

CONSUMER-LED DEVELOPMENT OF NOVEL SEA-BUCKTHORN BASED BEVERAGES

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ABSTRACT

In the context of a growing interest toward foods of local origin, this research explored consumer perceptions of novel sea-buckthorn-based beverages (SBBs), developed by combining sea-buckthorn (*hippophae rhamnoides* L.) berries in combination with other locally sourced ingredients.

Specifically, the aims of the present study were to test how newly developed SBBs were perceived compared to a selected market reference, and to determine their acceptability with a representative sample of the Danish consumer population. Using a combination of consumer-friendly product profiling methods, we investigated which product attributes were associated with different ingredient combinations. Promising prototypes were tested in a larger study where consumers ($N = 200$) reported hedonic response and appropriateness of use for the SBBs. Results showed that the developed SBBs were generally well liked, but were perceived as appropriate for fewer usages than the existing ones, suggesting that consumers may find it hard to envisage how to incorporate novel SBBs in their existing dietary habits. Consumer demographics and psychographics did not significantly affect product acceptance, indicating that sensory characteristics were the most important drivers of consumer preferences within this product category.

PRACTICAL APPLICATIONS

This study offers new insights into consumers' perception of novel food products of local origin. A key issue with such ingredients is that they have unique sensory properties which are unfamiliar to many consumers. We suggest evidence-based directions for product development and identify potential barriers to adoption that food producers should be aware of. Methodologically, this study shows a stepwise approach to consumer-driven product development that effectively differentiated between the products and identified most promising prototypes, and could, therefore, be beneficially applied to support product development efforts among small and medium-sized local producers.

INTRODUCTION

Acceptance of Novel Food and Beverages

New product development is necessary for survival in today's competitive global market, and consumer orientation in the development process is increasingly important. This truism is particularly relevant in the food and beverage industry where more than 90% of all new developed prod-

ucts are withdrawn within 1 year from launch (Lesschaeye and Bruwer 2010). There are at least three major reasons behind this high failure rate. An important one is the use of inadequate criteria for evaluating the likelihood of future market success, stressing the need to incorporate the "voice of the consumer" in early stages of the development process to ensure that products caters to the tastes of the intended consumer segment (Van Trijp and Van Kleef 2008).

Particularly for small scale producers, who often have limited or no resources for formal product tests, rapid sensory methods (Varela and Ares 2012) represent a useful tool to understand how different formulations affect sensory characteristics, and to use these insights to reach an informed go/no-go decision when time and/or resources are limited.

Further, there is an insufficient understanding of the theoretical basis for consumers' acceptance of food and beverage innovations. Recent research on flavor preferences has suggested that successful new foods and beverages must include novel elements but not deviate too much from consumers' expectations (Giacalone *et al.* 2014). Lack of an appropriate level of novelty in products will either cause product boredom, if the product is too similar to existing products, or be rejected as unpleasant because of deviating too much of what is typical for that product category (Van Trijp and Van Kleef 2008; Giacalone *et al.* 2014). This understanding was informed by early research in perception psychology describing sensory preferences as a function of a stimulus' "arousal potential," i.e., the degree to which they can stimulate and engage an individual (Berlyne 1967, 1970; Lévy *et al.* 2006; Van Trijp and Van Kleef 2008). According to Berlyne (1967), the arousal potential of a stimulus is determined by its collative properties, such as novelty, complexity and typicality. The relationship between arousal and hedonic response takes the shape of an inverted "U," reaching an optimum at a certain level of arousal potential. Originally applied to the visual domain (Hekkert *et al.* 2003), recent research indicated that this theory has predictive validity also with regards to flavor acceptance (Giacalone *et al.* 2014). The implication from a product development perspective is that, in order to create a successful new food or beverage, the product developer should strike a balance between novelty and typicality in trying to be as innovative as possible while preserving, as much as possible, some flavor elements that are recognizable to the consumers.

A third reason that might explain the high failure of food product innovation is insufficient knowledge of the target segment and of potential barriers to product adoption. For instance the food neophobia trait – a consumer's stable propensity to approach or avoid novel foods (Pliner and Hobden 1992) – is thought to influence consumers' willingness to accept food and beverage innovations (Tuorila *et al.* 1994; Henriques *et al.* 2009).

Finally, it is increasingly recognized that preference ratings (judgement of product liking/disliking) obtained in laboratory assessments are a relatively poor predictor of real consumer choices, and food testing by consumers in naturalistic conditions is considered to be more ecologically valid (Giacalone *et al.* 2013; Di Monaco *et al.* 2014). Furthermore, product development efforts should take into account not only how well a product is liked, but also whether it is appropriate for the specific real-life situation it is intended

for. A simple approach to take this aspect into account is the item-by-use (IBU) appropriateness method proposed by Schutz ((1994), in which consumers evaluate products and usage situations simultaneously, essentially being asked how well a product would fit each of the given usage situations. In product development, such data can assist in early screening, tailoring products for better market positioning, and/or improved targeting to specific consumer segments (Cardello and Schutz 1996).

Aims of the Present Study

As a backlash of the globalization of the food supply chain, an increasing interest in foods of local origin has been observed (Stolzenbach *et al.* 2011), fueling a growing demand for authentic, differentiated and value added food products of local origin. A regional example is the interest in "New Nordic" food (Nordic Council of Ministers 2014) which has been in full swing for some time now in Scandinavia, and has fueled significant business innovation and product development among local and regional food producers.

The New Nordic trend provides a relevant avenue for studying consumers' adoption of very novel products. Indeed, a key issue observed with many Nordic ingredients is that they have unique sensory properties that are unfamiliar to many consumers.

As a relevant case-study, we will focus on Sea-buckthorn (*hippophae rhamnoides L.*), a Nordic ingredient that has recently sparked significant interest. The juice obtained from its berries provides a nutritious beverage ingredient, high in suspended solids, vitamin C and carotenes (Beveridge *et al.* 1999). However, pure sea-buckthorn juice (average pH 3.13, Beveridge *et al.* 1999) is characterized by high acidity and astringency, sensations that need to be balanced, from a sensory point of view, to reach likeable products.

Situated within this context, this study investigated sensory properties and consumer perceptions of a range of sea-buckthorn based beverages (SBBs), with the aim of identifying recommendations for product development within this product category. To this end, a series of new SBBs were developed by combining sea-buckthorn juice with honey and/or other local fruit and vegetables characterized by higher sweetness and lower acidity, following the suggestion by Katoch *et al.* (2006). Using a combination of rapid sensory methods, we investigated which sensory characteristics were associated with these beverages. Large-scale hedonic and sensory testing was conducted with a representative consumer sample, in order to assess the acceptability of the developed formulations, and identify directions for further optimizations. Consumers' demographic and attitudinal data (e.g., appropriateness for use, previous experience with sea-buckthorn products) were also collected to get a better understanding of this market segment.

TABLE 1. INGREDIENT COMPOSITION OF THE SBBs DEVELOPED IN THE STUDY AS WELL AS THE REFERENCE BEVERAGE (“E”, EXISTING SBBs; “N”, NOVEL SBBs; “R”, REFERENCE BEVERAGE). PERCENTAGES INDICATE GRAMS PER 100 g

Ingredient	Novel SBBs						Existing SBBs			
	N_rosehip	N_fennel	N_pear	N_aronia	N_beetroot	N_redcurrant	E_pure	E_applejuice	E_orangejuice	R_omegn ^a
Sea-buckthorn	30%	53%	33%	26%	25%	29%	66%	11%	11%	17%
Pear			50%		59%	54%				
Apple				53%						
Honey	15% ^b	20% ^b								
Aronia				8%						
Beetroot					4%					
Redcurrant						2%				
Rosehip	20%									
Fennel		0.5% ^c								
Apple juice								83%		
Orange juice									83%	
Water	15% ^d	27% ^d	17% ^d	13% ^d	12% ^d	15% ^d	34% ^d	6% ^d	6% ^d	83%

^a “R_omegn” is a reference market product containing sea-buckthorn puree, sucrose, water, apple juice and citric acid in unspecified amounts.

^b The honey was melted in a pot to obtain low viscosity before it was mixed with the extracted fruit juice and nectar.

^c Simmering for 3 min at 42°C.

^d Approximately 1/3 of water was added to the sea buckthorn and aronia berries and 1/2 part water to the rosehip to be capable of blending them in the production process.

MATERIALS AND METHODS

Samples

In total 10 SBBs were included in this study; six “novel” SBBs, three “existing” SBBs and one market reference beverage (Table 1). The novel SBBs were developed as combinations of sea-buckthorn with other locally sourced ingredients: pear, apple, *aronia* (chokeberry), beetroot, redcurrant, rosehip, fennel and honey. One of the existing SBBs *E_pure* was made with only pure sea-buckthorn nectar; *E_applejuice* and *E_orangejuice* were produced with sea-buckthorn nectar and an addition of either apple or orange fruit juice made from concentrate. The reference beverage (*R_omegn*) was a concentrated sea-buckthorn puree (a squash) which is sold in bottles at the shop “Omegn” in Copenhagen, and was included in the study as the closest commercial alternative to the developed SBBs.

The sea-buckthorn berries were harvested near Fjaltring (Denmark), stored at −18°C, then thawed up and washed with heated water (40–45°C). The hand blending was lightened with an addition of 1/3 water. The *existing SBBs* were extracted using a manual fruit press whereas an electronic juicer with a centrifugation system was used for the *novel SBBs*. Then, the nectar was heated up in a pot using the method of HTST at 86 ± 2°C for 25–30 s. Then the pot was put in a water bath (10°C) to cool down the nectar to 25–30°C. Finally, the nectar was filtered through a dish towel in a metal strain, to reduce the solids and oil from the berries.

Experimental Design

The present research employed a four-steps approach (Fig. 1) that included (1) a tasting and discussion session with sensory professionals, (2) a pilot sensory evaluation using an expert sensory panel, (3) a second pilot evaluation using a consumer panel, and (4) a large-scale consumer test focusing on the most promising prototypes.

The first step (tasting and discussion session) was conducted to get “qualitative” feedbacks from sensory professionals ($N = 3$) about the developed SBBs, in order to make sure that the developed beverages were well-tasting and balanced from a sensory point of view. Three sessions were arranged to taste the novel SBBs, with discussions focusing on relevant sensory attributes for each beverage. Feedbacks were obtained regarding whether an ingredient should be included or excluded, or changed in amount.

Pilot Tests: Napping with Experts and Consumers

Following the experts’ feedback, two pilot tests were conducted in order to document the sensory characteristics of the developed SBBs, and to screen out samples with too similar sensory characteristics.

The first pilot test was conducted with a trained sensory panel ($N = 12$) which evaluated SBBs using the projective mapping approach known as Napping (Pagès 2005), a fast profiling method that requiring assessors to describe inter-samples differences as distances in a bidimensional space. When the assessors had individually reached final

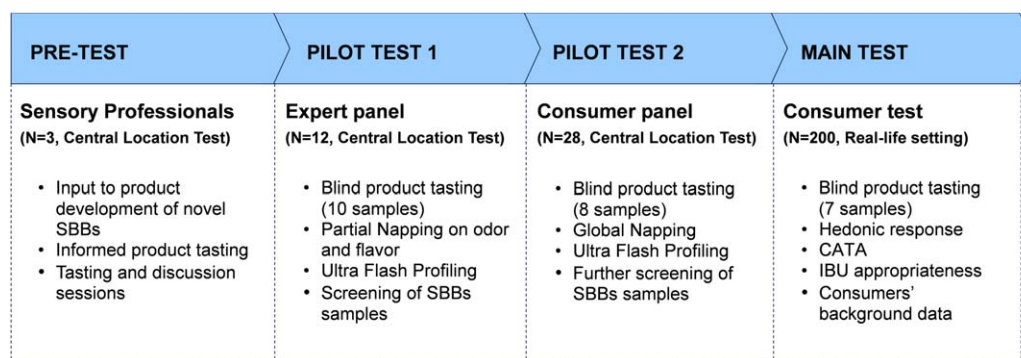


FIG. 1. SCHEMATIC ILLUSTRATION OF THE STEPWISE EXPERIMENTAL DESIGN ADOPTED IN THIS STUDY

configurations, they were instructed to write down up to three sensory attributes for each sample, a task known as Ultra-Flash Profile (UFP, Perrin and Pagès 2009). This verbalization task served both for interpreting the product space and for informing the design of the ballot for the main consumer test. Two Napping evaluations were performed by the assessors, one focusing on odor differences, and one focusing on flavor.

To increase the external validity, a second pilot test was performed with a panel of consumers ($N = 28$). Like the trained assessors, consumers evaluated the SBBs using the Napping approach, although this time they were free to choose their own criteria, and wrote down any attribute they associated with each sample. Finally, consumers were asked to write down in which situations they would imagine consuming the samples they had just tested, and also which situations they most frequently consume fruit juices in general.

Main Test

Seven SBBs from the initial 10 were included in the main study (three had been eliminated as redundant following the two Napping tests). The purpose of the main test was to determine the acceptability of the SBBs sample set with a representative sample of the Danish consumer population.

The test was conducted over three consecutive days in the popular food market “Torvehallerne” (<http://torvehallernekbh.dk/>) in Copenhagen, Denmark. Such location was chosen, among others, because it focuses on product diversity and local foods, thus constituting a natural venue for consumers who are interested in Nordic ingredients. In-store free trials are a staple of this location, so our product test fitted easily with the environment.

A convenience sample of consumers, essentially by-passers, took part in the study on a voluntary basis. A total of 200 consumers took part in this test. Their background characteristics are shown in Table 2.

Upon accepting to participate, each consumer was served the seven SBB samples on a tray. Each sample consisted of

3cl juice, served in semitransparent plastic cups at a temperature of approximately 6°C, blind labeled with a three digit code. The consumers were told to taste the SBBs monadically in the order predefined on the tray. The serving order was randomized between participants to minimize first-order and carry-over effects. Crackers and water were provided for rinsing of the palate between the samples. For each sample, consumers evaluated their degree of liking using a 9-point hedonic scale (1 = Dislike extremely, 9 = Like extremely), and completed a check-all-that-apply (CATA) question comprising 24 sensory and conceptual attributes, identified on the basis of the description obtained during the Napping tests with expert and consumers. This question format was chosen because it is easier and more intuitive for consumers, and because it has a low likelihood of biasing hedonic scores (Jaeger *et al.* 2013). The attributes included in the ballot were: *Artificial, Balanced, Bitter, Citrus, Complex, Cosy, Exclusive, Familiar, Fruity, Green, Mild, Novel,*

TABLE 2. BACKGROUND CHARACTERISTICS OF THE CONSUMER SAMPLE PARTICIPATING IN THE MAIN TEST ($N = 200$)

Background variable	%
Gender	
Men	23
Women	77
Age in years	
18–35	44
36–55	24
56+	32
Fruit juice consumption frequency	
Low (Once or Twice a year or less)	8
Medium (Once or twice a month or less)	50
High (Once a week or more)	42
Food neophobia score (FNS)	
Neophilic ($FNS \leq 23$)	30
Neutral ($23 < FNS < 36$)	47
Neophobic ($FNS \geq 36$)	23
Have tasted sea-buckthorn before	
Yes	68
No	32

Powerful, Prickly, Refreshing, Simple, Soil, Sour, Summery, Sweet, Traditional, Typical Danish, Unique and Watery. The order in which the CATA attributes appeared in the ballot was randomized between consumers to reduce response biases associated with the attribute position (Ares and Jaeger 2013). In a separate CATA question, consumers were asked to indicate IBU appropriateness for eight use situations – *At a café or restaurant, Between meals, For breakfast/brunch, For self-indulgence, For special occasions, In cocktails, When craving for something delicious and When exercising* – chosen on the basis of consumers' responses in the second pilot test.

After having evaluated all the samples, consumers were asked to fill out a short series of questions regarding their demographics (age, gender) and relevant usage patterns (frequency of fruit juice consumption, whether they had tasted sea-buckthorn before, and if yes in which form). Finally, the consumers filled out the Food Neophobia questionnaire (Pliner and Hobden 1992), consisting of 10 Likert item evaluated using a 7-point scale (1 = disagree strongly, 7 = agree strongly), using the adapted version by Reverdy and colleagues (2008).¹ As in Pliner *et al.* (1995), consumers with a cumulative score equal or smaller than 23 were categorized as food neophilics, those with score between 24 and 35 were categorized as neutral with respect to food neophobia, and those with a total score equal to or greater than 36 were considered food neophobics. Consumers spanned a significant range in terms of neophobia (Range: 10–53; Mean: 29.7, St. Dev.: 8.8). The percentage of consumers in each group is reported in Table 2.

Data Analysis

Analyses Pertaining to the Pilot Tests. For the Napping tests, sample positions were measured using a coordinate system with origin in the lower left corner. Frequency of mentions for each UFP attribute was computed and rendered into a contingency table (samples by attributes). In order to improve interpretability, attributes having hedonic value and/or attributes mentioned less than five times were eliminated (Giacalone *et al.* 2013), and attributes that were semantically close were aggregated.

The data from PN and GN were analyzed using Multiple Factor Analyses (MFA), using individual assessors' coordinates and the UFP contingency table as groups of variables (Pagès 2005, Perrin and Pagès 2009).

Analysis Pertaining to the Main Test. A mix of univariate and multivariate analysis was adopted to explore consumer preferences for the SBBs. First, a linear mixed model

¹Questions 1, 3, 7, 9 and 10 were given the score at face value, whereas questions 2, 4, 5, 6 and 8 had a reversed score (Reverdy *et al.*, 2008).

was performed to uncover differences in liking using *sample, gender, age, food neophobia, frequency of fruit juice consumption and having previously taste sea-buckthorn* as fixed effects, and *consumers* as random effect. Visual inspection of Q-Q plots was carried out to confirm the normality of the distribution of residuals from the fitted model. Post hoc pairwise comparison test (Tukey's test) was performed on the significant variables. A 5% level of significance was chosen. Two other models were tested namely the interactions *sample*gender* and *sample*age* to check for possible relevant interactions.

Furthermore, the CATA data (sensory, conceptual and IBU) were analyzed multivariately: first by discriminant partial least squares regression (D-PLSR) with cross validation. Weighted regression coefficients from the D-PLSR model were used to identify whether the CATA attributes were positively or negatively related with the different samples. We considered an effect positive or negative if the associated probability of being zero was smaller than 5%. Jack-knife resampling was used to test the significance of the beta coefficient obtained from the submodels computed during the model cross-validation (Rinnan *et al.* 2015). The cross validation was performed with 200 segments by removing seven rows (one consumer) at a time, as previously suggested for this type of data structure (Reinbach *et al.* 2014; Rinnan *et al.* 2015).

After removing nonsignificant CATA attributes, a contingency table containing frequency of mention for each of the remaining attributes in correspondence with each of the SBBs. Correspondence analysis (CA) was performed on such a table for graphic evaluation of the results. An additional column containing mean liking ratings by sample was added to the contingency table and liking was used as a supplementary variable to the CA.

All univariate analyses were performed in the statistical language environment R (R Development Core Team 2012), as well as MFA and CA analyses which were run using the FactoMineR package (Lê *et al.* 2008). The D-PLSR analysis was performed using the UnscramblerX ver. 10.3 (Camo, Norway).

RESULTS

Pretest Results

In total, 75 odor attributes and 80 taste/flavor attributes were obtained by the 12 expert assessors (pre-test and pilot test 1), whereas 189 attributes were obtained by the 28 consumers during the second pilot test. As mentioned previously, the purpose of the pre-test was to screen out SBBs based on product (dis)similarities uncovered during the Napping evaluations with different types of assessors. To evaluate product (dis)similarities, scores plots from the two

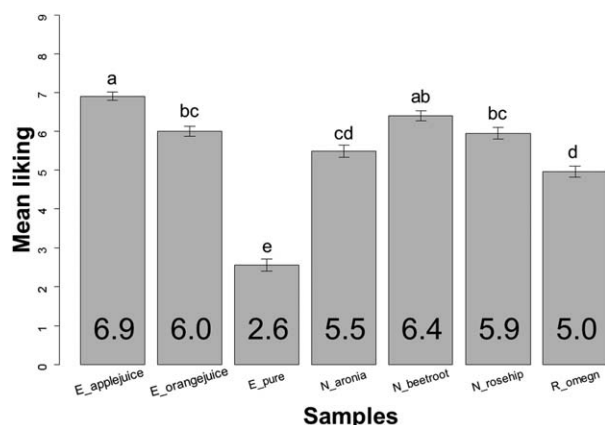


FIG. 2. BAR PLOT SHOWING MEAN LIKING (\pm SEM) FOR ALL SAMPLES

Samples means that do not share superscript letters are significantly different (Tukey $P < 0.05$).

respective MFA models (one for PN and one for GN) were visually inspected (plot not shown).

Based on the pre- and pilot test results, eight samples were chosen for inclusion in the main consumer test. These included three novel SBBs – *N_aronia*, *N_rosehip* and *N_beetroot*, three existing SBBs – *E_orangejuice*, *E_applejuice* and *E_pure*, and the market reference *R_omegn*.

Main Test Results

Mean liking ratings for the tested SBBs are shown in Fig. 2. The mean span in liking scores ranged from 2.6 to 6.9 (mean = 5.5), indicating that the different samples varied substantially with regards to their acceptability. Accordingly,

a significant effect for *sample* emerged from the mixed linear model ($F_{(6,1358)} = 103.7$, $P < 0.001$). Post hoc comparisons showed that the sample *E_applejuice* was significantly more liked than all the other SBBs except *N_beetroot* (Fig. 2).

On average, five of the SBBs – *E_applejuice*, *N_beetroot*, *E_orangejuice*, *N_rosehip* and *N_aronia* – were found acceptable as they scored above the neutral point 5. The novel SBBs had a mean liking scores between 5.5 and 6.4. *N_beetroot* was particularly well received, and in the same acceptability range of the two more familiar SBBs *E_applejuice* and *E_orangejuice*. The least liked sample was *E_pure* which stands clearly out from the other SBBs (Fig. 2).

The CA factor map (Fig. 3) graphically illustrates how the sensory, conceptual and IBU attributes are correlated to the seven samples, as well as to the mean liking. Visual inspection of the scree plot suggested that a two dimensional solution was optimal (76.5% explained variance). Dimension 1 (55.9% explained variance) opposed the sample *E_pure* – associated to the unpleasant attributes *bitter*, *sour*, *prickly* and *citrus* (characteristics of sea-buckthorn unique flavor) – to the sample *R_omegn* (Fig. 3). The latter was associated with the attributes *mild*, *simple* and *watery*, which make sense since this sample is essentially a squash (cf., Table 1). As both *E_pure* and *R_omegn* were the least liked samples, the first dimension is unrelated to acceptability. Accordingly, the liking vector lies toward the origo, indicating that it is poorly fit by the model.

The second dimension (20.6% explained variance) opposed *E_pure* and *R_omegn* to *N_beetroot* and, to a lesser extent, to *N_rosehip*. From a sensory perspective, Dimension 2 explains variation in soil (earthy) flavor, mostly associated with beetroot. This dimension is also important for

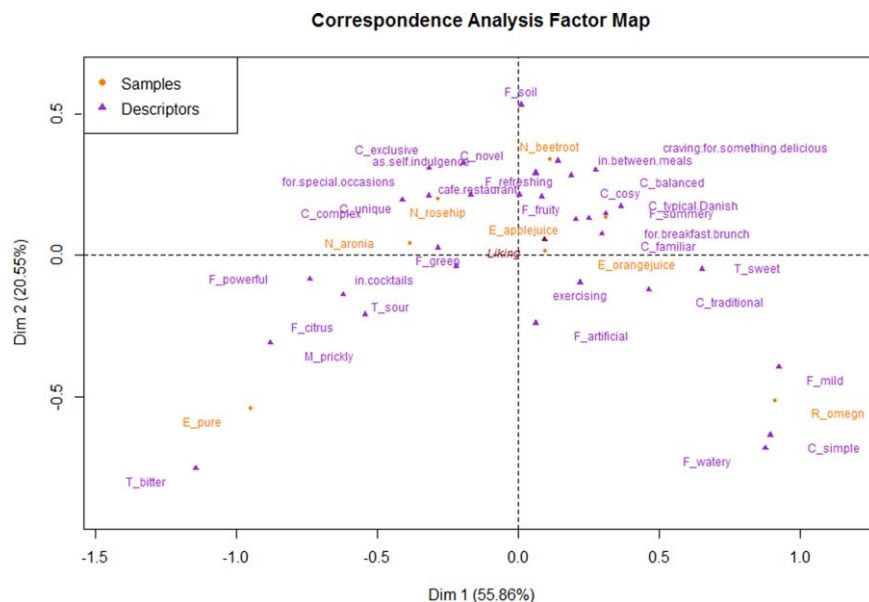


FIG. 3. CORRESPONDENCE ANALYSIS (FIRST TWO DIMENSIONS) PLOT SHOWING ASSOCIATIONS BETWEEN SAMPLES (ORANGE DOTS), CATA ATTRIBUTES (PURPLE TRIANGLES), AND OVERALL LIKING (CLARET TRIANGLE) CATA items are preceded by a letter indicating the type of attribute (T, taste; F, flavor; M, mouthfeel; C, conceptual).

TABLE 3. SIGNIFICANCE LEVELS FOR SENSORY AND CONCEPTUAL PRODUCT ATTRIBUTES INCLUDED IN THE MAIN CONSUMER TEST

	N_aronia	N_beetroot	N_rosehip	E_applejuice	E_orangejuice	E_pure	R_omegn
Artificial	* (−)	n.s.	n.s.	n.s.	** (+)	n.s.	n.s.
Balanced	n.s.	n.s.	n.s.	*** (+)	n.s.	*** (−)	n.s.
Bitter	*** (+)	n.s.	n.s.	*** (−)	* (−)	*** (+)	n.s.
Citrus	*** (+)	*** (−)	** (−)	n.s.	*** (+)	*** (+)	*** (−)
Complex	n.s.	n.s.	** (+)	* (−)	n.s.	n.s.	*** (−)
Cosy	* (−)	n.s.	n.s.	n.s.	* (−)	** (−)	n.s.
Exclusive	n.s.	n.s.	n.s.	n.s.	*** (−)	n.s.	n.s.
Familiar	n.s.	* (−)	n.s.	n.s.	*** (+)	*** (−)	*** (−)
Fruity	n.s.	* (−)	** (+)	*** (+)	*** (+)	*** (−)	* (−)
Green	n.s.	** (+)	n.s.	* (−)	n.s.	n.s.	* (−)
Mild	*** (−)	n.s.	*** (−)	*** (+)	*** (−)	* (−)	*** (+)
Novel	n.s.	*** (+)	n.s.	n.s.	*** (−)	n.s.	*** (−)
Powerful	n.s.	*** (−)	*** (+)	* (−)	** (−)	n.s.	* (−)
Prickly	*** (+)	n.s.	n.s.	n.s.	** (−)	*** (+)	n.s.
Refreshing	*** (+)	** (+)	*** (−)	*** (+)	n.s.	n.s.	*** (−)
Simple	*** (−)	** (−)	*** (−)	*** (+)	n.s.	** (−)	*** (+)
Soil	n.s.	*** (+)	* (−)	** (−)	*** (−)	* (−)	*** (−)
Sour	*** (+)	* (−)	n.s.	** (−)	n.s.	*** (+)	*** (−)
Summery	n.s.	n.s.	n.s.	*** (+)	n.s.	*** (−)	* (−)
Sweet	*** (−)	n.s.	n.s.	*** (+)	*** (−)	*** (−)	*** (+)
Traditional	n.s.	*** (−)	n.s.	n.s.	*** (+)	*** (−)	** (−)
Typical Danish	n.s.	n.s.	n.s.	n.s.	*** (+)	*** (−)	** (−)
Unique	n.s.	n.s.	n.s.	n.s.	*** (−)	n.s.	n.s.
Watery	** (−)	*** (−)	*** (−)	*** (+)	*** (−)	n.s.	*** (+)

Plus and minus signs refer to the sign of the beta coefficients from D-PLSR, and indicate a positive or negative association with each sample. *P* values are estimated by jack-knifing following the model cross-validation.

* $P < 0.001$

** $P < 0.01$

*** $P < 0.05$, n.s., not significant.

explaining variation in perceived product novelty, as it is related to the attributes *exclusive*, *novel*, *unique* and *for special occasions*, associated mostly with the novel SBBs *N_aronia* and *N_rosehip*, and to the attributes *simple* and *traditional*, associated with *R_omegn*. *E_orange* is also positively loaded on the second CA dimension, mostly associated with the attributes *fruity*, *familiar* and *summery*. With regards to situational appropriateness, Fig. 3 suggests that the most liked SBBs (*E_applejuice*, *N_beetroot* and *E_orangejuice*) were considered appropriate for consumption *in between meals*, *at café/restaurant* and *for breakfast/brunch*. *N_aronia* and especially *E_pure*, in spite of the lower acceptability, were considered highly appropriate for use *in cocktails*.

To supplement the exploratory analysis by CA, Tables 3 and 4 report the effects of individual CATA attributes on the SBBs, as assessed the D-PLSR regression. The direction of the effect corresponds to the sign of the regression coefficient, and the significance is established using a jack-knife resampling procedure.

The first observation upon examination of Tables 3 and 4 is that, except for the IBU attribute *When exercising*, all CATA attributes were significantly discriminating between the samples.

With regards to the sensory characterization, Table 3 supports the visual interpretation obtained from CA. The pure sea-buckthorn juice *E_pure* was strongly associated with the attributes *bitter*, *sour*, *prickly* and *citrus*, and negatively associated with *balanced*, *familiar* and *traditional*. Together with the low acceptability of this sample, this characterization confirms our expectations that sea-buckthorn in its pure form would be too novel and present undesirable sensory qualities for consumers. The market reference *R_omegn* was primarily described as *simple*, *mild* and *watery*, suggesting that it might be too bland and uninteresting from a sensory point of view. On the opposite end of the liking spectrum, the most preferred sample *E_applejuice* is mostly associated with positive attributes such as *sweet*, *balanced*, *fruity*, *mild*, *refreshing* and *summery*, and negatively with *bitter*, suggesting that masking bitterness through targeted formulations is important for acceptance of SBBs. The second best liked sample, *E_beetroot*, was described as *novel* and *soil* (earthy), and negatively associated to *citrus*, *powerful*, *traditional* and *watery*. *E_orangejuice* was characterized as *citrus*, *fruity*, *familiar*, *traditional* and *typical Danish*, and negatively with *exclusive*, *novel* and *unique*. Regarding the last two novel samples, *N_rosehip* was associated with *powerful* and

TABLE 4. SIGNIFICANCE LEVELS FOR IBU APPROPRIATENESS ATTRIBUTES INCLUDED IN THE MAIN CONSUMER TEST

	N_aronia	N_beetroot	N_rosehip	E_applejuice	E_orangejuice	E_pure	R_omegn
At a café or restaurant	n.s.	n.s.	n.s.	*** (+)	n.s.	*** (−)	n.s.
Between meals	n.s.	** (+)	n.s.	n.s.	n.s.	*** (−)	*** (−)
For breakfast/brunch	n.s.	n.s.	n.s.	** (+)	*** (+)	*** (−)	** (−)
For self-indulgence	n.s.	n.s.	* (+)	** (+)	*** (−)	** (−)	n.s.
For special occasions	n.s.	n.s.	n.s.	n.s.	** (−)	n.s.	n.s.
In cocktails	** (+)	n.s.	n.s.	n.s.	n.s.	* (+)	* (−)
When craving for something delicious	n.s.	n.s.	n.s.	** (+)	** (−)	*** (−)	n.s.
When exercising	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Plus and minus signs refer to the sign of the beta coefficients from D-PLSR, and indicate a positive or negative association with each sample. *P* values are estimated by jack-knifing following the model cross-validation.

* *P* < 0.001

** *P* < 0.01

*** *P* < 0.05

n.s., not significant.

negatively with *refreshing* and *watery*, while *N_aronia* was described very similarly to *E_pure* (*bitter*, *sour* and *prickly*) but the chokeberry juice also imparted a *refreshing* character to the juice which seems to have partly compensated for the less desirable taste and flavor qualities.

With regards to IBU appropriateness (Table 4), the two familiar samples *E_applejuice* and *E_orangejuice* showed the most significant positive associations, and were perceived as appropriate in situations such as *at a café or restaurant* and *for breakfast/brunch*. *E_pure* showed a significant negative association with nearly all evaluated usage situations, indicating a correlation between sensory acceptability and situational appropriateness. The less familiar SBBs showed very few or no significant associations in terms of IBU appropriateness, suggesting that consumers had problems envisaging appropriate consumption situations for products they were not familiar with.

DISCUSSION

This study investigated sensory properties and consumer perceptions of a range of SBBs. Large differences between the tested samples were found with regards to acceptance and sensory properties. To summarize, the results showed a separation of the two less liked samples, *E_Pure* and *R_Omegn*, from a group of SBBs with higher acceptability. The latter were constituted by sea-buckthorn juice combined with other local fruit and vegetables, and characterized by perceived higher sweetness and lower acidity, which were expected to counteract less desirable sensory qualities of sea-buckthorn juice. Furthermore, it was possible to distinguish between the existing SBBs *E_applejuice* and *E_orangejuice* and the novel SBBs based on sensory attributes, concepts and IBU appropriateness profiles. All of the product attributes but one significantly discriminated between the products. This positive result indicates that the attributes

included in the ballot were highly relevant for this product category, and can be attributed to the extensive pilot work conducted in this study.

Overall, *E_applejuice* and *E_orangejuice* were considered to be more familiar and simple, whereas the novel SBBs were considered to be rather complex and novel. A similar separation was found by Stolzenbach *et al.* (2013) in their test of honeys, as concept associations separated traditional honeys from novel ones.

Looking at the liking scores and at the product descriptions obtained from consumers, the results seem consistent with the “optimal arousal theory” described in the introduction (Berlyne 1970), in the sense that the disliked SBBs appear to be either too simple or too novel, and the liked SBBs are those that seem to strike a balance between familiarity and interestingness.

On the one hand of an ideal U-shaped curve, we find the reference product *R_omegn* which had too low arousal potential as it was relatively disliked and described as too simple and uninteresting. As sensory complexity increases so does acceptability, and accordingly we find two quite liked samples – *E_applejuice* and *E_orangejuice* – described as balanced and familiar. Given their mean liking scores (6.9 and 6.0 on a 9-point hedonic scale), they seem to have a slightly lower arousal potential than the optimum. Further we find the novel SBBs, *N_beetroot*, *N_aronia* and *N_rosehip*, which were also relatively liked (with mean scores ranging from 5.5 to 6.4) and described with attributes such as *complex* and *novel*. This suggests that these beverages were appreciated as interesting but were slightly too novel/complex. Finally, the pure sea-buckthorn nectar (*E_pure*) was disliked as it had some off-putting sensory qualities, and was found to be strongly negatively correlated with the attributes “familiar,” “balanced” and “traditional Danish,” suggesting that it was way too far in terms of arousal potential for most consumers.

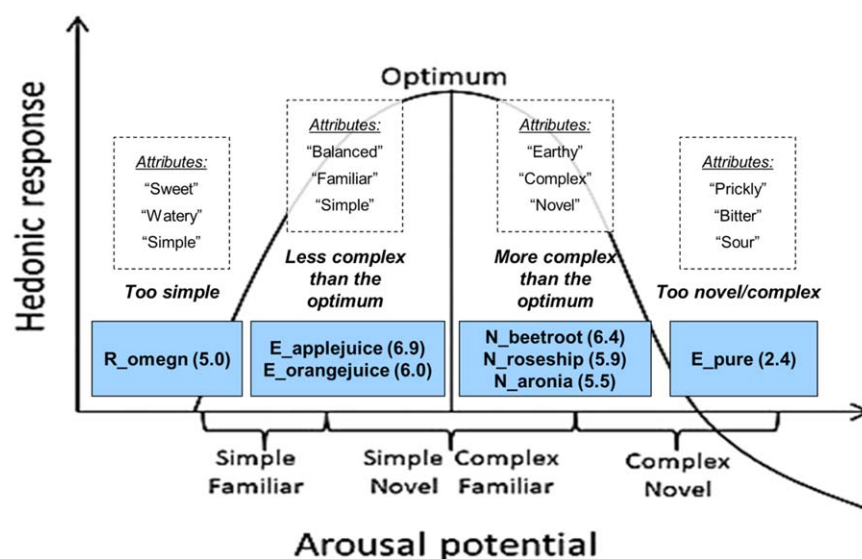


FIG. 4. A THEORETICAL ACCOUNT OF THE RELATIONSHIP BETWEEN HEDONIC RESPONSES TO THE SBBs AND THEIR "AROUSAL POTENTIAL" (BERLYNE, 1970), ESTIMATED THROUGH CONSUMERS' DESCRIPTION

A visual summary of this discussion is given in Fig. 4, in which the key sensory and conceptual descriptions obtained for the seven SBBs are represented in light of Berlyne's collative motivational model (Berlyne 1970). These results are in accordance with those obtained for other beverage categories, such as beer (Giacalone *et al.* 2014).

From an applied perspective, this discussion is relevant because relating acceptance to arousal potential of food and beverages may be used to infer long term market success and, therefore, support product development decisions. Based on the results obtained in this research, we suggest that the most promising solution would be to continue with the development of the novel SBBs, particularly the combination of sea-buckthorn and beetroot (*N_beetroot*) for two reasons. First, because the sample was equally liked compared to the more familiar combinations with orange and apple juice but, at the same time, it was perceived as more novel and interesting. This can be advantageous in terms of long term appreciation and market success. For example, research of Lévy *et al.* (2006) found that repeated exposure to a complex orange juice increased consumers' preference for complex flavors, while decreasing the appreciation of more simple and familiar juices. This result was explained by assuming that exposure to stimuli that are a bit more complex than the optimal level (so-called "pacers") would make consumers change their optimal level in the direction of this more complex stimulus. Accordingly, we expect that introducing a slightly less liked, but somewhat more complex, product (such as *N_beetroot*, but also the other two novel SBBs) will act as a "pacer" and that, in becoming less complex through exposure, might eventually meet consumers half way and be more successful in the long run.

An important caveat here is that, besides the intrinsic product characteristics, acceptability and arousal potential of foods are dependent on the individual (Köster and Mojet 2007). In particular, a consumer's previous product related exposures and his/her stable attitude toward novel foods are expected to change their perceptual abilities and consequently their optimal level of novelty in food and beverages (Giacalone *et al.* 2014). Nevertheless, in the present research none of the consumer-related variables considered, including food neophobia and previous experience with sea-buckthorn products, was shown to have an effect on acceptability of the SBBs. As this suggests little potential for segmentation, looking at aggregated results seems appropriate for this product category. However, it should be noted that for some of these variable, sample sizes for specific subgroups were relatively low (e.g., true neophobic consumers were less than 50) for us to conclude with confidence that no effects exist. Larger studies with more targeted recruiting would be needed to confirm that this indeed is the case.

The second reason why the novel SBBs are potentially more promising is that, besides the sea-buckthorn, they consists entirely of new Nordic ingredients (aronia, beetroot and rosehip), which could allow capitalizing on the growing interest in foods of local origins among European consumers, and Danish consumers in particular (Stolzenbach *et al.* 2011, 2013). This is advantageous for local producers who can use the "New Nordic" theme to differentiate their product from others' in an increasingly competitive market, for example, through targeted product information, packaging design, etc.

With regards to IBU appropriateness, consumers found easier to associate consumption situations with two particular SBBs, *E_orange* and *E_applejuice*. This is likely due to the

low content of sea-buckthorn nectar, and a corresponding higher content of apple/orange juice from concentrate, resulting in familiar sensory properties that the consumers could easily associate with previous consumption experiences.

Conversely, consumers did not find many appropriate consumption situations for the more novel samples. This result is consistent with previous research indicating that consumers have difficulties associating using situations with products they are not familiar with (Giacalone *et al.* 2015; Giacalone and Jaeger 2016). Overall, this suggests that consumers may have problems envisaging how to incorporate novel SBBs in their existing dietary practices. As IBU appropriateness is an indication of potential adoption barriers, it is likely that information about potential product usage is needed to guide the consumers toward “understanding” the novel SBBs. This could be done, in later product development stages, by targeted labelling showing or describing suggested usages. In addition, thematic retail display, that is, placing SBBs next to other products with a clear theme (e.g., breakfast, lunch, self-indulgence), could also help in increasing situational appropriateness for these products.

CONCLUSIONS

This work investigated how newly developed SBBs were perceived compared to a selected market reference with regards to overall acceptability, sensory characteristics and appropriate consumption situations associated with these beverages. The results showed that the developed SBBs were generally well liked with no significant difference in liking between the best liked novel and existing beverages. Consumers, however, clearly differentiated between the existing, novel and market reference SBBs on the basis of their sensory characteristics and IBU appropriateness. The existing SBBs were considered more familiar than the novel SBBs, whose sensory characteristics were perceived rather complex and novel by consumers. The novel SBBs developed in the study seemed to have an appropriate “arousal potential,” as they were perceived as complex and novel but at the same time had a high overall acceptability. This was especially true for the sea-buckthorn/beetroot combination (*N_beetroot*) which was the best liked samples overall on par with *E_applejuice*. Because of its novelty and complexity, from a sensory point of view *N_beetroot* is also suggested to have the highest chances of long-term market success. Nevertheless, another important result was also that the novel SBBs were associated to much fewer appropriate usages than the existing ones, suggesting a possible barrier to adoption for less familiar SBBs.

None of the background consumer variables included in the study significantly affected liking, indicating that the differences in consumer preferences for the SBBs were mostly related to the sensory aspects. The level of neophobia was

hypothesized to be important for adoption of local ingredients, but the results did not confirm that (neophilic consumers had a higher mean liking score than the neophobics, but the difference was not significant).

Methodologically, this study has shown a stepwise approach to consumer-driven product development based on fast and inexpensive sensory and consumer methods (Napping, CATA, hedonic rating) that can support early consumer involvement even with little or no budget for formal sensory analysis. The adopted approach effectively differentiated between SBBs and provided insights with regards to the most promising prototypes, and could, therefore, be beneficially applied to support product development efforts among small and medium-sized local producers.

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