternatives to know if distinct consumer segments exist. In essence, the question is whether there may be only two segments of consumers - those who prefer cow's milk and have specific sensory, emotional / cognitive, and situational uses for them vs those who prefer plant-based milk alternatives and who have a different set of perceptions and conceptualisations toward them. Alternatively, may there also be a number of additional consumer segments who are more nuanced in their responses to these products, with varied liking, perceptions and conceptualisations for dairy-based and plant-based beverages?

Against this backdrop, in the context of New Zealand consumers, the aims of the present research were: 1) to assess sensory, liking, emotional / cognitive, and situational responses to a variety of commercially available plant-based milk alternatives and dairy milks, and 2) to conduct a segmentation of consumers based on their liking of these products to determine whether multiple segments exist, and 3) characterise the segments in terms of the sensory, emotional / cognitive, and situational uses. To the extent that multiple consumer segments exist, it may be possible to target different plant-based milk alternatives to these segments or to design / formulate new products to better meet the expectations or intended uses for these products among different consumer groups.

2. Materials and methods

2.1. Participants

The research drew on responses from 345 New Zealand (NZ) adult consumers (54% women) between 20 and 66 years old with diverse socio-economic backgrounds (Part 1 of Supplementary Material has full details). Recruitment was managed by a professional agency. They selected candidates from their database who were regularly involved in household grocery shopping and were not vegetarian or vegan. All participants agreed to consume plant-based milk alternatives and cow's milk.

The research was covered by a general approval for sensory and consumer research from the Human Ethics Committee at The New Zealand Institute for Plant and Food Research Limited (PFR). Participants were assured that their responses would remain confidential and gave voluntary consent to participate. As compensation, participants received a cash payment.

2.2. Samples

The study included 10 samples, selected to span the commercially available product space for dairy milk and plant-based milk alternatives broadly while excluding flavoured options (e.g., chocolate milk/drink) and milk-based drinks (e.g., smoothie, iced coffee). The intent was to include plant-based milk alternatives from different plant sources as well as sweetened/unsweetened product variants. From available products at the time of the study, a pool of approximately 30 candidates were identified from which the 10 samples were selected following informal sensory evaluation by seven experienced Sensory-Consumer professionals at PFR. This process focused on selecting samples with diverse sensory properties.

A listing of the 10 samples together with key ingredients and nutritional facts is given in Table 1, specifically: dairy milk from cows at two fat content levels (3.4% and 0.1%), lactose-free dairy cow's milk (3.4% fat), sweetened soy milk at two fat content levels (3.0% and 1.4%), cashew nut milk (sweetened and unsweetened), rice milk (unsweetened), oat milk (unsweetened), and a blend of milk from three plant-based ingredients: oat, rice, and coconut. Part 2 of Supplementary Material has additional detail about ingredients and nutritional composition of the different samples; Part 3 of Supplementary Material shows the samples.

Serving size was 30 mL, and sufficient for three to four small sips. All samples were served in clear plastic cups labelled with 3-digit random codes. The samples were stored at 3–5 °C and served within 5 min of being removed from refrigeration (~8°C).

2.3. Empirical procedures

2.3.1. Sample evaluation

A multi-response ballot with four parts was used, structured in the order: i) acceptability, ii) sensory characteristics, iii) emotional / cognitive perceptions, and iii) situational uses.

Acceptability was measured using a fully labelled 9-pt category scale with end-point anchors 1 = 'dislike extremely' and 9 = 'like extremely' (Peryam & Pilgrim, 1957). Sensory product descriptions were obtained with a check-all-that-apply (CATA) question (Ares & Jaeger, 2015) containing 15 terms relevant for the focal set of samples: 'bean-like flavour', 'cardboard-like', 'coconut-like flavour', 'creamy mouthfeel', 'grain/wheat flavour', 'milk-like flavour', 'nutty flavour', 'oaty/cereal flavour', 'rice flavour', 'strong flavour', 'sweet taste', 'thick/viscous', 'thin/watery', 'weak/bland flavour', and 'white appearance'. Drawing on a general vocabulary (Thomson, 2016), a second CATA question with 20 terms was used to obtain responses relating to emotional and cognitive product conceptualisations: 'adventurous', 'boring', 'cheap', 'classy', 'comforting', 'energetic', 'feminine', 'genuine', 'happy', 'inspiring', 'irritating', 'masculine', 'modern', 'pretentious', 'relaxing', 'sensual', 'simple', 'sophisticated', 'traditional', and 'uninspiring'. Aspects relating to situational use of the milks and plant-based alternatives were measured in a third CATA question where the 16 terms were: 'as an alternative to drinking water', 'for a moment of indulgence', 'for daily consumption', 'for many different uses', 'for the whole family', 'in a smoothie/protein shake', 'to drink on its own', 'to drink with an evening meal', 'to give me a sense of wellbeing', 'to have with cereal', 'to make me feel refreshed', 'to quench my thirst', 'when I want something packed full of good nutrients', 'when I want something to fill me up', 'when I'm on a calorie restricted diet', and 'when I'm trying to be healthy'.

The seven experienced Sensory-Consumer professionals at PFR who contributed to sample selection, also helped to develop the sensory, emotional/conceptual, and situational use CATA terms. The terms were selected to be relevant for product characterisation and discrimination. General product knowledge/experience and marketing information guided this process, and in the case of sensory descriptors Vaikma et al. (2021) was also consulted.

2.3.2. Purchase, consumption and stated liking questionnaire

Following sample evaluations, participants completed a questionnaire related to purchase, consumption and stated liking for three different classes of dairy and plant-based milks (dairy, lactose-free dairy and dairy-free). Stated liking was recorded on a 9-pt scale from 1 = 'dislike extremely' to 9 = 'like extremely,' while an 8-pt scale was used to capture frequency of consumption where 8 = 'every day or almost every day,' 7 = '2 or more times a week,' 6 = 'about once a week,' 5 = 'about 2–3 times a month,' 4 = 'about once a month,' 3 = 'about once every 2–3 months,' 2 = 'about once a year or less,' and 1 = 'never.' These responses were obtained for three product categories: dairy milk, lactose-free dairy milk, and dairy-free milk alternatives. Frequency of

Table 1
Information about the ten beverage samples included in the study, with nutritional content (fat, protein carbohydrate and sugar) in g per 100 mL and energy in kJ per 100 mL. Part 2 of Supplementary Material has additional information.

Sample	Milk name	Specifics	Fat	Protein	Carbohydrate	Sugar	Energy
S1	Dairy	Cow's milk	3.4	3.3	4.8	4.8 g	263
S2	Dairy (low fat)	Cow's milk (skimmed)	0.1	4.0	5.0	5.0 g	156
S3	Dairy (lactose-free)	Cow's milk, lactase	3.4	3.3	4.7	4.7 g	265
S4	Soy	Water, soybeans 14%, sugar (UHT)	3.0	3.0	3.4	2.5 g	221
S5	Soy (reduced fat)	Water, soybeans 14%, sugar (UHT)	1.8	3.0	2.5	1.6 g	162
S6	Cashew (unsweetened)	Water, cashew nuts 3% (UHT)	1.4	0.4	0.8	0.1 g	73
S7	Cashew	Water, cashew nuts 3%, sugar (UHT)	1.5	0.5	3.6	2.8 g	123
S8	Rice (unsweetened)	Water, brown rice 13% (UHT)	1.2	0.3	9.5	5.8 g	213
S9	Oat (unsweetened)	Water, oats 10% (UHT)	1.2	0.9	8.5	3.7 g	209
S10	Oat/Rice/Coconut blend	Water, oats, rice flour, coconut (cream, oil)	2.5	0.9	9.6	1.5 g	272

Note. UHT = Ultra-high temperature processing.

purchase was captured with three response options: 3 = 'Have purchased in the last 1 month,' 2 = 'Have purchased in the last 12 months' or 1 = 'Have never purchased.' This question was used for dairy milk, lactose-free dairy milk, soy milk, oat milk, cashew milk and rice milk.

At the end of the research session, demographic and socio-economic information was obtained.

2.3.3. Data collection

Sample assessments took place in standard sensory testing booths (white lighting, 20–22 °C). Between samples there was a break of 45–60 s, and during this time water and plain crackers were available for palate cleansing. Sample presentation was monadic in accordance with a design based on a Williams Latin Square. Within each ballot component, CATA term order was randomised across participants (Ares, et al., 2015). Paper ballots were used.

2.4. Data analysis

All analyses were performed in XLSTAT (Addinsoft, 2021), using a 5% significance level.

2.4.1. Hedonic responses

Means and standard deviations were calculated for each product. Differences in mean liking were assessed using ANOVA and Tukey's HSD for post-hoc tests. The next step was to perform a cluster analysis of the participants based on their liking score using the Euclidean distance and the Ward criterion (Ward, 1963). Prior to clustering, the liking scores were centred by participant.

A four-cluster solution was retained based on the dendrogram (Part 4 of Supplementary Material). The alterative, based on the dendrogram was to retain a two-cluster solution, but interpretability and segment size (55 to 111 participants per cluster) made it possible to proceed with four clusters, which provided more insights into differential acceptability of plant-based milks by breaking a large cluster of 234 participants into three clusters with acceptability for some or none of the plant-based milk alternatives. Once the four clusters were constituted, ANOVAs for each product (liking of product as dependant variable and clustering solution as explanatory variable) were performed in order to study the differences between clusters. Within clusters, ANOVA was also used to determine between-product differences. Post-hoc analyses were performed using Tukey's HSD.

2.4.2. Product and attribute characterisation

For each type of data (sensory, emotional/cognitive, or situational use) the steps below were performed, whether for all participants or for each cluster.

To analyse the CATA data, Cochran's Q test was performed with the Sheskin procedure for post-hoc tests. Next, a product × term contingency matrix was constructed (Meyners, Castura & Carr, 2013), and the application of a Correspondence Analysis (Abdi & Béra, 2014) on this contingency matrix was performed using chi-square distances to obtain product and attribute maps, but also confidence ellipses determining if the products were perceived differently or not. Two-dimensional solutions, which accounted for >70% of inertia in the data were retained.

A penalty-lift analysis for each CATA term was performed to evaluate the importance of the presence of this term on the liking (Meyners, Castura & Carr, 2013). For the aggregate-level analysis, the threshold of 5% citation frequency was used to test the significance of the mean impact. Due to reduced sample size, this threshold was changed to 10% for the cluster-specific analyses.

On a term-by-term basis, comparisons across clusters were performed of the mean liking score when a focal CATA term was checked. To avoid the effects of some participants tending to give higher liking scores than others, the test was performed on mean-centred liking scores. Note that this test was conceptually different from the previous penalty analysis as it did not measure the direct impact of checking a CATA term versus not checking it. Rather, it enabled a comparison of clusters to understand which of these terms had the biggest effect on liking scores. For example, if the penalty analysis in all four clusters showed that the difference in liking between a focal term being checked and unchecked was positive and significantly different from zero, then the second test determined whether one of the clusters had higher liking scores than the others when the focal term was checked.

2.4.3. Participant variables

The different clusters were compared using data from the questionnaire responses. Mean charts and ANOVA were performed to determine whether the relationships between the clusters obtained and the participant variables existed or not.

3. Results

3.1. Aggregate level findings

3.1.1. Liking

Table 2 shows the mean liking ratings and standard deviations for the 10 beverage samples. A one-way ANOVA revealed significant differences among samples ($F_{9,3440} = 78.2$, $p < 0.0001$), and post-hoc comparisons showed that the most well-liked samples across all participants were the two full-fat (3.4% fat) dairy-based milks (mean liking for both = 6.7), followed by the milk blended from oat, rice, and coconut and the two soy milks (regular and reduced fat). Slightly less liked, on average, was the sweetened cashew-based milk and the low-fat dairy milk. The bottom three samples in terms of liking were the unsweetened plant-based milks made from oat, rice, or cashew nuts. The latter had an average rating of 3.6 (between 'dislike moderately' and 'dislike slightly').

Dispersion in the liking scores was seen for all samples, with a tendency for lower standard deviations for the dairy milk samples and some evidence of bi-modality in several plant-based milk samples (Part 5 of Supplementary Material).

3.1.2. Sensory

The beverage samples were significantly discriminated ($p < 0.0001$) on all sensory CATA terms (see Part 6A of Supplementary Material, which also has the sample × term frequency table with post-hoc tests). Fig. 1a shows the bi-plot of the first two dimensions of the Correspondence Analysis, and within this space the three dairy-based products were separated from the plant-based products, and the oat/rice/coconut blend was separated from both the dairy-based and plant-based products. The defining sensory characteristics for the latter were 'coconut-like flavour,' 'creamy mouthfeel' and 'thick/viscous' (citation frequencies of 75%, 64% and 49%, respectively). While the two full-fat dairy-based products were most saliently characterised by 'white appearance' and 'milk-like flavour' (~80% and ~90% citation frequencies, respectively), these terms applied less to the low-fat dairy milk. The latter and the unsweetened cashew-based milk were the products most strongly associated with the terms 'weak/bland flavour' and 'thin/watery' (~65–75% and ~50–55%). The terms 'cardboard-like' and 'sweet' were used, respectively, most (29%) and least (4%) frequently to describe the unsweetened cashew-based milk. The rice milk, which was also unsweetened, was still perceived as the sweetest of the samples (65%) and, together with the oat/rice/coconut blend, was most often described by 'strong flavour' (~45%). The sensory profiles of the remainder of the plant-based products were largely similar with overlapping 95% confidence ellipses for average sample positions (Part 6B of Supplementary Material). Applicable terms for these sample were, for example, 'bean-like flavour,' 'grain/wheat flavour' and 'nutty flavour.'

Insight on the sensory drivers of liking/disliking was gained through penalty/lift analysis, which determined the impact on average liking (across all 10 samples) that was associated with CATA term citation.

Table 2
Liking* for the beverage samples (1 = 'dislike extremely' to 9 = 'like extremely') with the results of Tukey's HSD post-hoc tests[$]. The results are shown for the aggregate level across 345 consumers and each of the four consumer segments retained following cluster analysis (C1 to C4)[$$]. Superscripts in upper case letters show the results of post-hoc tests within each cluster for differences between beverage samples. Superscripts in lower case letters are compared row-wise and pertain to the comparison on mean liking scores across clusters for individual samples.

Sample	Milk name	Aggregate	Cluster 1 Full-fat dairy Likers	Cluster 2 Dairy and tri-blend Likers	Cluster 3 Full-fat dairy / tri-blend / soy Likers	Cluster 4 Plant-based Likers
1	Dairy (full-fat)	6.7 (1.6)^{A}	7.0$^{A, b}$	7.6$^{A, a}$	7.4$^{A, ab}$	5.6$^{D, c}$
2	Dairy (low-fat)	5.4 (1.9)^{CD}	5.9$^{B, b}$	6.8$^{AB, a}$	4.9$^{C, c}$	4.6$^{E, c}$
3	Dairy (full-fat, lactose-free)	6.7 (1.6)^{A}	7.2$^{A, a}$	7.6$^{A, a}$	7.2$^{AB, a}$	5.7$^{D, b}$
4	Soy	5.9 (2.0)^{B}	5.4$^{B, b}$	4.5$^{DE, c}$	6.7$^{AB, a}$	6.5$^{ABC, a}$
5	Soy (reduced fat)	6.0 (1.8)^{B}	5.6$^{B, b}$	4.8$^{D, c}$	6.3$^{B, a}$	6.7$^{AB, a}$
6	Cashew (unsweetened)	3.6 (1.9)^{E}	3.3$^{D, b}$	3.6$^{EF, b}$	2.5$^{D, c}$	4.7$^{E, a}$
7	Cashew	5.8 (2.0)^{BC}	5.5$^{B, b}$	5.3$^{CD, b}$	5.1$^{C, b}$	6.9$^{A, a}$
8	Rice (unsweetened)	5.1 (2.2)^{D}	5.7$^{B, a}$	2.9$^{F, c}$	4.7$^{C, b}$	5.8$^{CD, a}$
9	Oat (unsweetened)	5.1 (1.9)^{D}	5.6$^{B, a}$	3.3$^{F, c}$	4.4$^{C, b}$	6.1$^{BCD, a}$
10	Oat/Rice/Coconut blend	6.0 (2.0)^{B}	4.7$^{C, c}$	6.1$^{BC, b}$	7.1$^{AB, a}$	6.6$^{AB, ab}$

Note. For parsimony, the term tri-blend is sometimes used to refer to oat/rice/coconut blend. *) For aggregate level results standard deviations are shown in brackets. $) Values that share a letter (case sensitive) are not significantly different at the 5% level. $$) The number of participants in the clusters were: 107 (C1), 55 (C2), 72 (C3), and 111 (C4).

Results for this analysis are shown in Fig. 1b, and among the most frequently used sensory terms (horizontal axis) the selection of 'creamy mouthfeel,' 'milk-like flavour,' 'sweet taste' and 'white appearance' was associated with a positive impact (lift) on average liking scores of 1.0 to 1.6 scale points (vertical axis). While less frequently used, the term 'thick/viscous' was also associated with a significant hedonic lift of one scale point. A penalty of 1.4 on average liking was seen for 'weak/bland flavour', while a drop of 2.4 points was linked to the use of 'cardboard-like.' Smaller, yet still significant penalties on average liking (~0.5 scale points) were seen for the terms 'grain/wheat flavour,' 'rice flavour' and 'bean-like flavour.' A modest, but significant, hedonic lift was associated with 'nutty flavour' (0.3 scale points). 'Strong flavour' was the only term not associated with a significant lift or penalty.

3.1.3. Emotional and cognitive

The beverage samples were significantly discriminated ($p < 0.0001$) on all emotional and cognitive CATA terms (see Part 6A of Supplementary Material, which also has the sample × term frequency table with post-hoc tests). In the bi-plot of the first two dimensions of the Correspondence Analysis (Fig. 2a), the more negative conceptualisations, e.g., 'boring,' 'cheap,' 'uninspiring,' 'irritating' and 'pretentious,' appeared on the positive side of Dimension 1, while the more positive conceptualisations appeared on the negative side of Dimension 1. In keeping with the valence of these conceptualisations, the least liked products (Table 2) appeared on the right-hand side of Fig. 2a, i.e., the unsweetened cashew, rice and oat milk alternatives and the low-fat dairy milk. Of the four products, the conceptualisations were most distinct for the unsweetened cashew-based milk, which across the 10 products had the lowest citation frequency for 'happy' (4%), 'genuine' (5%) and 'relaxing (6%), and the highest citation frequency for 'irritating' (29%). This product and the low-fat dairy milk also had the highest citation frequencies for 'boring' (~40%) and 'cheap' (~35%). The second dimension in Fig. 2a separated the oat/rice/coconut blend from the three dairy milk products, and in the upper left quadrant of the plot, the two full-fat dairy milk products were characterised by the positive concepts of 'traditional,' 'genuine,' and 'comforting,' and these terms were used significantly more often than any other sample. In the upper right quadrant, the low-fat dairy milk product was characterised by the negative but traditional concepts of 'simple' (62%) and 'uninspiring' (40%). In Fig. 2a, the other products did not stand out for special characterisation, except for the oat/rice/coconut blend. This product was highly associated with 'adventurous' (29%), in opposition to the dairy milk products which were the least 'adventurous' (2–5%). The tri-blend (oat/rice/coconut) was also the product described as most 'sophisticated' (18%) and least 'simple' (24%).

The penalty/lift analysis for the emotional and conceptual product characterisations (Fig. 2b) revealed that a significant penalty was associated with citation of four terms: 'uninspiring,' 'boring,' 'cheap' and 'irritating,' with the largest negative impact pertaining to 'irritating' (3.2). All other terms were associated with a significant hedonic lift, which was largest for 'happy' (2.2) and smallest for 'simple' (0.5). Two terms – 'pretentious' and 'masculine' – were excluded from the significance tests due to low average frequency of use (<5%).

3.1.4. Situational use

The beverage samples were significantly discriminated ($p < 0.0001$) on all situational use CATA terms (Part 6A of Supplementary Material, which also has the sample × term frequency table with post-hoc tests). Fig. 3a shows the bi-plot of the first two dimensions of the Correspondence Analysis, and samples were largely separated along the first dimension in a way that resembled their ordering according to average liking (Table 2). This placed the two full-fat dairy-milk samples at the most positive part of Dimension 1 and the unsweetened cashew-based milk at the most negative part of Dimension 1. The situational uses most strongly associated with these two dairy samples reflected conventional uses and versatility (e.g., 'to have with cereal' (~84%), 'for the whole family' (~66%), 'for many different uses' (~60%), and 'for daily consumption' (~55–60%)). The unsweetened cashew-based milk and many of the other plant-based alternatives had much lower citation frequencies for the studied use situations. The second dimension separated the oat/rice/coconut blend from the low-fat dairy milk. The former had a distinct profile with the highest citation frequencies for use situations that could be characterised as "nutrient dense" including 'when I want something packed full of good nutrition' (41%) and 'for a moment of indulgence' (30%). The low-fat dairy milk was similar to the full-fat dairy milks in being considered suitable for cereal (68%) and as an alternative to drinking water (24%), but it was not perceived as being filling (10%) nor being packed full of good nutrition (10%). It was similar to the unsweetened cashew milk in being regarded as the most suitable product for 'when I'm on a calorie restricted diet' (33%). The remaining products did not have notable profiles in terms of situational use characteristics and were positioned near the origin of Fig. 3a with overlapping 95% confidence ellipses (Part 6B of Supplementary Material).

Fig. 3b displays the results from the penalty/lift analysis for the situational use characterisations, showing that only use of the term 'when I'm on a calorie restricted diet' resulted in a penalty on average liking (0.7 scale points). The smallest positive impact on average liking rating (lift) was found for the terms 'when I'm trying to be healthy' (0.4) and 'as an alternative to water' (0.7 scale points). For the remaining

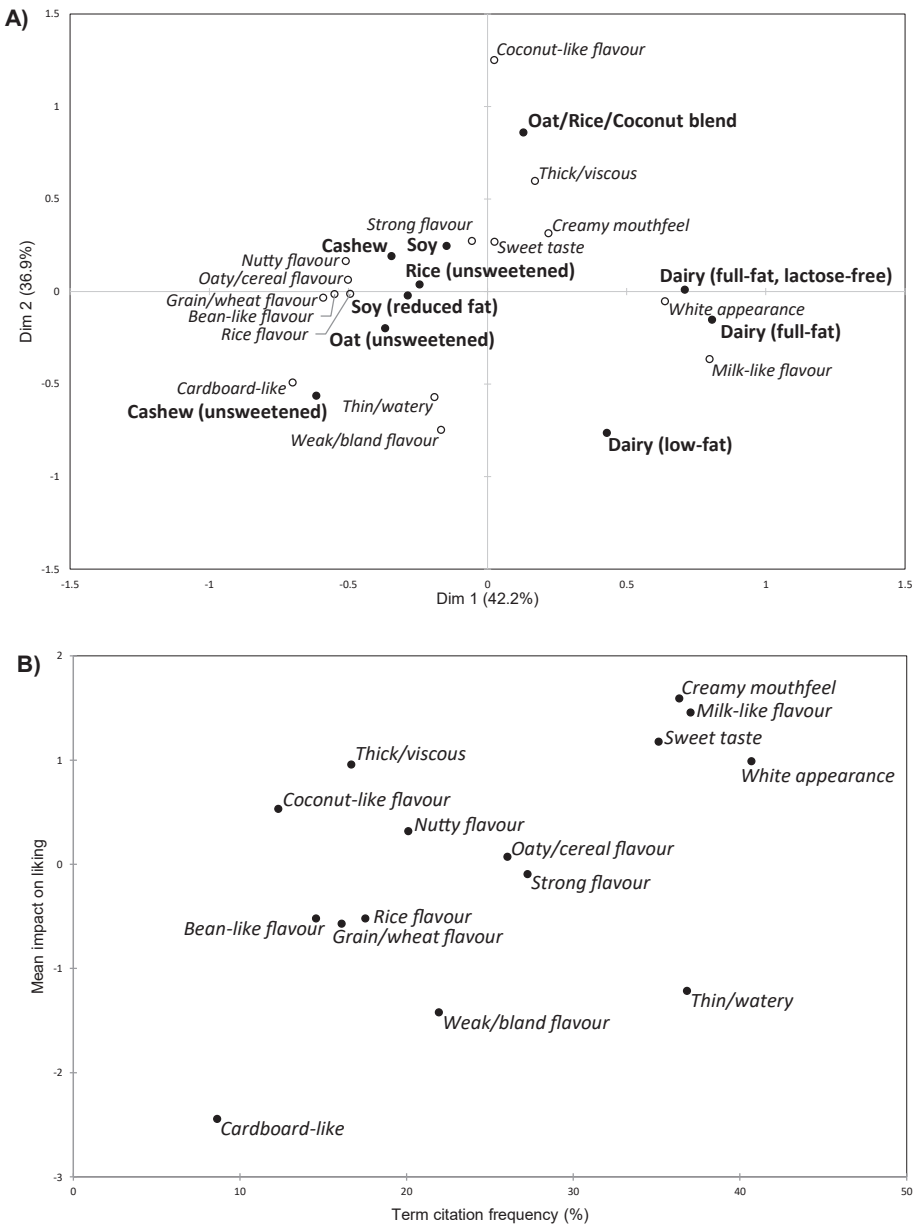

Fig. 1. Results linked to sensory product characterisation at the aggregate level across 345 consumers. A) Bi-plot spanned by the first two dimensions following Correspondence Analysis. Sample names are shown in bold font and CATA terms are shown in italic font. B) Indices from penalty/lift analysis with average CATA term citation frequency on the x-axis and the impact on average liking on the y-axis.

situational use terms, the mean impact ranged between 1.1 and 2.0 scale points and was largest for 'to drink on its own' and 'for daily consumption.'

3.1.5. Purchase, consumption and stated liking questionnaire

Table 3 shows the results from the purchase, consumption and stated liking questionnaire. The aggregate data are shown in the left-hand column. Frequency of consumption and stated liking was highest for dairy milk, followed by dairy-free (plant-based) milk and then lactose-free dairy milk. Dairy milk was also the most frequently purchased milk product, followed by soy, oat, and rice. Cashew milk and lactose free-milk were purchased least frequently.

3.2. Consumer segmentation: four-cluster solution

3.2.1. Liking

Table 2 shows the mean liking ratings for the 10 beverage samples for each of the four retained clusters. Within each product these clusters were compared and the post-hoc test results are shown by lower case letter designation. As can be seen, Cluster 1 (*Full-fat dairy Likers*) (n = 107) primarily liked the full-fat dairy products and had lower ratings for all other products. Cluster 2 (*Dairy and tri-blend Likers*) (n = 55) liked all of the dairy products, including the low-fat milk product. This cluster also liked the oat/rice/coconut blend but rated all of the other plant-based milk alternatives among the lowest of all the clusters. Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) (n = 72) liked the two full-fat dairy products as much as Cluster 2, but liked the low-fat dairy product significantly less. Cluster 3 also had a significantly higher rating of the oat/rice/coconut blend and of both soy alternatives than either Cluster 1 or Cluster 2. Lastly, Cluster 4 (*Plant-based Likers*) (n = 111) rated their liking of all of the plant-based products significantly higher or equal to that of all other clusters. Moreover, this segment of consumers rated all three dairy products significantly lower than the other clusters.

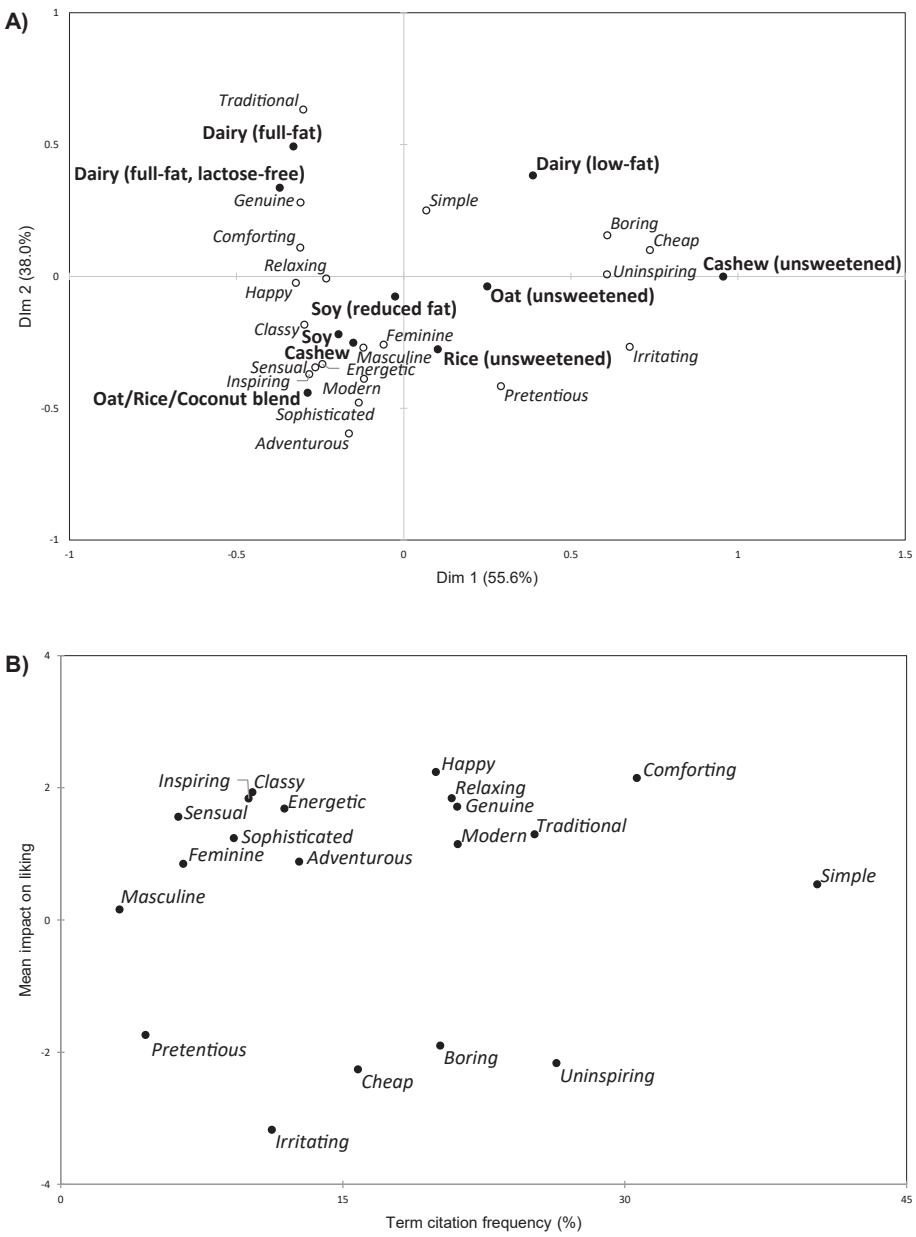

Fig. 2. Results linked to emotional and conceptual product characterization at the aggregate level across 345 consumers. A) Bi-plot spanned by the first two dimensions following Correspondence Analysis. Sample names are shown in bold font and CATA terms are shown in italic font. B) Indices from penalty/lift analysis with average CATA term citation frequency on the x-axis and the impact on average liking on the y-axis.

3.2.2. *Sensory drivers of liking*

Cochran's Q tests showed that the samples were significantly discriminated ($p < 0.05$) for all sensory CATA terms in all clusters. Rather than reporting the sensory product characterisations by cluster (for completeness, Part 7A of Supplementary Material has the product × term frequency table with post-hoc tests across samples for each cluster), focus is directed to insights about sensory drivers of liking gained from the penalty/lift analyses. These results are shown in Table 4, which, by cluster, presents: i) the average citation frequency for each sensory term across all samples, ii) the mean impact on liking (lift or penalty) associated with term citation across all samples and whether this change is significantly different from zero (if average citation frequency was <10% significance testing was not performed, show as #), and iii) the mean liking (based on mean-centred values) associated with term citation across all samples and post-hoc tests to compare mean liking across clusters. The first insights from Table 4 were that the impact of sensory terms on liking differed across the four clusters for all but two terms ('strong flavour' and 'sweet taste') and that these manifested as a mix of positive and negative impacts (respectively, lifts and penalties) across clusters, or manifested across clusters either as lifts or as penalties of varying impact. Collectively, this was evidence of cluster-specific sensory drivers of liking.

For Cluster 1 (*Full-fat dairy Likers*), the terms that impacted mean liking more than one scale point were those that had the same directional effects across all clusters [positive/neutral: 'creamy mouthfeel,' 'milk-like flavour,' 'sweet taste,' 'thick/viscous' and 'white appearance' or negative: 'cardboard-like flavour', 'thin/watery' and 'weak/bland'] and based on absolute values for mean impact, the top-3 sensory drivers were 'milk-like flavour' (+1.8), 'weak/bland flavour' (−1.3) and 'sweet taste' (+1.2) (Table 3). In comparison to the other three clusters, a non-significant but negative impact on liking (−0.3) was associated with 'coconut-like flavour,' and this fitted with 'coconut-like flavour' being highly characteristic of the tri-blend (oat/rice/coconut) sample (Fig. 1a), and this sample being disliked in Cluster 1 (4.7 of on 9-pt liking

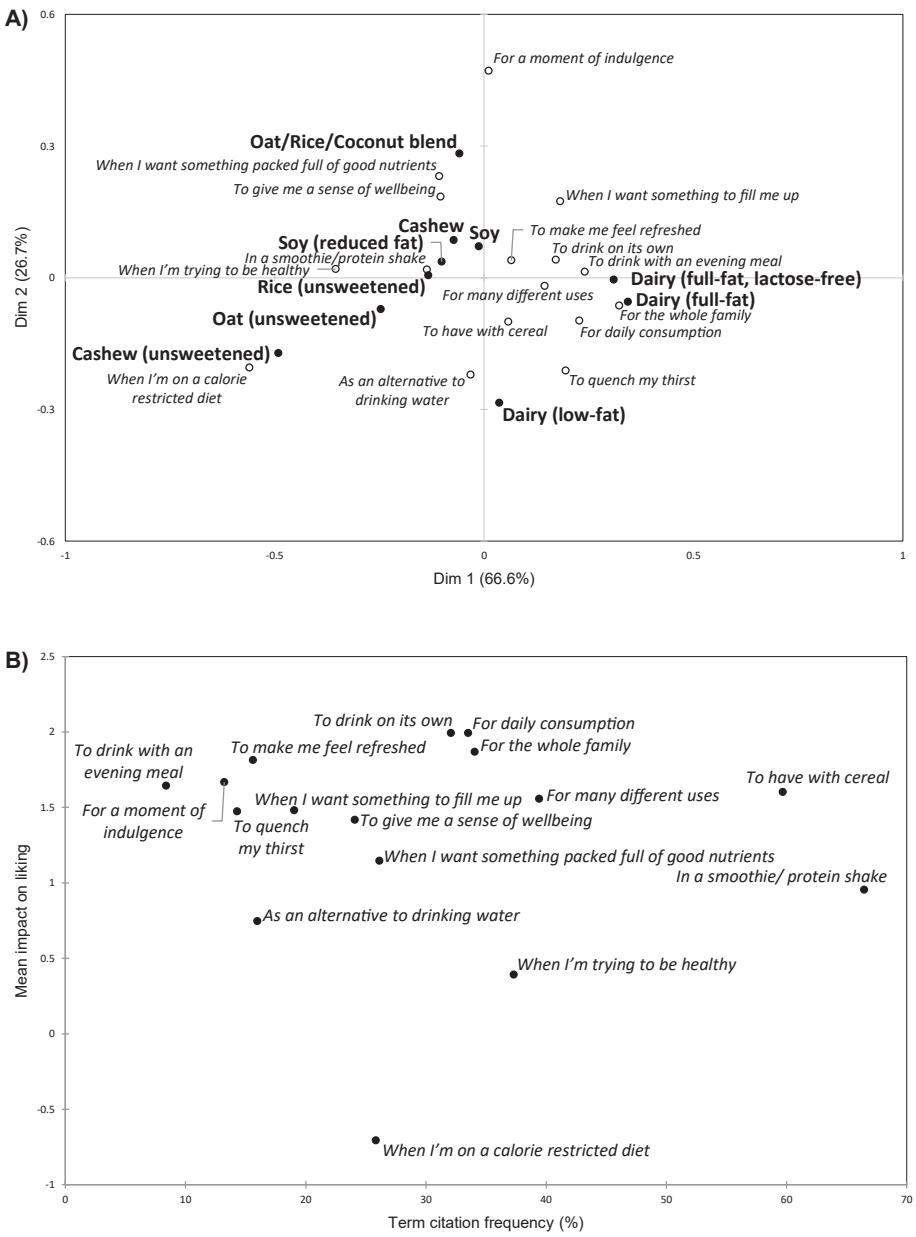

Fig. 3. Results linked to situational use product characterization at the aggregate level across 345 consumers. A) Bi-plot spanned by the first two dimensions following Correspondence Analysis. Sample names are shown in bold font and CATA terms are shown in italic font. B) Indices from penalty/lift analysis with average CATA term citation frequency on the x-axis and the impact on average liking on the y-axis.

scale) (Table 2).

In the small cluster that liked dairy milks and the oat/rice/coconut blend (Cluster 2), 'milk-like flavour' (+2.8), 'white appearance' (+2.0) and 'creamy mouthfeel' (+2.0) were the top three positive drivers of liking, with impacts that were significantly higher than observed in the other clusters (Table 3). This fitted well with the samples that were liked in this cluster (Table 2), as did the significantly higher penalties for 'grain/wheat flavour' (−2.0), 'bean-like flavour' (−1.5), 'rice flavour (−1.3) and 'oaty/cereal flavour' (−1.0). Among the plant-based milk alternatives, the consumers in Cluster 2 disliked the oat and rice products significantly more than did consumers in the other clusters (Table 2).

The sensory drivers of liking could be clearly linked to samples that were liked and disliked by consumers in Cluster 3 (*Dairy and tri-blend Likers*). Across the clusters, the top-3 penalties pertained to 'cardboard-like' (−3.1), 'weak/bland' (−2.0) and 'thin/watery' (−1.4), which were characteristic of the unsweetened cashew product, and, to a lesser extent, the low-fat dairy milk (Fig. 1a). These samples were disliked in Cluster 3, notably the former sample (Table 2). Conversely, 'coconut-like flavour', 'creamy mouthfeel' and 'thick/viscous,' which were characteristic of the tri-blend product (Fig. 1a), were associated with significantly higher lifts (respectively, +1.4, +1.2 and +0.6) (Table 3).

In parallel to product liking (Table 2), Cluster 4 (*Plant-based Likers*) was most differentiated from the other clusters. Among the terms with either positive or negative impacts across all clusters, the lifts associated with 'milk-like flavour' and 'white appearance' were significantly lower than in the other three clusters, as was the penalty for 'cardboard-like.' 'Bean-like flavour' which was associated with a penalty (−0.6 to −1.5) in the other three clusters, was associated with a small lift (+0.3) in Cluster 4. The impacts of 'rice flavour' and 'grain/wheat flavour' were also significantly less negative than in the other clusters, while the positive impact of 'oaty/cereal flavour' and 'nutty flavour' was larger than in the other clusters. Collectively, this fitted with consumers in this

Table 3
Stated liking*, consumption frequency* and purchase frequency* for dairy milk, lactose-free dairy milk and plant-based alternatives. Shown for the aggregate sample of 345 consumers and consumer segments C1 to C4[$]. Post hoc test for differences between clusters were performed using Tukey's HSD and within rows, clusters that share the same letter are not significantly different at the 5% level.

Response variable	Aggregate	Cluster 1 Full-fat dairy Likers	Cluster 2 Dairy and tri-blend Likers	Cluster 3 Full-fat dairy / tri-blend / soy Likers	Cluster 4 Plant-based Likers
Stated liking					
Dairy milk	7.3	7.6^{a}	8.2^{a}	7.6^{a}	6.4^{b}
Dairy milk (lactose-free)	5.1	5.2	4.7	5.1	5.2
Dairy-free milk alternatives	6.2	5.9^{b}	5.5^{b}	6.1^{b}	6.9^{a}
Frequency of consumption					
Dairy milk	7.2	7.4^{a}	7.3^{a}	7.7^{a}	6.4^{b}
Dairy milk (lactose-free)	1.8	1.8	1.3	1.8	2.0
Dairy-free milk alternatives	4.6	4.3^{b}	4.0^{b}	4.3^{b}	5.3^{a}
Purchase frequency					
Dairy milk	2.9	2.9^{a}	3.0^{a}	3.0^{a}	2.8^{b}
Dairy milk (lactose-free)	1.3	1.3	1.2	1.4	1.4
Soy milk alternative	2.0	2.0^{a}	1.6^{b}	1.9^{ab}	2.2^{a}
Cashew milk alternative	1.3	1.4^{ab}	1.1^{b}	1.3^{ab}	1.5^{a}
Rice milk alternative	1.5	1.5^{ab}	1.4^{b}	1.5^{ab}	1.7^{a}
Oat milk alternative	1.7	1.7^{ab}	1.4^{b}	1.7^{ab}	1.9^{a}

Notes. *) Stated liking was recorded on a 9-pt scale from 1 = 'dislike extremely' to 9 = 'like extremely.' An 8-pt scale was used to capture frequency of consumption with anchors: 8 = 'every day or almost every day,' 7 = '2 or more times a week,' 6 = 'about once a week,' 5 = 'about 2–3 times a month,' 4 = 'about once a month,' 3 = 'about once every 2–3 months,' 2 = 'about once a year or less,' and 1 = 'never.' Frequency of purchase was captured with three response options: 3 = 'Have purchased in the last 1 month,' 2 = 'Have purchased in the last 12 months' or 1 = 'Have never purchased.' $) The number of participants in the clusters were: 107 (C1), 55 (C2), 72 (C3), and 111 (C4).

Table 4
Results from penalty-lift analysis on liking scores (1 = 'dislike extremely' to 9 = 'like extremely') across the ten beverage samples by consumer segment (C1 to C4)[$] for 15 sensory terms evaluated using a CATA (check-all-that-apply) question. A penalty effect from CATA term selection is seen as a negative value for the variable 'mean impact,' and a lift effect is seen as a negative value for the variable 'mean impact.' All values for 'mean impact' are significantly different from zero at the 5% level of significance unless indicated as 'ns'. When the frequency of CATA term use is 10% or less, significance testing of mean impact ≠ 0 was not performed (indicated by #). A comparison of the clusters was performed using mean-centred liking scores associated with term citation followed by Tukey's HSD test[$$]. These results are shown in the columns labelled 'liking (MC).'.

	Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Full-fat dairy Likers			Dairy and tri-blend Likers			Full-fat dairy / tri-blend / soy Likers			Plant-based Likers		
Term	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)
Bean-like flavour ***	13.0	−0.6	-0.5^{B}	17.1	−1.5	-1.2^{C}	13.8	−0.9	-0.7^{BC}	15.4	0.3	0.2^{A}
Cardboard-like ***	7.3	$-2.2^{\#}$	-1.9^{B}	13.1	−2.7	-2.1^{BC}	10.6	−3.1	-2.6^{C}	6.5	$-1.7^{\#}$	-1.2^{A}
Coconut-like flavour ***	13.6	-0.3^{ns}	-0.3^{C}	10.9	0.8	0.7^{AB}	10.7	1.4	1.3^{A}	12.9	0.8	0.7^{B}
Creamy mouthfeel ***	37.3	1.3	0.7^{B}	35.3	2.0	1.2^{A}	35.6	2.1	1.2^{A}	36.6	1.4	0.6^{B}
Grain/wheat flavour ***	17.4	−0.6	-0.4^{B}	17.1	−2.0	-1.4^{C}	11.7	−0.5	-0.4^{AB}	17.3	0.1^{ns}	-0.1^{A}
Milk-like flavour ***	39.8	1.8	1.0^{B}	31.6	2.8	1.8^{A}	36.7	1.9	1.2^{B}	37.3	0.2^{ns}	0.0^{C}
Nutty flavour ***	17.9	-0.3^{ns}	-0.3^{C}	16.4	-0.4^{ns}	-0.2^{BC}	18.3	0.3^{ns}	0.3^{AB}	25.3	1.0	0.6^{A}
Oaty/cereal flavour ***	25.0	−0.3	-0.2^{B}	27.5	−1.0	-0.7^{C}	24.7	0.3^{ns}	0.3^{AB}	27.2	0.8	0.5^{A}
Rice flavour ***	16.6	−0.6	-0.5^{B}	20.9	−1.3	-1.1^{C}	15.8	−0.9	-0.8^{AB}	17.8	0.3^{ns}	0.0^{A}
Strong flavour [ns]	24.8	-0.1^{ns}	−0.2	29.1	−0.5	−0.3	30.3	0.1^{ns}	0.1	26.8	0.0^{ns}	0.0
Sweet taste [ns]	34.1	1.2	0.7	32.9	1.3	0.7	37.4	1.0	0.6	35.8	1.2	0.5
Thick/viscous ***	15.4	0.6	0.3^{A}	14.4	0.6	0.5^{B}	16.8	1.5	1.2^{A}	19.0	1.0	0.6^{B}
Thin/watery ***	35.7	−1.0	-0.5^{A}	34.0	−1.2	-0.7^{AB}	40.1	−1.7	-1.1^{B}	37.2	−1.1	-0.6^{A}
Weak/bland flavour ***	23.0	−1.3	-0.8^{A}	17.1	−1.0	-0.7^{A}	21.7	−2.0	-1.5^{B}	23.5	−1.4	-0.9^{A}
White appearance ***	42.1	1.0	0.6^{B}	40.2	2.0	1.2^{A}	36.5	1.4	0.9^{AB}	42.3	0.2^{ns}	0.0^{C}

Notes. $) The number of participants in the clusters were: 107 (C1), 55 (C2), 72 (C3), and 111 (C4). $$) Within rows, values that share a letter are not significantly different at the 5% level. The significance level for the cluster comparison is shown next to term names in the first column of the table and indicated as: *** for $P < 0.001$, ** for $P < 0.01$, * for $P < 0.05$ and ns for $p > 0.05$.

cluster being those who liked the plant-based milk alternatives most (Table 2).

3.2.3. Emotional/cognitive drivers of liking

Cochran's Q tests showed that the beverage samples were significantly discriminated ($p < 0.05$) by almost all of the emotional/cognitive CATA terms in all clusters. The three exceptions were: i) 'masculine' which was never significant, ii) 'feminine' which was not significant in Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) and Cluster 2 (*Dairy and tri-blend Likers*), and iii) 'pretentious' which was not significant in Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) and Cluster 4 (*Plant-based Likers*). Part 7B of Supplementary Material has full details, including the product × term frequency table with post-hoc tests across samples for each cluster.

Table 5 contains the penalty-lift results by cluster for the 20 emotional/cognitive CATA terms but is otherwise similar to Table 4. However, the findings differed in two ways, firstly with numerous instances of average term citation frequencies being less than 10% such that significance testing for mean impact being different to zero was not performed (shown as #). Secondly, all of the emotional/cognitive terms had penalties or lifts that were consistent across clusters (i.e., either only positive values for mean impact or only negative values for mean impact), and that fitted *a priori* expectations, because of the semantic valence of the word. What gave the results relevance was the fact that

Table 5
Results from penalty-lift analysis on liking scores (1 = 'dislike extremely' to 9 = 'like extremely') across the ten beverage samples by consumer segment (C1 to C4)[$] for 20 emotional and cognitive terms evaluated using a CATA (check-all-that-apply) question. A penalty effect from CATA term selection is seen as a negative value for the variable 'mean impact,' and a lift effect is seen as a negative value for the variable 'mean impact.' All values for 'mean impact' are significantly different from zero at the 5% level of significance unless indicated as 'ns'. When the frequency of CATA term use is 10% or less, significance testing of mean impact ≠ 0 was not performed (indicated by #). A comparison of the clusters was performed using mean-centred liking scores associated with term citation followed by Tukey's HSD test[$$]. These results are shown in the columns labelled 'liking (MC).'.

	Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Full-fat dairy Likers			Dairy and tri-blend Likers			Full-fat dairy / tri-blend / soy Likers			Plant-based Likers		
Term	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)
Adventurous ***	11.7	0.2^{ns}	0.2^{AB}	12.5	1.1	0.7^{B}	11.9	1.4	1.0^{A}	14.2	1.0	0.7^{AB}
Boring *	18.3	−1.6	-1.0^{A}	20.0	−1.9	-1.3^{AB}	24.4	−2.3	-1.6^{B}	19.4	−1.9	-1.3^{AB}
Cheap ***	15.8	−1.8	-1.3^{A}	17.1	−2.6	-1.7^{AB}	16.7	−2.5	-1.9^{B}	14.7	−2.3	-1.6^{AB}
Classy ***	8.9	$1.7^{\#}$	1.2^{BC}	8.2	$2.6^{\#}$	2.0^{A}	10.1	2.1	1.6^{AB}	12.5	1.7	1.1^{C}
Comforting ***	29.8	2.2	1.3^{B}	27.3	2.7	1.7^{A}	29.9	2.3	1.5^{AB}	33.7	1.6	0.8^{C}
Energetic ***	10.2	1.2	0.6^{B}	11.6	2.4	1.6^{A}	9.0	$2.2^{\#}$	1.7^{A}	15.6	1.5	1.0^{B}
Feminine *	6.2	$0.1^{\#}$	0.3^{B}	5.6	$1.1^{\#}$	0.8^{AB}	7.1	$1.4^{\#}$	1.1^{A}	6.9	$1.0^{\#}$	0.8^{AB}
Genuine ***	22.1	1.8	1.2^{B}	17.8	2.3	1.7^{A}	20.0	2.1	1.7^{A}	22.4	1.1	0.7^{C}
Happy ***	18.4	2.2	1.4^{C}	14.4	3.1	2.3^{A}	19.7	2.6	1.8^{B}	24.4	1.8	1.0^{D}
Inspiring ***	8.1	$1.6^{\#}$	1.1^{C}	7.3	$2.3^{\#}$	1.9^{A}	9.2	$2.0^{\#}$	1.5^{AB}	13.7	1.7	1.1^{BC}
Irritating ***	12.1	−2.8	-2.1^{A}	14.5	−3.5	-2.6^{B}	10.6	−3.4	-2.7^{B}	9.3	$-3.2^{\#}$	-2.2^{AB}
Masculine [ns]	3.5	$-0.5^{\#}$	−0.4	2.9	$0.4^{\#}$	0.4	2.4	$1.2^{\#}$	0.7	3.4	$0.2^{\#}$	0.4
Modern ***	21.4	0.6	0.3^{B}	18.4	1.7	1.1^{A}	20.6	1.3	1.0^{A}	22.6	1.2	0.8^{A}
Pretentious [ns]	6.4	$-1.6^{\#}$	−1.3	4.5	$-2.4^{\#}$	−1.9	3.3	$-1.6^{\#}$	−1.6	3.5	$-1.5^{\#}$	−1.0
Relaxing ***	20.7	1.7	1.0^{B}	17.5	2.6	1.8^{A}	17.1	2.0	1.5^{A}	25.0	1.5	0.8^{B}
Sensual ***	4.7	$0.9^{\#}$	0.7^{B}	5.5	$2.6^{\#}$	2.2^{A}	7.4	$2.2^{\#}$	1.8^{A}	7.5	$1.1^{\#}$	0.8^{B}
Simple ***	42.9	0.7	0.4^{A}	32.0	0.9	0.6^{A}	38.3	0.5	0.3^{AB}	43.1	0.2^{ns}	0.0^{B}
Sophisticated [ns]	7.0	$1.1^{\#}$	0.8	8.5	$1.2^{\#}$	1.1	9.6	$1.5^{\#}$	1.1	11.4	1.1	0.8
Traditional ***	24.7	1.6	1.1^{B}	24.5	2.3	1.7^{A}	22.4	1.6	1.3^{B}	27.9	0.4	0.1^{C}
Uninspiring ***	26.7	−1.9	-1.2^{A}	29.6	−2.6	-1.6^{BC}	26.5	−2.4	-1.8^{C}	24.3	−1.9	-1.3^{AB}

Notes. $) The number of participants in the clusters were: 107 (C1), 55 (C2), 72 (C3), and 111 (C4). $$) Within rows, values that share a letter are not significantly different at the 5% level. The significance level for the cluster comparison is shown next to term names in the first column of the table and indicated as: *** for $P < 0.001$, ** for $P < 0.01$, * for $P < 0.05$ and ns for $p > 0.05$.

Table 6
Results from penalty-lift analysis on liking scores (1 = 'dislike extremely' to 9 = 'like extremely') across the ten beverage samples by consumer segment (C1 to C4)[$] for 16 situational use terms evaluated using a CATA (check-all-that-apply) question. A penalty effect from CATA term selection is seen as a negative value for the variable 'mean impact,' and a lift effect is seen as a negative value for the variable 'mean impact.' All values for 'mean impact' are significantly different from zero at the 5% level of significance unless indicated as 'ns'. When the frequency of CATA term use is 10% or less, significance testing of mean impact ≠ 0 was not performed (indicated by #). A comparison of the clusters was performed using mean-centred liking scores associated with term citation followed by Tukey's HSD test[$$]. These results are shown in the columns labelled 'liking (MC).'

	Cluster 1			Cluster 2			Cluster 3			Cluster 4		
	Full-fat dairy Likers			Dairy and tri-blend Likers			Full-fat dairy / tri-blend / soy Likers			Plant-based Likers		
Term	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)	Frequency (%)	Mean impact	Liking (MC)
As an alternative to drinking water ***	19.0	0.5	0.4^{AB}	15.8	1.7	1.1^{A}	16.8	0.9	0.5^{AB}	12.6	0.5	0.4^{AB}
For a moment of indulgence ***	11.6	1.8	1.3^{B}	11.6	2.4	2.0^{A}	10.3	1.9	1.7^{AB}	17.5	1.2	0.8^{C}
For daily consumption ***	28.9	1.8	1.3^{B}	32.2	3.0	1.9^{A}	34.2	2.3	1.3^{B}	38.2	1.4	0.6^{C}
For many different uses ***	39.1	1.4	0.8^{B}	37.8	2.6	1.4^{A}	37.1	1.7	1.1^{A}	42.1	1.0	0.5^{C}
For the whole family ***	32.5	1.8	1.2^{B}	33.5	3.2	1.8^{A}	32.8	2.2	1.4^{B}	36.7	1.0	0.5^{C}
In a smoothie/protein shake [ns]	65.7	0.6	0.2	62.5	1.2	0.4	67.1	1.1	0.3	68.7	1.0	0.2
To drink on its own ***	29.9	1.8	1.1^{B}	32.2	2.6	1.6^{A}	29.9	2.3	1.4^{AB}	35.6	1.7	0.8^{C}
To drink with an evening meal ***	7.8	1.5	1.4^{A}	10.5	2.3	2.0^{A}	7.6	$2.0^{\#}$	1.6^{A}	8.4	$1.2^{\#}$	0.6^{B}
To give me a sense of wellbeing *	22.5	1.2	0.8^{A}	24.4	1.8	1.2^{A}	20.1	1.4	1.1^{A}	28.0	1.4	0.8^{A}
To have with cereal ***	58.6	1.4	0.6^{B}	53.6	2.5	1.0^{A}	57.2	2.2	0.8^{AB}	65.3	0.9	0.2^{C}
To make me feel refreshed ***	16.4	1.7	1.1^{BC}	13.5	2.8	2.2^{A}	14.3	1.9	1.5^{B}	16.8	1.4	0.9^{C}
To quench my thirst ***	14.2	1.3	0.9^{BC}	14.2	2.7	2.2^{A}	13.3	1.7	1.2^{B}	15.0	0.9	0.6^{C}
When I want something packed full of good nutrients ***	25.1	0.6	0.5^{B}	27.5	1.5	0.9^{AB}	21.8	1.7	1.2^{A}	29.2	1.1	0.6^{B}
When I want something to fill me up ***	19.3	1.3	0.8^{C}	16.5	2.6	2.0^{A}	16.9	1.8	1.4^{B}	21.4	1.0	0.6^{C}
When I'm on a calorie restricted diet ***	27.1	−1.1	-0.6^{B}	33.8	−0.6	-0.6^{B}	23.9	−1.2	-1.1^{B}	21.9	0.2^{ns}	-0.1^{A}
When I'm trying to be healthy *	38.5	0.0	0.0^{A}	41.5	0.8	0.2^{A}	34.3	0.2^{ns}	0.0^{A}	36.0	0.8	0.4^{A}

Notes. $) The number of participants in the clusters were: 107 (C1), 55 (C2), 72 (C3), and 111 (C4). $$) Within rows, values that share a letter are not significantly different at the 5% level. The significance level for the cluster comparison is shown next to term names in the first column of the table and indicated as: *** for $P < 0.001$, ** for $P < 0.01$, * for $P < 0.05$ and ns for $p > 0.05$.

the positive/negative impact was different across clusters and only for three terms were between-cluster differences non-significant ('masculine,' 'pretentious' and 'sophisticated').

When comparing the magnitudes of the penalties/lifts across clusters, it was seen that for every emotional/cognitive term, the impact on liking was less extreme (either positively or negatively) for Cluster 4 (*Plant-based Likers*) than for either Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) or Cluster 2 (*Dairy and tri-blend Likers*), the latter two of which were clusters of consumers who liked *both* dairy products and plant-based products. This fact was particularly exemplified by the emotional/cognitive terms 'comforting,' 'genuine,' 'happy' and 'traditional,' where Cluster 4 (*Plant-based Likers*) had significantly lower lifts for these terms (+1.6, +1.1, +1.8, +0.4) than did any of the other clusters [lift ranges = +1.6 to +2.6, +1.6 to +2.2, and +2.3 to +3.1 for Clusters 3 (*Full-fat dairy / tri-blend / soy Likers*), 1 (*Full-fat dairy Likers*), and 2 (*Dairy and tri-blend Likers*), respectively]. An exception to this general finding was seen for Cluster 1 (*Full-fat dairy Likers*). This cluster had a significantly lower lift for 'modern' than did any other cluster (+0.6 vs. +1.2 to +1.7).

3.2.4. Situational use drivers of liking

Cochran's Q tests showed that the samples were significantly discriminated ($p < 0.05$) for almost all situational use CATA terms in all clusters, with a single exception only – 'as an alternative to drinking water' in Cluster 1 (*Full-fat dairy Likers*). Part 7C of Supplementary Material has full details, including the product × term frequency table with post-hoc tests across samples for each cluster.

Table 6 extends Tables 4 and 5 and contains the results from penalty/lift analysis by cluster for the 16 situational use CATA terms. Evidencing cluster-specific results, the mean impact on average liking differed significantly across clusters for all of the CATA terms except 'in a smoothie/protein shake' (lift values between +0.6 and +1.2), and in parallel to the emotional/cognitive data (Table 5), the impacts were either positive or negative in all clusters. In fact, all of the impacts were positive which is logically consistent with the notion that the ability to use a product in a given situation can only be considered as a positive characteristic of the product. The only exception was 'when I'm on a calorie restricted diet' where significant penalties were found in three of the four clusters (except Cluster 4). In a point of departure from the results linked to sensory and emotional/conceptual terms, the relative impacts showed a consistent pattern where the lifts for situational uses were significantly greater in Cluster 2 (*Dairy and tri-blend Likers*) than in any other cluster, and in two instances ('for the whole family' and 'for daily consumption') they exceeded 3 scale points (Table 6). With regard to other differentiation among the clusters, it was clear that the lift afforded by many of the situational uses was significantly lower for Cluster 4 (*Plant-based Likers*) than all of the other clusters. This was true for the use situations 'for a moment of indulgence,' 'for daily consumption,' 'for many different uses,' 'for the whole family,' 'to drink on its own' and 'to have with cereal.'

3.2.5. Purchase, consumption and stated liking questionnaire

Table 3 shows the data obtained from the purchase, consumption and liking questionnaire by preference cluster. Consistent with the product liking data by clusters for the tasted milk products (Table 2), Cluster 4's (*Plant-based Likers*) stated liking of dairy-free milk alternatives was significantly higher than all of the other clusters, while their stated liking for dairy milk was significantly lower than all other clusters. A similar pattern was seen in the frequency of consumption data, where Cluster 4 (*Plant-based Likers*) reported that they consumed dairy-free milk alternatives significantly more often than did all other clusters and consumed dairy milk significantly less often than all other clusters. Purchase frequency showed similar trends, although the differences were not all significant.

4. Discussion

4.1. Aggregate data: Liking, sensory, emotional / cognitive, and product use characterizations

On an aggregate basis, there were clear and highly significant differences among the dairy-based milks and plant-based alternatives used in this study. The two most well-liked products were the two full-fat (3.4% fat) dairy-based milks (regular and lactose-free). Following in liking were the tri-blend product (containing oat, rice and coconut), and then the two soy milks (regular and reduced fat). As will be discussed below, liking for these specific plant-based products by different subgroups of consumers formed the basis for two segments of consumers who like both dairy-based and plant-based beverages. The least liked samples were the unsweetened plant-based milks made from either oat, rice, or cashew nuts. As will be discussed, only one segment of consumers liked these products, and these consumers were designated as *Plant-based Likers*.

In addition to the significant differences among the test products in terms of liking, the results showed that beverage samples were significantly discriminated by all of the sensory, emotional / cognitive and situational uses. The most highly liked products (i.e., the two full-fat dairy products) were characterised by 'white appearance' and 'milk-like flavour' and these two attributes imparted lifts to the aggregate liking ratings, reflecting the importance of these attributes to consumers and their relevance to optimising plant-based milk alternatives. The fact that the low-fat dairy product was less often characterised by the term 'milk-like flavour' and more often characterised by 'weak/bland flavour' and 'thin/watery' mouthfeel, which imparted a significant penalty on liking scores, confirmed common experience with low-fat milk products and explained why liking for the low-fat product was significantly lower than for the other dairy products. With that said, it was clear from the Correspondence Analysis of the sensory data (Fig. 1a) that all three dairy-based products were differentiated from the plant-based products. Further, the blended oat/rice/coconut alternative, which was differentiated from both the dairy-based and plant-based products in the sensory product space, had notable 'coconut-like flavour,' 'creamy mouthfeel' and 'thick/viscous' texture. The salience of the coconut-like flavour and its positive lift on liking ratings may account for why this product was liked more than all of the other plant-based products by one consumer segment who, otherwise preferred the dairy-based products (see below). Many of the other plant-based beverages were largely similar, grouped together, and overlapping in their sensory Correspondence Analysis biplot (Part 6B of Supplementary Material) and were characterised by such terms as 'bean-like flavour,' 'grain/wheat flavour,' 'nutty flavour,' and 'cardboard-like.' All of these terms imparted penalties on liking ratings, which accounted for the low aggregate liking ratings for these products in all but one segment of consumers (see below).

Regarding the emotional / cognitive variables, the fact that the positive lift for 'traditional,' 'genuine' and 'comforting,' were for the terms most often used to characterise the most traditional and well-liked products (i.e., the full-fat dairy products) was not surprising. Similarly unsurprising was the fact that the term 'irritating,' which had the highest penalty on liking ratings, was used to characterise the least liked of the products, i.e., the unsweetened cashew-based milk alternative. This highly negative emotional / cognitive association was the reason why only one of the four consumer segments, the *Plant-based Likers* segment (Cluster 4), rated this product above 3.6 on the 9-pt hedonic scale (see Section 4.2.1 below).

With regard to situational uses, the two full-fat dairy products were associated with conventional uses for such beverages (e.g., 'to have with cereal') and with versatility (i.e., 'for the whole family,' 'for many different uses' and 'for daily consumption'). Versatility of use of a product has been previously associated with higher liking for the product, i.e., the greater the number of situations for which a product is appropriate for use, the greater is its rated liking (Shepherd, et al., 1993;

Cardello & Schutz, 1996). The fact that the unsweetened cashew-based beverage (the least liked of the 10 products) and many of the other lesser-liked plant-based alternatives had low citation frequencies for many of the use situations further confirmed this association between versatility of use and liking ratings.

It was of some note in the aggregate data that the oat/rice/coconut blend product, which was the most well-liked plant-based product, had strong associations with the emotional / cognitive terms 'adventurous' and 'sophisticated' and with the situational uses 'when I want something packed full of good nutrition' and 'for a moment of indulgence,' all of which exerted lift on the liking scores. In contrast, the low-fat dairy product and the unsweetened cashew-based alternative were not associated with uses related to satiety, e.g., 'filling' or good nutrition. Rather these products were more associated with 'as an alternative to drinking water' (low-fat dairy milk) and for 'when I'm on a calorie restricted diet.'

In summary, the aggregate-level data showed that most of the consumers in this study preferred the traditional, full-fat dairy products. However, the oat/rice/coconut blend plant-based beverage was also well liked. This was due to its 'coconut-like flavour' and 'thick/viscous' texture, both of which were associated with a nutrient rich and 'indulgent' product. Most of the other plant-based beverages (soy (regular and lite), sweetened cashew, rice and oat) were less well liked and on a par with the low-fat dairy milk. The unsweetened cashew-based alternative was the least liked product by the majority of consumers, because of a 'cardboard-like flavour' and an 'irritating' emotional / cognitive association.

4.2. Consumer segmentation of dairy and plant-based milk consumers

The cluster analysis based on liking responses to the products revealed four distinct clusters of consumers. Moreover, the sensory, emotional/cognitive and situational use characterisations were found to differ significantly among these four clusters and to provide important insights related to the cluster preferences, enabling inferences to made about the possible origins of these clusters in light of what is known about the drivers of consumer liking and the evolution over time of plant-based milk alternatives in the market.

4.2.1. Segments based on liking

On an *a priori* basis, one might expect that the consumers in this study would segment simply on the basis of whether they preferred dairy-based milks or plant-based milks. Such a proposition might be supported by the aggregate liking data that show the three dairy products to have the highest liking ratings and all plant-based products to have lower levels of liking. However, the bi-modality in liking ratings for several of the plant-based samples (Part 5 of Supplementary Material) suggested that this simplistic assumption may not hold.

Foremost among the four consumer segments identified by the cluster analysis was a large group of consumers who, primarily, liked the full-fat dairy-based beverages. As shown in the results, this was Cluster 1 (*Full-fat dairy Likers*) (n = 107). In addition, there was an equally large cluster who primarily preferred the plant-based alternatives, i.e., Cluster 4 (*Plant-based Likers*) (n = 111). However, the cluster analysis revealed two additional, albeit smaller, segments of consumers who liked some combination of both dairy-based milks and plant-based milk products. These segments revealed themselves in the two additional clusters shown in the results: Cluster 2 (*Dairy and tri-blend Likers*) (n = 55), who liked all of the dairy-based products and the blended plant-based oat/rice/coconut product, and another separate cluster, Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) (n = 72), who liked the full-fat dairy products, the blended plant-based product and the two soy-based products.

The identification of these four clusters provides evidence that dairy milk consumers and plant-based milk alternative consumers are not monoliths in this market. Rather, there exist more nuanced segments of consumers who prefer both dairy- and plant-based beverages. In addition, by examining the sensory, emotional/cognitive, and situational uses for their preferred products, it was possible to provide important insights into the drivers of each segment's milk and milk-substitute preferences.

4.2.2. Sensory characterisations among liking segments

Examining the results from the sensory characterisations of the beverages by segment, the *Full-fat dairy Likers* (Cluster 1) most frequently used the positive sensory terms of 'creamy mouthfeel,' 'milk-like flavour,' 'sweet taste,' 'thick/viscous' and 'white appearance' in their characterisations of the products. Although these terms would be expected to apply to a number of the dairy-based and plant-based products (see, for example, the sample photographs in Part 3 of Supplementary Materials), these terms all had high lift on the liking ratings for this group of consumers. In a sense, this cluster is similar to the cluster of consumers identified by Palacios, et al. (2009) which were described as 'cream likers' following segmentation analysis of liking scores for lactose-free dairy milks and soy milks. These investigators described this segment as consumers who "prefer stronger milk aroma and flavour" and "creamy and smooth" texture. Also, strikingly, among Cluster 1 (in comparison to the other three clusters), the term 'coconut-like flavour' had a penalty on liking ratings that was not reflected within the other segments. Consequently, these consumers had the lowest mean-centred liking for this sensory descriptor and the lowest liking for the tri-blend (oat/rice/coconut) product that was characterised by 'coconut-like flavour.' In addition, although these consumers characterised the tri-blend product as having a 'creamy mouthfeel,' they, along with the *Plant-based Liker* cluster (Cluster 4), had a lower lift for this descriptor than did either Cluster 2 (*Dairy and tri-blend Likers*) or Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*). Thus, it may be that the preference for the tri-blend product among the latter two clusters was due to their preference for its coconut flavour or its thick creamy mouthfeel. However, upon examining the penalty/lift analyses for these two attributes between the latter clusters, while both clusters had similarly high lifts for 'creamy mouthfeel,' Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) had a higher lift than Cluster 2 (*Dairy and tri-blend Likers*) for 'coconut-like flavour,' suggesting that the coconut flavour may have been a more important sensory driver of the liking of this product for Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*). This explanation is consistent with the literature showing that the primary sensory drivers of liking across a broad range of products is taste/flavour, as opposed to texture (Schutz & Wahl, 1981; Tuorila-Ollikainen, et al., 1984; Moskowitz & Krieger, 1995; Bower & Whitten, 2000; Andersen, et al., 2019).

Based on the above analysis of preferences for 'coconut-like flavour,' it may well be that Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) were more open to other non-traditional (non-dairy) flavours in these products than Cluster 2 (*Dairy and tri-blend Likers*). This is consistent with the fact that consumers in Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) were also accepting of the two soy-based beverages, whereas the only other beverage that Cluster 2 (*Dairy and tri-blend Likers*) liked was the low-fat dairy milk, which retains a characteristic dairy flavour. This difference in the acceptance of non-dairy, non-milk flavours was also a defining characteristic of the fourth cluster, Cluster 4 (*Plant-based Likers*), which was the only cluster that preferred a large range of the plant-based beverages examined in this study. In fact, Cluster 4 (*Plant-based Likers*) was the only cluster that had less negative or positive lifts for many of the non-dairy, non-milk-like flavours, e.g., 'grain/wheat flavour,' 'nutty flavour,' 'oaty/cereal flavour' and 'rice flavour,' for which the other clusters often had penalties. Furthermore, this was true in spite of the fact that, across clusters, there was fairly good agreement about the sensory differences among the products (see Part 6B of Supplementary Material). This indicated that the differences among the four clusters that emerged in this study were not a result of differential perceptions of the sensory characteristics of the products, but rather, linked to differential preferences (penalties/lifts) toward, especially, the

flavour of the plant-based products.

4.2.3. Emotional / cognitive characterisations by liking segments

The above findings, as they relate to the differences in preference among clusters for non-dairy, non-milk flavours, was also reflected in the emotional/cognitive data, where Cluster 4 (*Plant-based Likers*) had significantly lower lifts for the emotional/cognitive terms 'comforting,' 'genuine,' 'happy' and 'traditional,' than did any of the other clusters, whereas Cluster 1 (*Full-fat dairy Likers*) had a significantly lower lift for 'modern' than did any other cluster. Based on these data, it can be concluded that Cluster 4 (*Plant-based Likers*) was less attracted to emotional/cognitive associations that might be communicated by more 'genuine,' 'traditional' or 'comforting' flavours (e.g., dairy and milk-like flavours), whereas consumers in Cluster 1 (*Full-fat dairy Likers*) were less attracted by emotional cognitive associations that might be communicated by more 'modern' flavours for milk-based beverages, e.g., those imparted by the plant-based alternatives.

It was also of some note that for Cluster 4 (*Plant-based Likers*), the impact on liking was less extreme (either positively or negatively) for all of the emotional/cognitive terms. For this consumer segment, emotional/cognitive associations with the products had far less impact on their liking ratings of the products than they did for other clusters. This relative indifference to emotional/cognitive associations suggested that past experiences with these general classes of beverages (Table 3) may have fostered a more eclectic approach towards, and a wider acceptance of, new and non-traditional plant-based beverages.

4.2.4. Situational use characterisations by liking segments

Not unlike the emotional/cognitive data, the hedonic lift afforded by many of the situational uses was significantly lower for Cluster 4 (*Plant-based Likers*) than for the other three clusters. As such, Cluster 4 appeared to be less influenced by the commonly associated uses for these products than were the other clusters. For example, these *Plant-based Likers* may be less restrained by the fact that they are using the product 'to have with cereal' or 'for the whole family.' Rather, they appeared more open to using these milk substitutes for any situation. Since this cluster had a higher purchase and consumption frequency for dairy-free milk alternatives compared to the other three clusters (Table 3), this finding seemed consistent with research on vegetarian and flexitarian consumers who are much more willing to substitute from dairy to plant-based beverages across a wide variety of use situations (Wolf, et al., 2020).

This brings us to the fact that all of the situational use impacts on liking, except for 'when I'm on a calorie restricted diet,' were positive within all clusters, albeit that the lifts were significantly greater in Cluster 2 (*Dairy and tri-blend Likers*). Although the positive impacts on liking for most situational uses were consistent with past literature (Shepherd et al., 1993; Cardello & Schutz, 1996; Cardello, et al., 2016; Jaeger, et al., 2017), the higher lifts for Cluster 2 (*Dairy and tri-blend Likers*) were more difficult to explain. One might speculate that, among these consumers, because liking for these products was more affected by their situational use and that their preference was either for dairy milks or the tri-blend product, that they use the dairy products primarily for one set of situations and the tri-blend product for another. In point of fact, among these consumers in Cluster 2 (*Dairy and tri-blend Likers*), the five most frequently selected uses for all three dairy products were 'to have with cereal,' 'for daily consumption,' 'to drink on its own,' 'in a smoothie / protein shake,' 'for the whole family' and 'for many different uses.' In contrast, the most frequently cited use situations for the tri-blend plant-based product were 'in a smoothie / protein shake,' 'when I'm trying to be healthy', 'to have with cereal,' 'for many different uses' and 'when I want something packed full of good nutrients.' As such, it seems that these consumers perceive the nutrient and health benefits of this plant-based product and use it (as opposed to the traditional dairy products) for situations in which they desire a health or nutrient benefit, which is known to be a primary reason for the intention to buy and consume these products (de Graaf, et al., 2016; Bus & Worsley, 2003a; 2003b; McCarthy, et al., 2017).

4.2.5. Purchase, consumption and stated liking questionnaire

The data on purchase, consumption and stated liking of dairy milk, lactose-free milk and dairy-free milks obtained at the end of the study (Table 3) show consistency with the segment clusters' liking ratings for the tasted dairy and plant-based products used in the study. These data provide concurrent validity for the segments identified and show that consumers' consumption patterns and stated liking (on a questionnaire) conform to their liking of products when actually tasted. Since this is associative data only, it is impossible to determine how liking and behaviour influence one another, but it is safe to say that the relationship reflects a feedback loop in which tasted liking influences consumption (and purchase), while repeated consumption enhances liking through familiarity effects.

4.3. General discussion

The combined liking, sensory, emotional/cognitive, and situational use data for the dairy and plant-based milks and milk alternatives used in this study enabled a clearer characterisation of the different consumers segments that exist in this beverage market and provided insights into the likely reasons for their choice of these products.

Examining first the sensory characterisations of the beverages, it seemed clear that consumers generally agreed on the sensory attributes associated with these products. However, their liking/disliking of these sensory properties was different, as reflected in the penalty/lift data, resulting in the various preference segments found in the market. Second, this research revealed multiple consumer segments in the market, including two large clusters of consumers, who preferred only full-fat dairy products [Cluster 1 (*Full-fat dairy Likers*)] or a wide range of plant-based dairy alternatives [Cluster 4 (*Plant-based Likers*)]. The former cluster of consumers exhibited large lifts for such product-related sensory attributes as 'creamy mouthfeel', 'milk-like flavour' and 'white appearance,' all terms highly associated with full-fat dairy products. Perhaps, not unsurprisingly, these consumers also exhibited a large penalty on their liking ratings for emotional/cognitive associations to the term 'modern.' In contrast, the *Plant-based Likers* segment (Cluster 4) was the only cluster that exhibited positive lifts on liking from many of the plant-like flavour terms, e.g., 'grain/wheat flavour,' 'nutty flavour,' 'oaty/cereal flavour' and 'rice flavour.' As opposed to the penalty exhibited for the emotional/cognitive term 'modern' exhibited by the *Full-fat Dairy Likers*, these *Plant-based Likers* experienced lower impact from such terms as 'traditional' and 'genuine.' In addition, the *Plant-based Likers* cluster had less impact on their liking ratings from the majority of emotional/cognitive or situational use characterisations of the products, reflecting a reduced influence from traditional or existing product associations and uses. In sum, these two consumer groups, Cluster 1 (*Full-fat dairy Likers*) and Cluster 4/ (*Plant-based Likers*) may well be viewed as extremes on a continuum of consumers of dairy milk and plant-based alternatives.

Closest to the *Full-fat dairy Likers* (Cluster 1) on this hypothetical continuum were consumers who liked not only the full-fat dairy milks, but low-fat dairy milk and the oat/rice/coconut blend beverage used in this study. These were the consumers in Cluster 2 (*Dairy and tri-blend Likers*), whose liking for the low-fat dairy product was likely related to the fact that this product retains a milk-like flavour. However, based on the sensory penalty/lift results, it appeared that the preference of these consumers for the tri-blend product was related to their liking of the coconut flavour of the product, which is a highly characterising sensory attribute of this product. In addition, these consumers appeared to use the tri-blend product when nutritional or health benefits are desired.

The final cluster of consumers identified in this research, Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*), extended the liking for products beyond the full-fat dairy products and the tri-blend to the two soy-based

products, while eschewing the low-fat dairy product. The preference of these consumers for the tri-blend product was likely also due to their preference for its coconut flavour, for which they showed an even higher lift on liking ratings for this attribute than Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*). In addition, their preference for the soy-based products was likely due to the fact that the impact of plant-based flavours on these consumers' liking ratings were more neutral/positive than either Cluster 1 (*Full-fat dairy Likers*) or Cluster 2 (*Dairy and tri-blend Likers*), although not as positive as for Cluster 4 (*Plant-based Likers*). These consumers also found the soy products to be more 'comforting' and 'relaxing' than Cluster 1 (*Full-fat dairy Likers*) and Cluster 2 (*Dairy and tri-blend Likers*) and even characterised the soy products as more appropriate for use 'with cereal' than all other clusters, including the *Plant-based Likers* cluster (Cluster 4).

In a recent paper focused on how behavioural science can develop interventions to promote alternative protein consumption, four systematic research steps were identified (Onwezen, 2022). The first of these is to identify the behaviour, including measuring baseline behaviours and identifying specific target segments. The second is exploring the drivers of the behaviour. The present research contributes to each of these goals by measuring baseline preference behaviours toward dairy and plant-based at the aggregate level, identifying different preference segments within the population, and, finally, exploring sensory, emotional/cognitive and situational use drivers of the behaviour. However, Onwezen, et al. (2021) also focused extensively on the role of familiarity and habits as factors that may deter the acceptance and use of alternative protein products. From this perspective, it may be useful to speculate on how or why the consumer segments that were identified in this research may have evolved against issues of familiarity and habit.

Before plant-based milk alternatives became popular in the market, consumers, presumably, either liked and consumed dairy-based milk products or did not like them or consume them (some for health or dietary reasons). However, as plant-based beverages, especially soy products, became more popular, those consumers who were vegan/flexitarian, health-oriented, held animal safety values or who just preferred new or unique products began to try the plant-based offerings on the market. Since taste (flavour) has been repeatedly shown to be the primary driver of liking for foods and beverages (Moskowitz & Kreiger, 1995), the development of preferred flavour profiles for plant-based foods and beverages was an important goal of product developers. However, based on our knowledge of the role of sensory expectations on product liking, in which products that disconfirm claimed or expected sensory or hedonic quality may suffer exaggerated dislike through mechanisms of perceptual contrast (Zellner, et al, 2004; Zellner et al., 2006; Cardello, 2007; Aschemann-Witzel, et al., 2019), attempts by plant-based beverage developers to position plant-based milks as tasting like dairy milk when they do not may have had negative effects on consumer perceptions and acceptance of these milk alternatives, perhaps more than simply introducing these products as entirely new or different tasting products.

Taking the above factors into account when re-examining the uncovered clusters in our data, it may well be that the tri-blend product containing oat, rice and coconut, with a coconut flavour and thick creamy texture, may offer a product profile that is well liked and sufficiently distinct from traditional dairy products so as not to elicit a direct comparison with dairy milks and, thereby, attract consumers who, otherwise, prefer traditional dairy products, i.e. Cluster 2 (*Dairy and tri-blend Likers*) and Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*). Somewhat more speculative, the liking of the soy products by Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) and Cluster 4 (*Plant-based Likers*) may be more attributable to the longevity of soy-based products in the market and the familiarity that has accrued to these products, especially among consumers like those in Cluster 3 (*Full-fat dairy / tri-blend / soy Likers*) and Cluster 4 (*Plant-based Likers*), who do not dislike the flavours associated with most plant-based products, in contrast to consumers in Cluster 1 (*Full-fat dairy Likers*) and Cluster 2 (*Dairy and tri-blend Likers*).

Overall, from our data, it appeared that the sensory attributes of the milk and plant-based alternatives examined in this study, especially their flavour, were more potent drivers of their liking among different segments of consumers than were their emotional/cognitive associations or their intended use situations. Although the latter may be used to differentiate among certain clusters of consumers in this market, they do not appear to be the main drivers of preference toward the products. Whether these results are due to the fact that the study was conducted using blind taste tests, as opposed to including extrinsic variables (e.g., price and packaging) is unclear.

Further, it was apparent that any simple characterisation of consumers of these products, e.g., as "dairy only" or "plant-based only" is unjustified and not supported by the present data. Rather the market appears to be more complex than this, earmarked by a variety of individual segments that fall along a continuum from those who exclusively drink full-fat dairy beverages to those who prefer a wide range of plant-based beverages, but each having distinct and characterising hedonic, sensory, emotional/cognitive and situational uses for these milk and plant-based beverages.

4.3.1. Limitations and suggestions for future research

There were several limitations to the present research. The results were specific to New Zealand adults and the 10 selected products. Participants who were self-declared vegans or vegetarians were excluded, and considering that this segment is growing, such people would be relevant to study. Another extension could be in relation to product selection, since plant-based milk alternatives other than those included in the research exist, for example, made from almonds, macadamia nuts or hemp. In addition, it should be pointed out that some of the test products were processed by UHT, while others were not (the dairy and tri-blend products). In the future, the role of UHT processing should be assessed to ensure that off-flavours from the UHT process are not confounded with other product differences. Finally, a more extensive characterisation of perceived sensory properties would be relevant, which should include odour, aftertaste and greater detail on texture and mouthfeel. More so than for emotional/cognitive and situational use, the sensory characteristics provided detailed and actionable product insights with relevance for product innovation.

It would also be relevant to further explore if the consumer segments identified in the present research differed in their demographic, socio-economic, behavioural and/or psychographic variables. Although the data on past consumption show strong associations with the segments found in this research, the data in Part 1 of Supplementary Material, which shows the segment profiles in relation to selected demographic and socio-economic characteristics, pointed to few major differences. Tentatively, psychographic variables such as food neophobia should be included in future research, as it is often an insightful variable in consumer research within this product space (e.g., Jaeger & Giacalone, 2021).

5. Conclusions

The primary insight from the present data where 345 New Zealand consumers tasted 10 dairy and plant-based milk beverages was consumer segmentation that went beyond the simplistic liking for "dairy only" or "plant-based only." Instead, four consumer segments were identified that fell along a continuum from *Full-fat dairy Likers* to *Plant-based Likers*, with *Dairy and tri-blend Likers* and *Full-fat dairy / tri-blend / soy Likers* as the intermediary preference clusters. Each cluster had distinct and characterising sensory, emotional/cognitive and situational uses for the tested dairy and plant-based beverages, and penalty/lift analysis was used to determine how these positively or negatively impacted product liking, as well as the magnitude of these effects in the four clusters. In relation to promoting alternative protein consumption within the context of plant-based beverages, the present research contributed to two of four systematic research steps by i) measuring

baseline preferences/behaviours and identifying target consumer segments, and ii) exploring the drivers of the behaviour.

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CRediT authorship contribution statement

Armand V. Cardello: Conceptualization, Writing – original draft, Writing – review & editing. **Fabien Llobell:** Formal analysis, Visualization, Writing – review & editing. **Davide Giacalone:** Conceptualization, Methodology, Writing – review & editing. **Christina M. Roigard:** Investigation. **Sara R. Jaeger:** Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

Given their roles as Editor at the time of submission, authors AVC and SRJ were not involved in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another editor, as per the journal guidelines. All other authors declare no conflicts of interest.

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Appendix A. Supplementary data

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