Future Foods 6 (2022) 100168

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo

Consumer perception of plant-based burger recipes studied by projective mapping

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ARTICLE INFO

Keywords:
Clean label
Sustainability
Plant-based meat alternatives
Consumer research
Perceptual mapping
Back-of-pack labeling

ABSTRACT

Driven by consumer interest in sustainable diets, plant-based meat alternatives (PBMA) are gaining popularity with more products available on the market. Consumers increasingly demand "clean label" (CL) products free of additives and using a limited number of ingredients. This is a challenge for PBMA producers due to the difficulty of imitating meat-like properties without using additives. Against this backdrop, this study investigated consumer understanding and interpretation of CL status in PBMA, using plant-based burger recipes as case study. Eight plant-based burger recipes – systematically varying in main plant protein ingredient, recipe length, familiarity of ingredients, and clean-label status – were evaluated by consumers ($N = 55$) using projective mapping. The length of the ingredients list, together with the main ingredients was the primary aspect that caught the attention of the consumers. Consumers separated longer recipes – described as more complex, processed, unhealthy but also tasty – from shorter recipes – perceived as simpler and healthier, but less meat-like. Furthermore, a smaller part of the data was explained by the presence of chemical additives. Overall, this study indicates that the length the ingredient list is more important for consumer perception of CL status in PBMA than the presence of chemical additives per se.

1. Introduction

The production of food – meat and dairy in particular – is a major contributor to the global environmental changes due to its contributions to greenhouse gasses emissions (GHGE), biodiversity loss, freshwater use, eutrophication, and land-system change (Willett et al., 2019). Further, there is strong scientific evidence that a higher consumption of plant-based food (fruit, vegetables, whole grain, legumes, nuts, seeds and no animal products (Ostfeld, 2017) and a lower consumption of animal-based foods is beneficial for both human health and environmental sustainability (Dinu et al., 2017; He et al., 2020; Helms, 2004; Perignon et al., 2017; Willett et al., 2019).

Accordingly, there is an increasing societal interest in plant-based food products (Reipurth et al., 2019), and growing consumer demand for plant-based food alternatives that are healthy, ethical and environmentally sustainable (Aschemann-Witzel et al., 2021; Mintel GNPD, 2021). Although not all plant-based food products are necessarily better with regards to key nutrients (Curtain and Grafenauer, 2019) and GHGE (Perignon et al., 2017) than animal products, consumer demand is growing driven by health concern, ethical considerations and other process characteristics (i.e. organic production, local production, animal welfare, use of GMO, and sustainability) (Grunert, 2013; Weinrich, 2019).

Sensory aspects, such as the appearance and taste of these products, are crucial factors for the consumer quality evaluation and their consumption on a regular basis (Grunert, 2005; Weinrich, 2019). Accordingly, current plant-based meat alternatives (PBMA) are produced to mimic the same taste, texture and color as animal-based products in order to make them appealing to meat eaters (Estell et al., 2021). Consumers who identify themselves as omnivores are reportedly less open to try new plant-based foods in general (Hielkema and Lund, 2021; Lacroix and Gifford, 2019), and since a total exclusion of meat is not a realistic strategy in the short term, the focus should be on reducing the intake over time (Hielkema and Lund, 2021). PBMA represent an option in this direction, particularly for omnivores and flexitarian consumers who are most attached to the sensory experiences from meat. This is also include hybrid meat products (a mix of meat and plant) that are reportedly highly accepted by consumers and could be a gentle transition towards a more plant-based diet (Caputo et al., 2022; Grasso et al., 2022).

In parallel to the growing interest in sustainability and health, consumers are increasingly interested in which components are used in the food products they consume (Euromonitor International, 2016). Accordingly, another emerging consumer trend is that of "clean label" products. The concept of clean label (CL) does not yet have an official or clear defi-

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https://doi.org/10.1016/j.fufo.2022.100168
Received 4 April 2022; Received in revised form 25 May 2022; Accepted 22 June 2022

nition (Delgado-Pando et al., 2021), however Asioli et al. (2017) suggest two interpretations consumers can use the term: in a broad sense, the consumer expects the product to be "clean" based on prior knowledge beliefs about the category and/or based on visual or textual claims ("natural, organic, free-from") found primarily on the front of the pack. In a strict sense, the consumer looks at the back of the pack and find the product to be clean if the inspects ingredients list is "short, simple, no artificial ingredients, not chemical-sounding and using otherwise familiar ingredients".

This is an issue in particular for PBMA because mimicking the sensory properties of meat is not easy and generally requires the use of food additives, defined as "*…any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food…*" (Regulation (EC) No 1333/2008). For example, in their initial state plant-based protein such as soy and wheat generally have an unappealing beige or yellow color (Kyriakopoulou et al., 2018), and therefore coloring agents (such as soy leghemoglobin) and precursors are commonly added to achieve the characteristics color of meat both before and after cooking (Fraser et al., 2018). Flavor enhancers such as nutritional yeast are often used in enhancing the umami flavor that is characteristics of meat and that is otherwise lacking in plants (Mouritsen and Styrbæk, 2020). Another challenge is in recreating the characteristics texture and "juiciness" in meat product, which is often achieved by using hydrocolloids with gelling, thickening and emulsifying properties (common options found in PBMA include such as carrageenan, xanthan gum, konjac mannan and methylcellulose) (Kumar et al., 2017; Kyriakopoulou et al., 2018).

Even though authorities such the European Food Safety Authority (EFSA) in the EU and Food and Drug Administration (FDA) in the USA provide the food producers with a list of permitted additives and their maximum level of use (Commission Regulation (EU), 2011), the presence of "chemical sounding" names is perceived as risky and undesirable by many consumers, who generally prefer transparency and familiar sounding ingredients (that is, clean label) (Lusk, 2013). The wording of nutritional labeling is important in and of itself. On that note, it is crucial for food producers to take the consumers perception into account when both developing new food products and writing the ingredients list, if they want to meet market success (Delgado-Pando et al., 2021).

Even though PBMA only account for a very limited share of the total meat sale (e.g., 0.7% of total meat sale in the EU and UK in 2019 (Geijer and Gammoudy, 2020)), their market is in rapid expansion (Aschemann-Witzel et al., 2021; Curtain and Grafenauer, 2019) and PBMA have recently gained increasing interest among food producers and researchers (He et al., 2020). While consumers mostly demand that the PBMA are healthy and sustainable, taste and look like meat and are CL, little is known about how consumers inspect the ingredients list and how this affects their perception on the product (Aschemann-Witzel and Peschel Odile, 2019). It is, therefore, interesting to understand how consumers perceive the ingredient list of a PBMA which is an important aspect of consumer choice in e.g. a supermarket, where consumers do not generally have the option of tasting products prior to purchasing them and may be instead driven by other extrinsic elements. With respect to the CL status, the ingredients list may be a particularly relevant aspect at least for consumers who are more interested in naturalness and health aspects of food.

Situated within this context, the main research question addressed in this paper is to investigate the consumers understanding and interpretation of CL of eight different plant-based burger recipes, by inspecting the ingredient list. To investigate what ingredients consumers identify as CL and perceive as healthy and natural, we studied eight different plant-based burger recipes, using the projective mapping approach (Risvik et al., 1994). This method was successfully applied in similarly motivated studies looking at the consumers perception on CL in other plant-based products (Aschemann-Witzel et al., 2019; Noguerol et al., 2021), suggesting that consumers categorize CL ingredients as "known-natural-good".

Furthermore, the same studies show that consumers perceive CL differently based on their dietary status, where flexitarians, vegetarians and vegans weight differently on different aspects of PBMA. We know, for example, that omnivore cares less about natural products and CL status than vegetarians and vegans do (Noguerol et al., 2021), whereas the latter are more about human health and the environmental sustainability (Dinu et al., 2017; He et al., 2020; Helms, 2004; Perignon et al., 2017; Willett et al., 2019). We also know that individual consumers vary in the importance they ascribe to different aspects of food such as healthy, taste, and naturalness in products, and that this variation can be operationalized with instruments like the Health and Taste Attitude Scales (HATS) (Roininen et al., 1999). Therefore, a secondary, more exploratory aim of the paper is to investigate differences in perception of PBMA between segments defined by gender, dietary status and by scores in the HATS subdomains covering health and natural food product interest (Roininen et al., 1999).

2. Materials and methods

2.1. Plant-based burger recipes

The recipes used were based on actual plant-based burger products already on the Danish market as well as on ongoing new product development, with some modifications to vary in dimensions of interest. The recipes were selected based on the following criteria: 1) they should have different main plant ingredients, 2) the length of the ingredients list should vary, and 3) the recipes must include both familiar and less known ingredients, such as food additives. From the first two criteria four initial recipes were chosen based on split pea, quinoa, fava bean and pea (Table 1). Eight final recipes were obtained when developing clean label (CL) and non-clean label (NCL) of each, according to the third criterion (Table 1). To standardize the base appearance and taste, a common set of ingredients – including beetroot juice, salt, onion powder and garlic powder – was present in all eight recipes. Likewise, all NCL included the same additives, namely "natural aroma" and "methylcellulose".

2.2. Participants

Participants ($N = 55$, 25 females and 30 males) were between the age of 19–37 years old (mean age = 26) and were recruited on a voluntary basis among students at the University of Southern Denmark. Written consent for participation was obtained prior to participation. The sample size was defined based on existing recommendations for conducting Projective Mapping (PM) with untrained participants (Vidal et al., 2014) which indicate $N \geq 50$ as a safe and conservative recommendation. Thirty-eight consumers identified as omnivores, 15 as flexitarians and two as vegetarians. The majority (32) reported having consumed plant-based burgers at some point, and 20 of those that they had consumed one or more plant-based burgers within the past 12 months.

2.3. Experimental procedures

PM (Risvik et al., 1994) was applied to study the consumer perception of important, similar and different ingredients in plant-based "beef" burger recipes. Specifically, we used an informed PM method (Varela et al., 2017) where consumers evaluated eight different recipes to plant-based burger. Consumers were asked to read the eight recipes (presented to them as paper print-outs) and position them on a white A2 (approx. 60×40 cm) rectangular paper sheet according to Pagès (2005). The consumers received a short presentation of the PM methodology prior to the actual task (geometric shapes varying in size and color were used to convey the task). The explanation emphasized that they were free to sort the recipes according to their own criteria and that there were no "right" or "wrong" answers. After placing all the recipes printouts on the sheet, participants were instructed to write down (next to

Table 1
Recipes used as stimuli in the projective mapping task. Ingredients that differed between the clean label and not clean label versions of each recipe are italicized.

Name	Clean label	Not clean label
Fava bean	Fava bean, corn flour, rapeseed, soybean, beetroot juice, salt, onion powder, garlic powder. (no. of ingredients: 8) (no. of words: 13)	Fava bean, corn flour, rapeseed, soybean, *natural aroma*, beetroot juice, salt, *methylcellulose*, onion powder, garlic powder. (no. of ingredients: 10) (no. of words: 16)
Quinoa	Quinoa, hemp, fava bean, buckwheat, beetroot juice, salt, onion powder, garlic powder. (no. of ingredients: 8) (no. of words: 12)	Quinoa, hemp, fava bean, buckwheat, *natural aroma*, beetroot juice, salt, *methylcellulose, lecithin*, onion powder, garlic powder. (no. of ingredients: 11) (no. of words: 16)
Pea	Water, pea protein, coconut oil, psyllium husk, caramelized sugar, beetroot juice, carrot concentrate, acerola juice, lemon juice, salt, onion powder, garlic powder. (no. of ingredients: 12) (no. of words: 22)	Water, pea protein, *refined* coconut oil, *wheat gluten, natural aroma, fermented dextrose, methylcellulose*, caramelized sugar, beetroot juice, carrot concentrate, acerola juice, *citric acid*, salt, onion powder, garlic powder. (no. of ingredients: 15) (no. of words: 28)
Split pea	Boiled yellow split peas, boiled kidney beans, mushrooms, potatoes, lupin flakes, psyllium husk, rapeseed oil, beetroot juice, onion powder, chia seeds, fermented onions, garlic powder, salt. (no. of ingredients: 13) (no. of words: 26)	Boiled yellow split peas, boiled kidney beans, mushrooms, potatoes, *modified* pea protein, *natural aroma, refined* rapeseed oil, beetroot juice, onion powder, chia seeds, fermented onions, garlic powder, salt, *methylcellulose, lecithin*. (no. of ingredients: 15) (no. of words: 30)

each recipe) descriptions or explanation of why they mapped the recipes in the chosen way. This described procedure is sometimes referred to as ultra-flash profile, is often combined in combination to PM to aid in the interpretation of the product configurations (Perrin and Pagès, 2009).

After the PM task was completed, consumers answered a short background questionnaire with key demographics (age and gender), dietary status (based on nine questions defining the dietary status of omnivore, flexitarian and vegetarian) (De Backer and Hudders, 2015), frequency of consumption of plant-burgers. Then, the consumers reported their agreement with 14 statements covering health interest (8) and natural product interest (6), selected from the corresponding sections of the HATS (Roininen et al., 1999).

2.4. Data analysis

The position of each recipe on each participant's sheet was recorded by measuring x and y coordinates (in cm) using the bottom left corner as origin of the coordinate system. The descriptors were entered into an excel sheet and similar words was grouped together into one word based on semantic relatedness (the original and final list of words are given in Appendix A). To further improve interpretability, words mentioned fewer than 10 times by the panel as a whole were excluded, providing a total of 40 words (Appendix B).

A Multiple Factor Analysis (MFA) was used to analyze the product placement for all consumers. The MFA was conducted by considering each participant as individual groups of variables, as customary for this type of data (Pagès, 2005) whereas a contingency table containing frequency of occurrence of each word for each product was used as supplementary group. The analysis was performed using the `FactoMineR` package (Lê et al., 2008) in the statistical environment R (R Core Team, 2021).

Cumulative scores, means and standard deviation for health and natural products interest were computed. To uncover possible differences in PM results between consumer segments, Hierarchical Multiple Factor Analysis (HMFA) (Le Dien and Pagès, 2003) was used to compared product spaces obtained by consumers with different dietary status (omnivores vs others) and different level of interest in health and natural product. For dietary status, the comparison considered omnivores vs flexitarians and vegans (the latter were jointly considered due to there being only two vegetarians in our consumer sample). For HATS scores, a median split was used to separate consumers based on their interest in health and natural food (high vs low). Dietary status, health interest and natural interest were then considered as the second level of the hierarchy in their respective HMFA models (the first being again the individual consumers). Differences between partial configurations obtained from participants with different dietary status and HATS score were investigated qualitatively, i.e. by visual inspection, as well as quantitatively by computation of the RV coefficient (Robert and Escoufier, 2008) between the partial configurations considering the first four HMFA dimensions.

3. Results

3.1. Perception and categorization of the burger recipes via projective mapping

The first four dimensions of the MFA model (Fig. 1) on the PM data accounted for over 90% of the variance in the data, showing the existence of clear patterns on the perceptions of the eight recipes.

The first component (Dim 1) explains almost half (48.4%) of the data variance. Dim 1 shows that the difference between a shorter (fava bean and quinoa) and longer (split pea and pea) ingredients list was the main criterion used by consumers to discriminate between the samples, as this dimension separates recipes by the number of ingredients (Fig. 1 and Table 1). This can also clearly be seen by looking at the words that significantly correlate with Dim 1 (Table 2) where the consumers describe the longer recipes as *'more ingredients'* and *'complex'*, and the shorter recipes as *'less ingredients'* and *'simple'*.

The consumers further describe the longer (split pea/pea) recipes as being high in *'protein'*, having a *'high like'*, *'good taste', 'meat like taste', 'juicy', 'appealing'* and a *'good texture'*. However, the consumers also describe the longer recipes as being *'processed'* and *'less healthy'*. By contrast, the shorter (fava bean/quinoa) recipes are described as being *'dry', 'less juicy'* and having *'low like', 'dull taste'* and *'no meat taste'*. Dimension 1, therefore, also captures expectations about liking, and shows that consumers expect longer recipes to taste better, but also to be more processed and less healthy.

The second and third component (Dim 2, Dim 3) (Fig. 1) explain 20.1% and 13.4% of the variance of the data, respectively. Compared to Dim 1, it is less clear from the recipes and the correlating descriptors (Table 2), what those two dimensions explains but they are tentatively related to specific ingredients. For Dim 2, from the recipes we can see that a common denominator for the fava bean/split pea is rape-

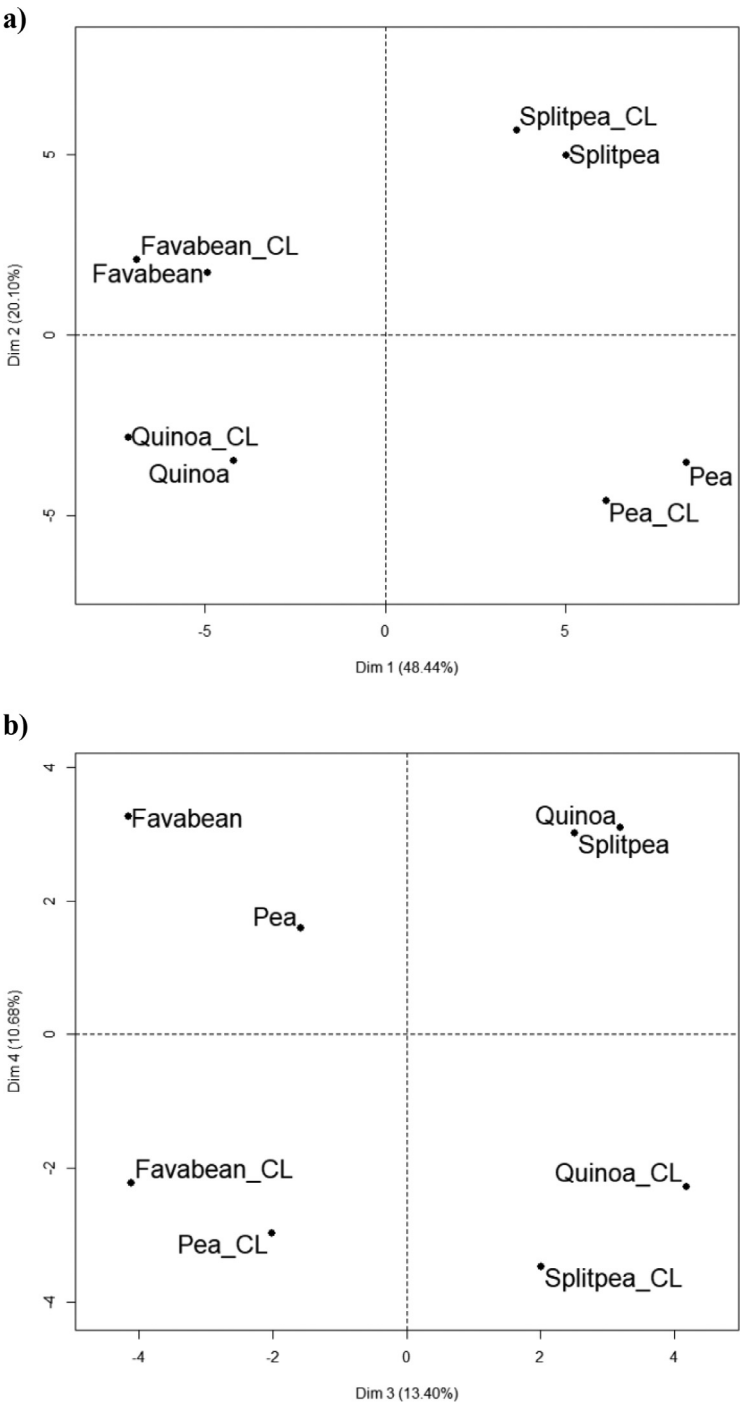

Fig. 1. Product factor map showing the coordinates of each recipe on the first four MFA dimensions. Figure 1a shows dimension 1 vs dimensions 2, and figure 1b show dimension 3 vs dimensions 4. (CL = Clean Label).

seeds and otherwise familiar vegetables names. This is confirmed by the fact that this dimension is highly correlated with the word *'vegetables'* (Fig. 1), which is significantly (p<0.001) correlated (0.92) with these two recipes. No further words were correlated to Dim 2.

With respect to Dim 3 (Fig. 1), from Table 1 we can see a common denominator for the quinoa/split pea is lecithin. Further, even though we find no significant correlations words with Dimension 3, quinoa/split pea are in fact described as *'healthy'*, twice as often than pea/fava bean (Appendix B).

The fourth component (Dim 4) explains 10% of the data variance, and shows a clear difference between the CL and NCL recipes (Fig. 1). This is further validated by the significantly correlating words of Dim 4 (Table 2). The consumers described the CL recipes as *'natural', 'less processed'* and *'known ingredients'*, whereas the NCL recipes are described as *'additives', 'not natural', 'unfamiliar ingredients',* and *'natural aroma'*.

3.2. Differences between consumer segments

Table 3 reports descriptive statistics pertaining to the HATS score for healthy food and natural product interest, and also compares results across dietary groups. Based on the cumulative score, those two food interests are only moderately correlated (Pearson's $r = 0.47$, $p < 0.001$).

Based on the cumulative score (Table 3), we see a tendency ($p = 0.088$) for vegetarians and flexitarians consumers to care more about the healthy food products than omnivores; furthermore, vegetarians and flexitarians significantly (p<0.001) score higher in interest for

Table 2
Correlation (Pearson's r) and associated p-value of the consumer determined descriptors for the four dimension of the MFA model. For brevity, only correlations that are significant or approaching significance $p < 0.1$ are reported (for the full list, see Appendix C).

	Negative correlations			Positive correlations		
MFA Dimension	Descriptor	*r*	*p*	Descriptor	*r*	*p*
Dimension 1 ('short vs *long ingredient lists')*	Cereals	−0.95	<0.001	Protein	0.94	<0.001
	Dry	−0.95	<0.001	Complex	0.94	0.001
	Simple	−0.94	0.001	Pea	0.94	0.001
	Dull taste	−0.93	0.001	Good taste	0.93	0.001
	Beans	−0.89	0.003	More ingredients	0.92	0.001
	Low like	−0.83	0.011	Less healthy	0.91	0.002
	Less juicy	−0.75	0.032	High like	0.87	0.004
	Less ingredients	−0.73	0.042	Juicy	0.82	0.013
	No meat taste	−0.70	0.054	Appealing	0.82	0.013
	Fiber	−0.68	0.062	Acidic	0.78	0.023
	Salt	−0.63	0.097	Meat like taste	0.77	0.026
				Good texture	0.76	0.028
				Processed	0.75	0.033
				Refined oil	0.71	0.047
				Natural oil	0.70	0.053
				Sweet	0.69	0.059
Dimension 2 ('Quinoa / Pea vs. *Fava bean / Split pea')*	Sweet	−0.64	0.090	Vegetables	0.92	0.001
	Fiber	−0.63	0.093	Firm texture	0.69	0.057
Dimension 3 ('Fava bean / Pea vs. *Quinoa /Split pea')*				Quinoa	0.67	0.070
				No meat taste	0.64	0.086
Dimension 4 ('Clean label vs. *Non clean label')*	Less processed	−0.92	0.001	Additives	0.96	<0.001
	Natural	−0.89	0.003	Not natural	0.92	0.001
	Known ingredients	−0.75	0.032	Unfamiliar ingredients	0.85	0.007
	Pink color	−0.73	0.041	Natural aroma	0.84	0.010

Table 3
Healthy food and natural food interest means, standard deviation (SD) and p-values from *t*-test, for difference between omnivore and flexitarians & vegetarians.

		All consumers ($n = 55$)		Omnivore ($n = 38$)		Vegetarians &Flexitarians ($n = 17$)		
		mean	(SD)	mean	(SD)	mean	(SD)	p-value
Healthy food products								
Cumulative score		33.6	(8.5)	32.3	(8.5)	36.6	(7.7)	0.088
Q1	I am very particular about the healthiness of food	5.2	(1.2)	5.1	(1.3)	5.5	(1.1)	0.195
Q2	I always follow a healthy and balanced diet	4.2	(1.6)	4.2	(1.5)	4.4	(1.7)	0.667
Q3	It is important for me that my diet is low in fat	3.7	(1.4)	3.7	(1.4)	3.5	(1.4)	0.666
Q4	It is important for me that my daily diet contains a lot of vitamins and minerals.	4.9	(1.4)	4.8	(1.4)	5.2	(1.3)	0.279
Q5*	I eat what I like, and I do not worry about healthiness of food	4.0	(1.7)	3.7	(1.7)	4.5	(1.6)	0.099
Q6*	I do not avoid any foods, even if they may raise my cholesterol	3.2	(1.4)	2.9	(1.2)	3.8	(1.5)	**0.018**
Q7*	The healthiness of food has little impact on my food choices	4.5	(1.5)	4.3	(1.5)	4.9	(1.5)	0.162
Q8*	The healthiness of snacks makes no difference to me	4.0	(1.6)	3.7	(1.5)	4.6	(1.7)	**0.050**
Natural food products								
Cumulative score		23.8	(6.4)	21.9	(7.7)	28.1	(5.8)	**<0.001**
Q9*	I do not care about additives in my daily diet	4.5	(1.6)	4.1	(1.6)	5.5	(1.3)	**0.002**
Q10*	In my opinion, organically grown foods are no better for my health than those grown conventionally	4.2	(1.6)	3.9	(1.6)	5.0	(1.2)	**0.015**
Q11*	In my opinion, artificially flavored foods are not harmful for my health	4.4	(1.2)	4.4	(1.1)	4.4	(1.4)	0.962
Q12	I try to eat foods that do not contain additives	4.1	(1.5)	3.8	(1.4)	4.9	(1.3)	**0.007**
Q13	I would like to eat only organically grown vegetables	3.5	(1.9)	2.8	(1.6)	5.0	(1.4)	**<0.001**
Q14	I do not eat processed foods, because I do not know what they contain	3.1	(1.4)	3.0	(1.3)	3.2	(1.5)	0.566

All items are from HATS (Roininen et al., 1999) and were measured on 7-point Likert scales where 1 ="*strongly disagree*", 4 ="*neither agree nor disagree*" and 7 = "*strongly agree*".

* Indicates reversed items.

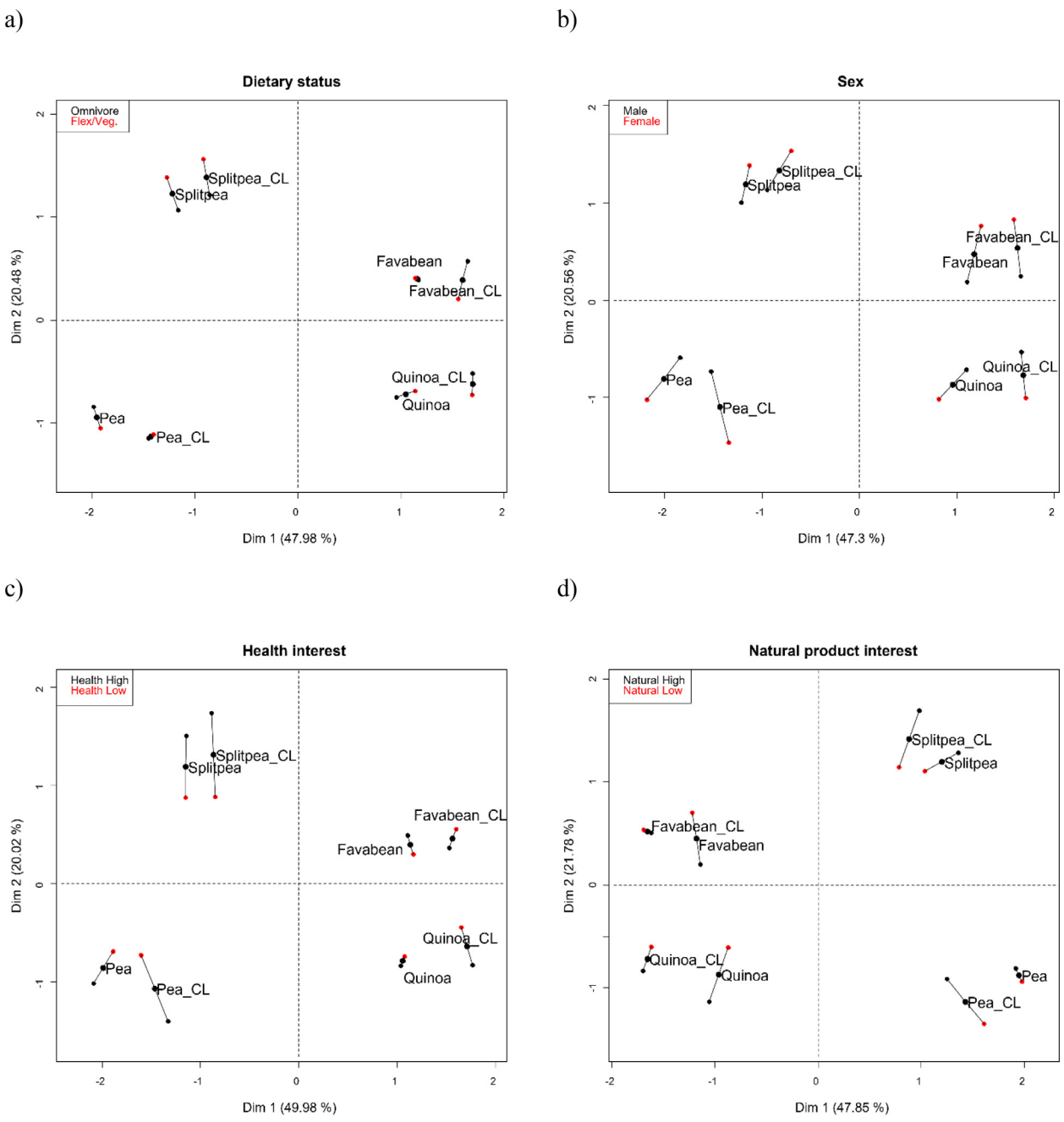

Fig. 2. HMFA models (first vs. second dimension) showing the consensus sample space with superimposed representation of the partial points obtained by different groups defined by dietary status (a), sex (b), health interest (c) and natural food products interest (d).

natural food products than omnivores. Vegetarians and flexitarians are significantly more aware of the healthiness of the snack they eat (Q8) and this further extend to avoiding cholesterol in food (Q6). Vegetarians and flexitarians are significantly more concerned about the additives in food and try to avoid them (Q9, Q12) and they also significantly think that organic food is better and would like to eat more (Q10, Q13).

From healthy food interest, we classified, based on a median split, that 27 of the 55 consumers as having high interest in healthy food. This group included more female than male, and more vegetarians and flexitarians have than omnivore (Appendix D).

For natural food product interest, we found, again based on the median of total score, that 23 of the 55 consumers have high interest in natural food. Most of the vegetarians and flexitarians have interest in natural products above the median, whereas only a third of the omnivore was classified in this group (Appendix D).

With respect to the differences in the PM results, visual inspection of the HMFA analysis shows that, although some differences are noticeable, the partial points of both the gender, dietary status, and healthy and natural food interest (Fig. 2) the partial points are close to the consensus point, in particular regarding the product positions in the first HMFA dimension (Fig. 2 shows the first two dimension for each model. Dimensions 3 and 4 are shown in Appendix E). Therefore, overall, consumers with different gender, dietary status and health and natural product interest perceived the PB burger recipes similarly. This was further confirmed from the calculation of the RV coefficients between the partial configurations obtained from the two groups in both the dietary status, gender and both food interest. This result shows that neither the

consumer gender (male vs female: RV 0.96, $p < 0.001$), dietary status (Omnivore vs flexitarian/vegetarian: RV = 0.95, $p < 0.001$) nor their food interest (Health interest high vs. low: RV = 0.96, $p < 0.001$ and Natural high vs. low: RV = 0.97, $p < 0.001$) affected how the consumers perceive the relative differences and similarities between the recipes (the RV coefficients here reported refer to coordinates on four HMFA model dimensions; for separate comparisons based on specific components, see Appendix F).

4. Discussion

The main aim of this paper was to investigate the consumers understanding and interpretation of the 'clean label' status of eight different plant-based burgers recipes – varying in length, CL status and ingredients – by using the projective mapping approach.

Taken collectively, the results show that length of the recipe was the most important factor consumers considered when sorting the eight recipes based on perceived differences and similarities. Variation in ingredients list length alone explained almost half of the variance in the PM data. A short ingredients list is suggested to be perceived, by consumers, to be a CL product (Asioli et al., 2017; Ingredion, 2014). In this study, the consumers did find the length of the ingredient list a very important indicator, however they also told us that this is a separate aspect from CL status (i.e. presence of chemical additives). The PM data also showed significant interactions between our experimental design (recipe length and CL status) and specific product aspects of ingredients. For example, the word *'protein'* is the highest correlating word to the longer (split pea/pea) recipes, though this is most likely not related to length but rather to the fact that pea protein is mentioned as the second ingredient in the split pea recipe, and is also mentioned in the NCL version of the pea recipe.

Another noteworthy finding was that the first MFA dimension indicated a perceived trade-off between taste and health, based on the length of the ingredient list, with the shorter recipes described by the consumers as having *low like, dull taste* and *no meat taste* and the longer recipes to have *high like, good taste, meat like taste*. That the consumers also finds the longer recipes as *less healthy* and *processed* comes as no surprise, as the label "free-from" on a food product is considered as a more healthy product (Hartmann et al., 2018), and "free-from" is used as CL indicator (Asioli et al., 2017).

Clean label status "strictly defined", i.e. as presence of food additives, was relatively less important (10% of explained variance in the data) although it was also clearly attended to by consumers, who found clear difference between CL and NCL recipes in Dim 4. The consumers described the CL as *natural, less processed* and *known ingredients*, whereas the NCL recipes is described as *additives, not natural, unfamiliar ingredients,* and *natural aroma*. Those descriptions are in agreement with current literature describing CL products (Asioli et al., 2017; Ingredion, 2014; Song and Schwarz, 2009). Aschemann-Witzel et al. (2019) further described the CL products as "known-natural-good" and NCL as the opposite. No hedonic words (e.g., "good" or "bad") were correlated with the CL and NCL recipes in our study. Instead, consumers taste expectations were mostly related to specific ingredients and length of ingredients (as mentioned earlier, recipes with longer ingredients list were perceived as less healthy but more tasty). These results are consistent with "natural flavors" being generally accepted by consumers in Europe despite the ambiguous meaning (Ingredion, 2014), and in general consumers prefer "natural" additives compared to synthetic additives (Carocho et al., 2014, 2015). Further, consumers perceive additives with difficult pronunciation names as more harmful than additives with more easy names (Song and Schwarz, 2009). The consumers' descriptions of the longer and non CL recipes are consistent with the literature indicating that many consumers do not see PBMA as healthy, because they perceive them as being highly processed (Varela et al., 2022). Further, many consumers do not consider a plant-based diet to be as nutritionally balanced as one including meat. Consumers may fear that PBMA lack essential nutrients (Corrin and Papadopoulos, 2017), and many consumers think that they will suffer protein deficiency if the substitute meat (Weinrich, 2019).

Overall, based on the semantic description of the MFA dimensions, both recipe length and the presence of additives contributed to consumer perception of clean label in plant-based burgers, although looking at the explained variance, the former appeared to be a much bigger contributor. One important caveat to this pertains to the PM methodology, in which it was arguably easier for consumers to focus on length first since that does not require an in depth-processing of the recipes. In this sense, the results strictly speaking indicate that recipe length was more important for consumers' discrimination of the sample, and not necessarily the biggest contributor to the perception of clean label status. Still, stimuli formats used in this study were ecologically valid (i.e., they reflect the way recipes would be reported in actual PBMA) so the important point is that consumers are much more likely to attend to overall recipe length than to process it in depth. Relatedly, while perception of "naturalness" and "familiarity" pertained to both recipe length and presence of additives, consumers descriptions of health and taste and expectations were instead mostly or only related to recipe length.

The study also provided some interesting findings pertaining to the perception of specific ingredients. For instance, fava bean and quinoa recipes containing no oil were describes as being *dry* and *less juicy,* whereas the split pea and pea recipes containing oil were describes as being *juicy*. Improving texture and juiciness in PBMA traiditionally require the use of hydrocolloids as binding agents to maintain the water holding capacity, emulsification properties (Kumar et al., 2017; Kyriakopoulou et al., 2018). Future PBMA producers might need to investigate clean ingredients that solves the same challenges as hydrocolloids do, in order to satisfy the consumers' demand for clean PBMA. For example, using ingredients such as legumes (e.g. chickpea, pea, lentil, lupine) which are not only important as a protein source but are also known for their functional properties, such as emulsification, foam stabilization, and gel formation (Kyriakopoulou et al., 2018). The use of simple and familiar ingredients will also increase the authenticity in the food product (de Boer and Aiking, 2019; Lonkila and Kaljonen, 2022).

The secondary aim of the paper was to investigate differences in perception between segments defined by gender, dietary status and by the HATS questions regarding health and natural food product interest. From the HMFA we found no significant differences in consumer overall perception of the PB burger recipes between neither the dietary status nor the food interest. This suggests that product-related aspects – such as specific plant ingredients, the length of the ingredients list and the clean label status – are more important than individual differences. It should be noted that our study used relatively different products and thus it is possible that differences between consumer segments may emerge when controlling for e.g. plant-based sources.

Regarding HATS, few studies investigated those two interests in the same papers, however they do find the same general tendency as we do (Caracciolo et al., 2019; Niva and Vainio, 2021). Consumer attitudes towards natural food have been studied comprehensively, and the majority of consumers, in developed countries, finds the natural in food product important (Román et al., 2017). From the cumulative score of healthy food interest, we found no significant difference between dietary groups, although there was tendency for vegetarians and flexitarian to care about health more than omnivores which is consistent with previous studies (Noguerol et al., 2021), and this effect could have likely become significant with a larger sample size of vegetarian participants. Further we found that vegetarians and flexitarian significant cares more about natural food products than omnivore, this is also consistent other studies (Noguerol et al., 2021).

4.1. Limitations and future research

We should acknowledge some important limitations of this study that could productively be addressed in future research. First, this study only

included Danish consumers and therefore results may not readily generalize to other cultures, particularly with non-western countries where plant-based diets may be more common. Likewise, it only focused on one PBMA (burgers), so future studies might explore whether similar results can be replicated in other PBMA categories such as e.g., plant-based sausages, nuggets, meatballs and steaks.

Furthermore, with respect to the secondary aim, we found no or very minor differences between our four different segments. As mentioned 50+ consumers is a safe and conservative recommendation when using PM (Vidal et al., 2014) but this recommendation pertains to results at the aggregate level and also depends on the product differences, where the more similar the products, the larger N of consumers amount is reccomended. In this study, the PBMA recipes were clearly different and therefore we can be reasonably confident that the sample size was sufficient to yield robust findings at the aggregate level. As mentioned in the introduction this second aim was of a more exploratory nature, but a greater focus on segmentation, and using a larger and more balanced consumers group, would be advantageous in future studies. Particularly differences between omnivores, flexitarians and vegans should be explored as we believe that with a greater sample size, and in particular a larger number of vegetarian we might have seen further differences based on results from other studies (Noguerol et al., 2021). We also limited ourselves to four aspects (gender, dietary status, health and natural food interest), but there are other influencing factors that may affect consumer perception of clean label PBMA, such as food neophobia, or attitudes towards food technology and processing in food products.

Finally, while in this study we have focused on CL status in PBMA, this will necessarily interact with other aspects – such as nutritional facts, sensory aspects (e.g., appearance, taste, texture), perceived sustainability, and authenticity – to determine the global consumer perception. Future studies are needed to further to unravel the ranking and relative importance of these aspects. What aspect are the consumer most willing to forgo, both in a purchase and when consuming the product. Future research need to look at novel ingredients and processing and manufacturing methods to ensure a PBMA compatible with consumer demands. Also, we do not really know which (how many) consumers want a meat-alternative to substitute the meat in a meal and which are looking for an alternative that is not necessarily meat-like, but rather a novel plant-protein-based meal (de Boer and Aiking, 2019; Lonkila and Kaljonen, 2022). Future studies, therefore, also need to unravel whether the consumers want a convenient PBMA or something authentic, using familiar and CL ingredients (Aschemann-Witzel et al., 2019).

5. Conclusions

Situated within the context of growing interest in clean label plant-based meat alternative, this study investigated consumer perception of ingredients' lists in different plant-based "beef" burger products via projective mapping. Generally, consumers showed good agreement on the perception of the eight recipes, with little of evidence of segmentation related to individual characteristics.

The length of the ingredients list, together with the main ingredients was the primary aspect that caught the attention of the consumers, explaining nearly half of the variance in the PM data. Accordingly, the first dimension of the MFA from PM data separated longer recipes – described as more complex, processed, unhealthy but also tasty – from shorter recipes – which were perceived as simpler and healthier, but less meat-like. Furthermore, a smaller part of the data (10%) was explained by the presence of chemical additives. The consumers described the CL recipes as *natural, less processed* and *known ingredients*, whereas the NCL recipes were described as *additives, not natural, unfamiliar ingredients,* and *natural aroma*.

Overall, this shows that the length and simplicity of the ingredient list is more important for consumer perception of clean label status in PBMA than the presence of chemical additives per se, although both inform consumer understanding of CL status.

Declaration of Competing Interests

All authors declare that they have no known competing financial or personal interest that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Christina J. Birke Rune: Conceptualization, Methodology, Visualization, Investigation, Data curation, Formal analysis, Writing – original draft. **Qiushuang Song:** Investigation, Data curation. **Mathias P. Clausen:** Methodology, Funding acquisition, Writing – review & editing. **Davide Giacalone:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Ethical statement

Ethical approval was not sought for the present study because the study did not present any risks to participants nor did it deal with sensitive topics. Written informed consent was obtained by each participant prior to beginning the study. The study was fully anonymous and no identifying information was collected from participants.

Acknowledgments

Financial support for this work was provided by the program "SMV: Food Innovation" funded by Syddansk Vækstforum and the EU Regional development Fund.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2022.100168.

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