Food Research International 116 (2019) 1183–1191

Contents lists available at ScienceDirect

Food Research International

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

Development of a sensory wheel and lexicon for chocolate

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ARTICLE INFO

Keywords:
Chocolate
Sensory lexicon
Sensory wheel
Focus group
Descriptive analysis
Consumer

ABSTRACT

Cocoa is one of the most important cultivated crops worldwide both in production and processing. But due to the change in weather conditions, pest and diseases, producers are looking into new bean varieties and alternatives (e.g. carob) which can influence the sensory properties of chocolate. But also the other ingredients, the production process and storage conditions play a role in the sensory properties of chocolate products. Although chocolate has been widely used as a product for scientific research, especially given its association with the arousal of pleasure by consumers, there is a lack of a sensory lexicon of chocolate products generated by consumers.

This study aims to identify sensory characteristics with respect to the four sensory modalities (appearance, aroma, texture and flavour), which are important for chocolate consumption and visualize them in a chocolate sensory wheel. Five focus groups with consumers (n = 48) generated in total 104 descriptors using a range of white (5 different samples), milk (8 different samples) and dark (9 different samples) chocolate samples. A three-tiered chocolate sensory wheel, comprising the 4 sensory modalities, 21 categories and 61 descriptors, was created to form a graphical presentation of the sensory lexicon. Based on the descriptors obtained from the five focus groups, in total nine commercial samples of white, milk and dark chocolate were characterised using descriptive analysis by a trained sensory panel. The results of the descriptive analysis show that samples can be differentiated based on the attributes of the sensory lexicon.

Given that identifying, understanding and using the most important sensory characteristics is crucial for companies but also for scientists using chocolate products, this chocolate sensory lexicon will be of added value in new product development and quality assurance.

1. Introduction

Nowadays, the change in weather patterns is increasingly affecting the cocoa trees. Periods of drought and of excessive rain due to climate changes can have a negative impact on the growth of cocoa influencing cocoa prices (Beg, Ahmad, Jan, & Bashir, 2017; Schroth, Läderach, Martinez-Valle, Bunn, & Jassogne, 2016). Moreover, the chemical composition of cocoa beans (e.g. antioxidant content, N, Fe, and Cu) changes during periods of higher temperature and lower rainfall which impacts cocoa bean quality (Niether et al., 2017). Sampling is currently used with visual checking of the cocoa beans as a quality control tool (International Cocoa Organization, 2012). Therefore, chocolate producers are always looking for ways to make a product that meets the needs and desires of consumers and producing it at a low cost. As a result, producers are using different cocoa bean varieties changing the production process or searching for alternatives for the necessary ingredients (Afoakwa, 2010). These alterations have an effect on the sensory characteristics of chocolate. The most important parameters when evaluating the quality of chocolate are the appearance, aroma, texture, taste and flavour of the chocolate (Afoakwa, 2016).

The sensory characteristics of chocolate are also influenced by the ingredients used next to the cocoa beans. Cocoa has a natural bitter taste which is caused by the presence of polyphenols and alkaloids. In order to prevent the chocolate of being too bitter, sugar is added. Sucrose is mostly used in chocolate confectionary, lactose in milk chocolate (Beckett, 1999). The size of the sugar particles is crucial for a smooth mouthfeel. In the production of milk chocolate, milk powder needs to be added. This contains milk fat which softens the chocolate and influences the shelf life of the chocolate (Beckett, 2000; German & Dillard, 1998).

The final characteristic that influences the sensory aspects of chocolate is storage. When the perishable date is exceeded, the quality of the appearance and the taste will decrease. To prevent this from happening, the storage temperature is very important as chocolate is highly sensitive for temperature fluctuations and heat. The ideal storage temperature for chocolate ranges from 14 °C – 18 °C (Ghosh, Ziegler, &

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https://doi.org/10.1016/j.foodres.2018.09.063
Received 17 June 2018; Received in revised form 16 September 2018; Accepted 28 September 2018
Available online 02 October 2018
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Anantheswaran, 2002). If the humidity in the storage environment is too high, sugar bloom can develop. Air and light can cause a decomposition of the fats in the chocolate. The oxidation process causes a change of taste and the development of an unpleasant smell. Cocoa butter absorbs strong aromas and therefore it is not advisable to store chocolate together with strong smelling products (Lonchampt & Hartel, 2004).

Literature indicates that chocolate consumption is mostly driven by the arousal of sensory pleasure due to the specific melting behaviour, aroma and taste (Januszewska & Viaene, 2002; Mela, 2000; Parker, Parker, & Brotchie, 2006).

There is a growing application of novel rapid sensory profiling methods, such as check-all-that-apply (CATA), rate-all-that-apply (RATA), napping, enabling the use of untrained panellists or even consumers for obtaining sensory profiles of food products (Varela & Ares, 2012). But in order to use such novel methods, it is crucial that an appropriate sensory lexicon is established based upon the input of consumers so that the terms can also be used with consumers. Terms can be generated based upon descriptors used by trained assessors panels, but these have the disadvantage that they may not always be easy to understand for consumers (Varela & Ares, 2012). Moreover, defining attributes by consumers provide valuable input to descriptive analysis (Lawless & Heymann, 2010). Indeed, it assures that descriptive analysis considers sensory attributes that are strongly influential on consumer acceptance (Chambers & Smith, 1991).

The main objective of this study was to identify the sensory attributes that are decisive factors in the choice of consumers for chocolate food products. Moreover, this study aims to group these sensory attributes and visualize them in a sensory wheel.

2. Materials and methods

2.1. Experimental design

This study first organised five focus groups in order to obtain a sensory lexicon for chocolate. Based upon the frequency of mentioned terms, a selection was made of the most relevant terms in order to construct a sensory wheel. Next, a trained sensory panel (consisting out of 9 persons) evaluated in total 9 chocolate samples using a reduced list of the sensory lexicon.

2.2. Development of the consumer-defined sensory lexicon

2.2.1. Chocolate samples

For the focus groups, a total of 22 commercial chocolate samples were selected as illustration of possible sensory differences among the samples (Table 1). A range of white (5 different samples), milk (8 different samples) and dark (9 different samples) chocolate were provided during the focus groups. This makes it easier for the participants in the focus groups to come up with different sensory descriptors. When developing a sensory lexicon it is necessary to include a range of sensory profiles in the development process so that as many potential sensory attributes as possible are captured (Koch, Muller, Joubert, van der Rijst, & Næs, 2012). For this reason, the chocolate samples were randomly selected and differed in price, brand and ingredients (Drake & Civille, 2003). Belgian and internationally produced chocolate samples were bought in local supermarkets. The chocolate products were purchased in large batches and all samples were from the same batch. Samples were stored at constant temperature of 20 °C. Chocolate samples were presented in odourless transparent cups, containing a small amount of chocolate (around 10 g), foreseen with a random 3-digit code.

2.2.2. Focus groups

A total of 48 consumers (26 males / 22 females), recruited at the university, were divided among 5 focus groups. In order to have a broad range in age, consumers were recruited from 18 to 75 years. All the participants were frequent chocolate consumers (at least once a week). The number of participants in each group was determined based on general guidelines for conducting focus group research (Morgan, 1997). Specifically, to sustain the discussion and to control the group, it is recommended to select between six and eight participants (Morgan, 1997). However, for sensory research focus groups up to 12 persons are common (Lawless & Heymann, 2010). The number of focus groups was based on practical and saturation criteria. The saturation criteria were related to the degree to which new data repeat what was expressed in previous data (Saunders et al., 2018). After having conducted five focus groups, additional data collection would no longer yield new insights. The focus groups used a structured interview format which facilitated achieving data saturation. The focus groups took place at a meeting room in which all the participants were gathered around a round table. The moderator of the focus groups made sure that everyone participated and kept the participants on track. Every participant received a ballot on which they could write down their attributes. This was an extra way of collecting information next to oral expressions of the participants. Each focus group lasted around one hour and a half.

A script for the focus groups was initially constructed (Lawless & Heymann, 2010). At the start of the focus group, the moderator welcomed the participants, explained that they were participating in a focus group and that the goal was to find sensory descriptors for white, milk and dark chocolate in the categories appearance, aroma, texture and flavour which are important for their choice of chocolate products. Participants were asked to write down, according to their own vocabulary, attributes and key associations detected in the different chocolate samples for each sensory modality separately (Larssen, Monteleone, & Hersleth, 2018). The focus groups started with a discussion on the appearance of white chocolate, then the aroma, next the texture and finally the flavour. A second discussion covered sensory attributes for milk chocolate and a third for dark chocolate.

2.2.3. Development of the sensory lexicon and construction of the sensory wheel

After the focus groups, participants were asked to submit their papers containing the sensory terms for the different types of chocolate. The 2199 attributes generated through the focus groups were grouped together on input of the focus groups and on a semantic basis by the researchers involved in this study (Larssen et al., 2018). Expressions with the same or similar meaning and redundant terms were eliminated and only the most common term was used (Larssen et al., 2018). Only terms which were relevant, unambiguous, non-redundant and non-hedonic were included in a list of preliminary descriptive terms ($n = 108$) (Koch et al., 2012).

In order to facilitate the sensory profiling task, the list of preliminary descriptive was further limited based on how frequent the terms were used during the focus groups (> 5%) (Koch et al., 2012). The basic flavours sweet, bitter and sour were added to the remaining descriptive terms in order to have a list of sensory attributes for the sensory wheel. All the attributes of the chocolate sensory wheel were grouped together to form coherent categories based upon input of the focus groups and the expertise of the researchers. The sensory wheel was constructed using the XLSTAT software (Addinsoft, France) version 2018.4.

2.3. Sensory description of chocolate

2.3.1. Samples

Out of the 22 initial chocolate samples, three white chocolate, three milk chocolate and three dark chocolate, were selected to perform descriptive analysis by a trained panel. Samples were selected to represent the sensory variety among products on the Belgian market and samples were in Belgium or abroad produced. All samples were bought in local supermarkets. Samples were from the same batch and had a similar shelf-life.

Table 1
Overview of the chocolate products used during the focus group with sugars and cocoa percentages. Chocolate of brands with * were used with a trained panel.

White chocolate									
Brand	Carrefour Discount	Galak Nestlé	Côte d'Or*	Bellarom*	Carrefour*				
Sugars (%)	55	59	61	55	54				
Milk chocolate									
Brand	Fin Carré	Jacques*	Carrefour*	Côte d'Or*	Château	Carrefour Discount	Fairglobe	Bio solidair	
Sugars (%)	56	50	53	55	52	54	52	50	
Cocoa (%)	30	30	32	34	32	30	32	39	
Dark chocolate									
Brand	Côte d'Or	Carrefour	Lindt*	Bellarom*	Fin carré	Château	Jacques	Fairglobe*	Bio solidair
Sugars (%)	54	50	30	26	47	47	45	29	27
Cocoa (%)	46	49	70	74	50	50	52	70	72

Samples were presented in transparent plastic cups labelled with a random three-digit code. These samples were served at room temperature (21 °C ± 1 °C) and about 10 g of each sample was provided for the sensory evaluation. Product samples were presented in monadic sequence. Evaluation of the samples was grouped by category (white / milk / dark) with a design balanced for presentation order and carry-over effects (Williams' design) within a category and between categories (MacFie, Bratchell, Greenhoff, & Vallis, 1989). Between the evaluation of each category, a break (15 min) was foreseen to prevent fatigueness. Water and plain crackers were available for palate rinsing. Each participant participated in three evaluation session so that chocolate samples were tested in triplicates over the course of three weeks (one session a week).

2.3.2. Selection of the sensory terms

Vannier, Brun, and Feinberg (1999) indicated that an efficient sensory profiling is possible with about 20 attributes. Therefore, the number of attributes was greatly reduced by disregarding the attributes that were perceived by a small amount of participants (Stolzenbach, Byrne, & Bredie, 2011). The reduced list of attributes is shown in Table 2 and was established by consensus of the trained panel.

For apppearance, only three attributes were selected. The attributes "shape" and "thickness" were not included in the sensory profiling as these are dependent on the chocolate producer and the serving of the sample. These attributes were not considered as inherent to the chocolate product. After discussion with the trained panel, it was decided to use the attribute "graininess" of the cross section instead of roughness of the surface. The aroma and flavour attributes were different for the three types of chocolate. The "fruit" aroma and flavour does not refer to a specific fruit but is the sum of the different fruits that were associated with the chocolate such as dried raisin, coconut and red berries. The basic tastes sweet, sour and bitter were also included in the list. Salt was not included as it was not relevant for the evaluation of chocolate samples. In total there were 28, 32 and 28 attributes for respectively white, milk and dark chocolate (Table 2).

2.3.3. Descriptive analysis

Descriptive sensory profiling, according to the generic descriptive analysis (Lawless & Heymann, 2010), was used to evaluate the selected chocolate samples. This was conducted with a trained sensory panel with experience (two years) in the evaluation of chocolate products (Piggott, Simpson, & Williams, 1998). This panel consisted of 9 assessors (8 female, aged between 25 and 50 years old) which were originally selected from a pool of 50 possible candidates. Assessors were selected and recruited in compliance with ISO standards and participated in a 3 month training period (Murray, Delahunty, & Baxter, 2001). They were selected based on their abilities to identify and describe differences in chocolate and filled chocolate and their ranking of different concentrations of ingredients of chocolate. Continuous panel performance and monitoring techniques were used to ensure all assessors maintained a high level of competence (Moussaoui & Varela, 2010). Specific for this study, training was organised for the fixed trained panel based upon the sensory lexicon generated by the consumers containing 28 terms for the white chocolate products, 32 terms for milk chocolate

Table 2
Selected sensory attributes for descriptive analysis.

Appearance	Aroma			Texture	Flavour		
	White	Milk	Dark		White	Milk	Dark
Colour	Fruit	Fruit	Fruit	Graininess	Fruit	Fruit	Fruit
Gloss	Vanilla	Vanilla	Nuts	Dryness	Honey	Caramel	Coffee
Graininess	Caramel	Caramel	Coffee	Stickiness	Caramel	Marzipan	Cocoa
	Burnt sugar	Honey	Cocoa	Creaminess	Vanilla	Nuts	Tobacco
	Honey	Nuts	Wood	Hardness	Milk	Cocoa	Wood
	Cream/milk	Coffee	Earth	Snap	Butter	Wood	Earth
	Butter	Cocoa	Vegetable	Melting behaviour	Sweet	Milk	Sweet
		Wood		Thickness	Sour	Sweet	Sour
		Tobacco			Bitter	Sour	Bitter
		Cream/milk			Aftertaste	Bitter	Aftertaste
						Aftertaste	

and 28 terms for dark chocolate. The products were evaluated in repeated trials (triplicate) to obtain quantitative descriptions and reliable, consistent results (Jones, Macfie, & Beilken, 1989; Lawless, 1984).

The descriptive analysis was carried out at the sensory facilities of Ghent University. Panellists were seated in individual booths and performed the monadic evaluation of each sample at their own speed. The assessors scored the samples using a 9-point scale (1 = low intensity – 9 = high intensity).

2.4. Statistical analysis

ANOVA was used to analyse the quantitative data from the trained panel and to identify significant differences between the chocolate samples using IBM SPSS 23 (Armonk, NY) (Larssen et al., 2018). The ANOVA model considered two main effects namely product (fixed effect) and assessor (random effect) and their interaction effect (random effect). Principal component analysis (PCA) using the correlation matrix was conducted using Panelcheck (Version 1.3.2, www.panelcheck.com) to visualize the relationships between the chocolate samples and the attributes for the three different types of chocolate (white, milk and dark) seperately (Naes, Brockhoff, & Tomic, 2010).

Panel performance was monitored using PanelCheck Software (Version 1.3.2, www.panelcheck.com).

3. Results

3.1. Sensory lexicon

The consumers generated in total 2199 terms during the five focus groups. It should be mentioned that participants were allowed to add additional terms during the focus groups, so the 2199 terms were collected when the focus groups were over. Through term selection and grouping, some terms were merged with similar terms resulting in a list of 108 descriptive terms (Table 3). Of these 108 attributes, 13 were related to appearance, 42 were aroma attributes, 15 were texture attributes and 38 flavour attributes were generated.

Based on the frequency of quotation (> 5%), 8 appearance, 21 aroma, 11 texture and 18 flavour attributes were selected from the list of descriptive terms generated by the attendees in the focus groups (Koch et al., 2012). The basic flavours sweet, bitter and sour were added to these attributes. The 61 terms were depicted in a three-tiered wheel (Fig. 1). The descriptors forming the outer tier are the specific attributes, while the secondary descriptors that group a certain type of attributes are the second tier. The inner tier contains the 4 major sensory modalities, namely appearance, aroma, texture and flavour.

3.2. Sensory description

As different attributes are used for the aroma and the flavour description of the types of chocolate, the results of the sensory profiles of white, milk and dark chocolate are given separately.

3.2.1. White chocolate

There was a significant difference between the colour of the white chocolate. White A (7.4) was evaluated as slightly more yellow than White B (5.1) and C (4.3). No significant difference was found for gloss of the chocolate. The cross section of White C (3.9) was found to be more grainy than the cross section of White A (3.2). White B (2.4) has the least grainy cross section.

The vanilla and milk/cream aroma was more profound in White C (6.3 and 6.0). There was no significant difference in those aroma attributes between White A (4.5 and 3.9) and B (5.1 and 4.5). Butter and sugar aroma were also perceived as present in the white chocolate but no significant differences were observed.

For texture, significant differences were found for hardness and creaminess. White B (6.2) was found to be harder than White C (5.6) and White A (4.9). White C (5.2) had a significant creamier feeling in the mouth than White B (4.5) and White A (3.9).

White C (6.3) was found to be sweeter than White B (5.5) and White A (4.6). There was a higher sour taste in White A (3.0) than in White B (2.0) and White C (1.7). Similar to the aroma, the vanilla and milk/cream flavour was more pronounced in White C (6.3 and 6.0). Although butter and caramel were present in the three samples, no significant differences were found.

3.2.2. Milk chocolate

No significant differences were found for the graininess of the cross section and the gloss of the milk chocolate. However, Milk B (6.2) had a significant darker colour than Milk A (5.4) and Milk C (4.2).

For the aroma profile of the milk chocolate, no significant differences were found. The cocoa aroma was perceived for all the samples and also milk/cream, caramel and vanilla aroma were present in all three samples.

The most significant differences were found in the texture of the chocolate. Milk B was found to be the hardest (5.7) and had the highest snap (6.2). Milk A was perceived as the softest (4.3) with the lowest snap (4.7). After eating, the dryness in mouth was the highest for Milk B (5.0) in comparison to Milk C (4.6) and Milk A (4.0).

The milk chocolate tasted sweet with a little bitter note, but no significant differences were found for the basic tastes. The flavours that were perceived with the highest intensity were cocoa, milk/cream and caramel. For cocoa flavour, a significant difference was found between Milk B (5.7) on the one hand and Milk C (5.3) and Milk A (4.9) on the other hand.

3.2.3. Dark chocolate

The trained panel indicated that no significant difference was present in the appearance of the three dark chocolate. The cocoa aroma was dominating the aroma of the dark chocolate although hints of coffee, tobacco, plants and fruit were perceived. Again, no significant differences were found among the dark chocolate. Further, the evaluations of the trained panel indicated that no significant differences were found in texture of the three chocolate. The melting behaviour of the three dark chocolate samples was also found to be very similar.

The differences between the samples were found in the taste and flavour of the chocolate. The bitter taste was found to be most present in dark chocolate. Dark A (6.9) was evaluated as the most bitter chocolate. No significant difference was found between Dark C (5.4) and Dark B (5.7) regarding the bitter taste. Dark C (3.8) had a significantly higher sour taste than Dark A (2.1) and Dark B (2.4). Other significant differences were found for fruit and cocoa flavour. The fruity flavour of Dark C (3.4) was higher than for Dark B (1.7) and Dark A (1.3). The cocoa flavour was more pronounced for Dark A (7.1) and least pronounced for Dark C (5.4). Finally the aftertaste after swallowing the samples was higher for Dark C (6.9) than Dark A (5.9) and Dark B (5.4).

3.2.4. PCA analysis of the three types of chocolate

Standardized PCA plots using the correlation matrix are commonly used in sensory analysis to display differences between attributes as well as between samples. The PCA loadings plot display the positioning and association between the chocolate attributes. Fig. 2 shows four different plots for appearance (Fig. 2a), texture (Fig. 2b), aroma (Fig. 2c) and flavour (Fig. 2d).

For the PCA loadings plot of appearance, colour is not included as the trained panel evaluated each type of chocolate on a different colour scale relevant to the specific chocolate. Fig. 2a indicates that the other two sensory attributes, gloss and graininess creates a grouping of the white, milk and dark chocolate. The plot shows that White C has a similar gloss as the three dark chocolate. Graininess is correlated to milk and dark chocolate and not to white chocolate.

In the PCA loadings plot of the texture attributes (Fig. 2b), the three groups of different types of chocolate are formed although within these

Table 3
Complete list of preliminary descriptive terms generated during focus groups for all chocolate samples.

Appearance			
Colour	White	Milk	Dark
Colour difference	38	45	41
Gloss	36	27	36
Fat bloom	1	3	1
Colour evenness	2	4	3
Surface			
Rough	18	18	20
Hardness	3	6	4
Fatty feeling	2	1	1
Air bubbles	3	4	2
Flakiness	4	5	4
Shape			
Thickness	23	21	22
Shape	23	19	22
Cross section			
Graininess	6	11	10
Layered	5	7	5

Texture			
Mouthfeel			
Graininess	22	22	23
Dryness	6	9	12
Coating	6	7	2
Stickiness	28	24	23
Creaminess	19	16	3
Roughness	3	4	3
Fattiness	3	4	4
Bite			
Hardness	36	34	37
Snap	24	26	27
Even bite	1	1	1
Crunchy	3	4	4
Crumbly	8	9	9
Melting			
Melting behaviour	38	38	32
Cohesion	6	6	6
Shape			
Thickness	8	7	7

Aroma			
Fruit	White	Milk	Dark
Dried raisin	10	9	7
Tropical fruit	1	/	3
Dried banana	4	/	1
Prunes	/	3	1
Cherry	/	/	1
Red berry	/	15	13
Coconut	/	14	3
Floral			
Jasmine	3	3	2
Roses	2	/	/
Orange blossom	1	3	4
Vanilla	44	9	2
Sweet			
Caramel	8	27	3
Burnt sugar	5	2	/
Marzipan	/	4	4
Jam	/	/	5
Honey	10	5	1
Beeswax	1	2	4
Liquorice	/	11	5
Vanilla cooky	/	/	2
Earthy			
Nuts	1	16	6
Leather	2	3	6
Coffee	2	15	19
Cocoa	1	29	39
Wood	1	18	19
Roasted almonds	/	4	6
Tobacco	/	7	11
Mushroom	/	2	/
Moss	/	1	7
Fresh grass	/	1	6
Smoke	/	2	2
Earth	/	1	14
Forest	/	1	1
Manure	/	/	1
Vegetable			
Tea	/	3	6
Hay	/	4	8
Dairy			
Cream/milk	33	14	2
Butter	36	4	1
Spicy			
Cinnamon	/	1	/
Bakery			
Flour	1	1	/
Bread / Toast	/	3	/
Other			
Plastic	/	4	/
Insects	/	/	8

Flavour			
Fruit	White	Milk	Dark
Raisin	/	/	2
Red Berry	1	2	2
Banana	7	1	1
Coconut	/	17	1
Other fruit	5	14	11
Sweet			
Jam	1	/	/
Honey			9
Sugar	2	1	2
Caramel	5	22	2
Liquorice		/	/
Ginger cookie	1	/	/
Marzipan		/	13
Vegetable			
Mint	/	1	2
Olives	/	1	/
Tea		1	/
Hay	/	3	5
Floral			
Rose	/	1	/
Vanilla	32	6	3
Other flowers		/	1
Alcohol			
Alcohol	/	2	4
Earthy			
Nuts	1	14	3
Coffee	/	8	18
Cocoa	/	14	22
Tobacco	/	4	8
Wood	/	12	7
Mushroom	/	/	1
Moss	/	1	2
Fresh grass	/	2	1
Earth	/	/	12
Forest	/	/	1
Spicy			
Cinnamon	/	/	1
Dairy			
Cream	5	5	1
Milk	14	10	0
Butter	29	7	1
Other			
Insects	/	1	2
Plastic	/	1	1
Cough syrup	/	/	3
Aftertaste	13	12	12

groups the chocolate are positioned further from each other than in Fig. 2c and Fig. 2d. This indicates that among the white chocolate larger differences are present for texture than for aroma and flavour. The same explanation can be given for milk and dark chocolate. The plot shows that hardness, snap and aftertaste are characteristic for dark chocolate. The close position of hardness and snap towards each other indicates that these two descriptors are strongly correlated. The graininess and stickiness are mostly felt in white and milk chocolate. Creaminess is mostly present in milk chocolate and dryness in milk and dark chocolate.

Fig. 2c shows that the three chocolate are closely related in terms of aroma. This suggests that the difference between the three types of chocolate is larger when looking at the aroma of the chocolate. This is also due to the fact that not all aromas were used in the testing of the different chocolate. Further, the plot shows that the chocolate within milk and dark chocolate are positioned close to each other. For white chocolate, the chocolate samples are further from each other which indicates that these are more different from each other in aroma than the other two types of chocolate. The white chocolates have a buttery and sugary aroma whereas milk/cream, vanilla, honey aroma are representative for both white and milk chocolate. Caramel aroma is only related to milk chocolate. Milk and dark chocolate have the nutty, woody, tobacco, coffee and cocoa aroma in common. Aromas of plants and earth are only characteristic for dark chocolates.

The visual relationship between the basic tastes and flavour are presented in Fig. 2d. Similar to the PCA loadings plot for aroma (Fig. 2c), the three types of chocolate are grouped together with little differences among the samples within one type of chocolate. The bitter taste and to a lesser extent sour taste are only related to dark chocolate. Coffee, tobacco, earth and fruity flavour are also related to dark chocolate. Cocoa flavour is related to both dark and milk chocolate whereas nutty, caramel, marzipan, and milk/cream flavour are more

Fig. 1. Chocolate sensory wheel

closely related to milk chocolate. Sweet taste is more linked to milk chocolate than to white chocolate. White chocolate is more associated to butter, honey and vanilla flavour.

The figures show that the panel was able to distinguish between the products using the sensory lexicon generated by the consumers.

4. Discussion

In this study, focus groups with chocolate consumers were organised for collecting information on the sensory attributes of white, milk and dark chocolate. The goal was to identify a broad range of sensory attributes which can be useful to evaluate and characterise all kinds of chocolate products. Sensory characterisation of chocolate can be used to understand which characteristics are influencing consumers' preference. Therefore, the results of this study create opportunities for product improvement or product development. The most important descriptors were visualised in a sensory wheel.

This study worked with a selection of 22 commercial chocolate samples including white, milk and dark chocolates. The chocolate samples were produced by 11 different companies, both from Belgium and abroad. The selected chocolate samples represent a selection of the available chocolate products in Belgium, containing conventional, organic and fair trade chocolate. The selected chocolate samples also differed in price, brand and ingredients as it is important to include a range of products with different sensory profiles to develop a sensory lexicon (Drake & Civille, 2003; Koch et al., 2012). The same approach was used in other studies for the development of a sensory lexicon for rooibos tea (Koch et al., 2012), honey bush tea (Theron et al., 2014) and marine oil (Larssen et al., 2018). This study opted to include white, milk and dark chocolate so that the sensory lexicon would be broad. This is in contrast with the approach used by Aparicio, Morales, and Alonso (1996) which excluded 'extra virgin' and 'pomance' oil for examining the relationship between volatile components and sensory attributes in 16 olive oil samples. This study used 22 samples to generate a sensory lexicon, which is in line with other research using 16 and 20 samples to develop a sensory lexicon for respectively olive oil (Mojet & de Jong, 1994) and honey (Galán-Soldevilla, Ruiz-Pérez-Cacho, Serrano Jiménez, Jodral Villarejo, & Manzanares, 2005). However, other studies used around 44 (Larssen et al., 2018) to 69 (Koch et al., 2012) different samples to develop a sensory wheel but this study worked with consumers and not trained panellists. One need to bear in mind that although the variety of used chocolate samples to develop a sensory lexicon in this study was broad in the context of the Belgian market, other samples could have other sensory characteristics due to other ingredients, processing methods and storage conditions. Nevertheless, the sensory lexicon generated through the focus groups of this study can be seen as a groundwork for further research especially given the growing application of rapid sensory profiling methods using consumers or non-trained panellists (Delarue, Lawlor, & Rogeaux, 2015; Varela & Ares, 2012).

This study opted to work with 5 focus groups using consumers (n = 48) to generate a sensory lexicon. Lawless and Heymann (2010) declared that focus groups are of interest for the identification and exploration of specific sensory interest. Generation of sensory attributes can not only be conducted with technical personnel or trained panellists, which is often the case when developing a sensory lexicon for descriptive analysis, but also with consumers (Chambers & Smith, 1991). The advantage of working with consumers is that also attributes will be included which are strongly influential on consumer acceptance (Chambers & Smith, 1991). Consumer focus groups could also be of

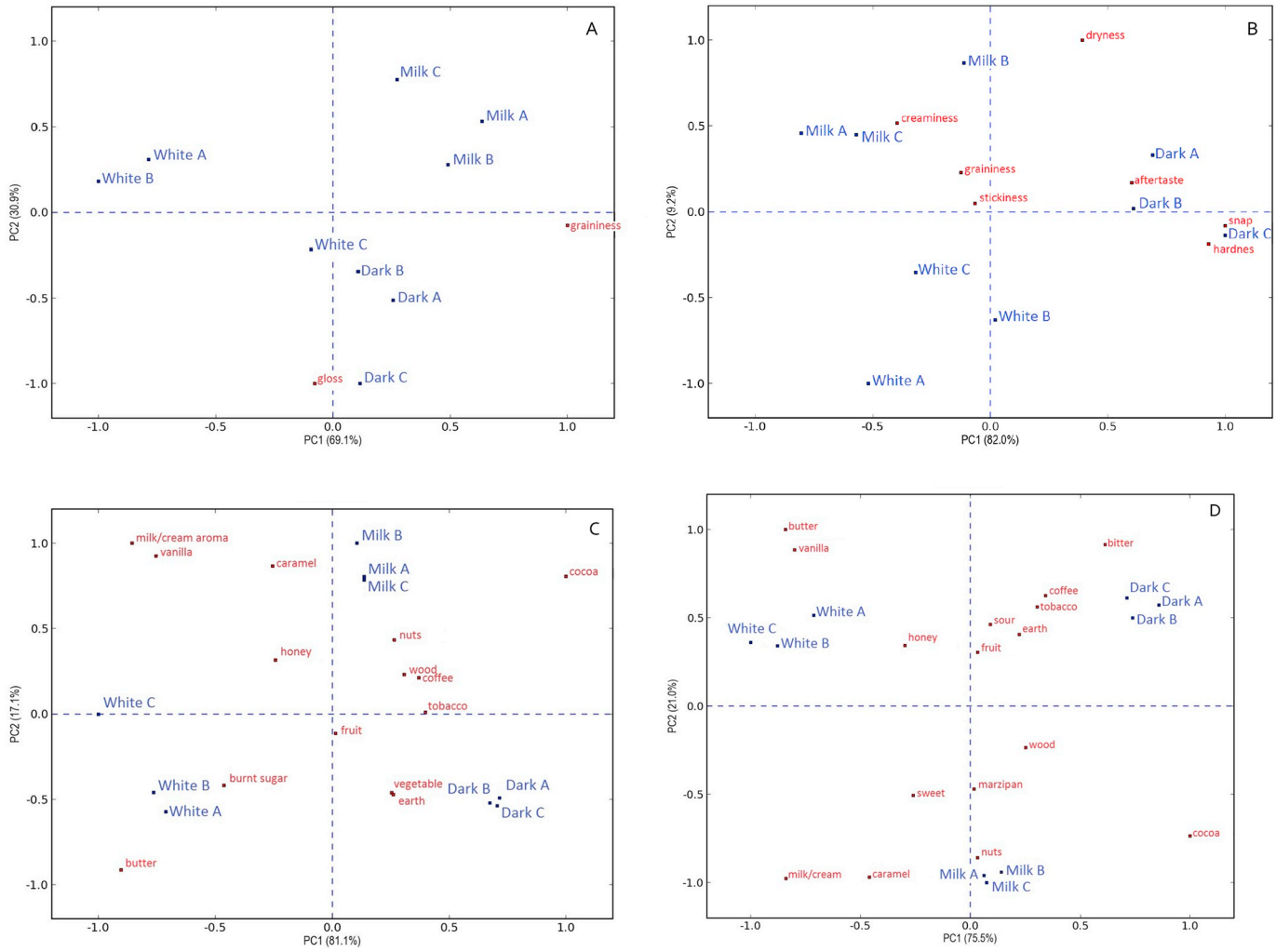

Fig. 2. PCA analysis of the significant attributes for the three types of chocolate on A) Appearance, B) Texture, C) Aroma and D) Flavour

interest for generating sensory terms for rapid sensory profiling, which is still one of their main challenges (Varela & Ares, 2012). This study opted to work with focus groups of 9–10 persons, while groups with up to 12 persons are common in sensory research (Lawless & Heymann, 2010). Saturation criteria were used to determine the number of focus groups, namely the degree to which new data repeat what was expressed in previous data obtained in earlier focus groups (Saunders et al., 2018). The number of focus groups should therefore be sufficient to obtain qualitative data. The number of persons who participated in the focus groups (n = 48) is higher compared to the number of participants for generating sensory lexicons and sensory wheels in previous studies which varied between 9 and 22 persons (Gawel, Oberholster, & Francis, 2000; Koch et al., 2012; Larssen et al., 2018; Theron et al., 2014). However, one need to consider that these studies worked with experts while the current study worked with consumers.

The focus groups generated in total 2199 attributes which were reduced to a list of 108 descriptive terms through sorting, ranking and grouping. The approach applied in this study is similar to the one used by Gawel et al. (2000) generating descriptions of mouthfeel of red wine, and Larssen et al. (2018) describing marine oil. In this study, the sorting was conducted by the researchers which is a similar procedure as Larssen et al. (2018) while Gawel et al. (2000) used the panellists for the sorting task. Similar to the study by Koch et al. (2012) only relevant, unambiguous, non-redundant and non-hedonic terms were withheld for the preliminary list with descriptive terms (n = 108). Given that this is still a long list, this preliminary list was further limited based upon the usage frequency during focus groups (> 5%) (Koch et al., 2012). The researchers also opted to include the basic flavours sweet, bitter and sour resulting in a final sensory lexicon containing 61 terms. This total number of attributes is in line with other research (Gawel et al., 2000; Larssen et al., 2018) and also considering that a too rigid reduction of sensory descriptors might result in losing sensory attributes which are crucial for obtaining unique sensory product profiles (Theron et al., 2014; Wolters & Allchurch, 1994). In order to visualize the obtained chocolate sensory lexicon, a three-tiered sensory wheel was constructed using XLSTAT software (Addinsoft, France) version 2018.4. The grouping of the attributes was based upon input of the focus groups and the expertise of the researchers (Gawel et al., 2000). The largest differences were found in the aroma and flavour descriptors of white, milk and dark chocolate. These characteristics are determined by the composition of the ingredients. The more cocoa mass is added to chocolate, the more extensive the aroma and flavour spectrum of the chocolate becomes. The more exotic and special flavours occur in the origin chocolate.

For appearance and texture, similar attributes are pointed out as being important for being discriminating. However, other standards are set for these attributes according to the type of chocolate. For example hardness and snap need to be different in white, milk and dark chocolate. Regarding aroma and flavour, the evaluation of chocolate becomes a technicality. The descriptors for appearance and texture are mostly dependent on the production parameters. Despite the effort of the manufacturers to create unique products, consumers appear to be

limited in their vocabulary to describe the sensory properties of chocolate (Thamke, Duerrschmid, & Rohm, 2009). This is also consistent with previous descriptive studies in dark and milk chocolates. Prior research found only few aroma descriptors but indicated that taste and mouthfeel were the most significant sensory categories for describing chocolate products (Dürrschmid, Albrecht, Schleining, & Kneifel, 2006; Thamke et al., 2009).

Few significant differences were found among the chocolate samples within one type chocolate (white / milk / dark chocolate). It could be that rather similar ingredients were used and that also the process conditions were similar. White C chocolate had the highest milk/cream and vanilla aroma and was evaluated as being the sweetest. The PCA loadings suggest that milk/cream aroma is linked with creaminess. The results of the milk chocolate show that snap is related to hardness. Moreover a stronger cocoa flavour could be linked to a dryer mouthfeel. In dark chocolate, the cocoa flavour is related to bitter taste and fruity flavour to sour taste.

The comparison between the types of chocolate can indicate which attributes were typical for white, milk and dark chocolate. For dark chocolate, the high gloss, snap, hardness, and aftertaste are the most important attributes. Dryness in mouth is less pronounced than the former attributes but still more characteristic for dark chocolate than other chocolate. The creaminess is important for milk chocolate.

PCA plots can also be used to indicate whether certain attributes are redundant and may be reduced to a simplified set of terms. This is to prevent different attributes from being used to describe an identical sensory characteristic (Naes et al., 2010). These plots can also demonstrate whether correlations exist between an aroma and flavour attribute that has been analysed by nose and by mouth. Most of these attributes such as milk/cream, caramel, nuts, cocoa, tobacco, fruity, honey, earth were closely associated with one another, indicating that these notes were perceived similarly on the nose as well as the palate with the same intensity. Future research could combine this analysis from a trained panel with instrumental aroma or flavour analysis (e.g. gas chromatography–mass spectrometry, Moreira, Vilela, Santos, Lima, and Schwan (2018)). This was not included in this research due to limited time and funding.

It should be noted that this study was only a first attempt at developing a complete chocolate sensory wheel. It can be expected that certain modifications have to be made over time as the wheel is presented to and used by the chocolate industry. Previous examples, such as the wine aroma wheel developed by Noble et al. (1984) was modified after having collected constructive suggestions from the industry (Noble et al., 1987). Some attributes were removed from the wheel while others were added. Moreover, the reference standards provided for each of the terms and the order of the attributes was altered. Koch et al. (2012) anticipates that similar alterations will be necessary for the sensory wheel for rooibos infusions. Therefore, the complete sensory chocolate wheel might be improved and refined in the future due to feedback from the industry and other researchers.

5. Conclusion

The most defining descriptors for appearance of chocolate are colour, gloss and smoothness of the surface. Hardness, snap, melting behaviour and graininess are the texture attributes on which the choice of consumers is based. Although these descriptors were used for white, milk and dark chocolate, different standards are set for them for the different types of chocolate. The main differences were found in the aroma and flavour profile.

Perfection is difficult to achieve but all chocolate producers are thriving to produce the product with optimum sensory characteristics for each segment of the market. In order to achieve this, the understanding of consumers, the instrumental evaluation and the evaluation with a sensory trained panel are very important. As a producer, it is important to know which sensory descriptors are important and steering the decision of the consumer to buy, eat and repeat the process. Through focus groups, these descriptors can be identified and an extensive consumer test can indicate the importance and expectations of these attributes. A trained sensory panel can finally evaluate the end product or a novel rapid sensory profiling method (e.g. CATA, RATA, …) can be used. This sensory profiling can then be linked to the preference of consumers in order to understand the drivers of liking.

The evaluation and measurement of commercial chocolate has as main drawback that the complete ingredient list is not known in detail and that no information is available on the production process, transportation and storage. Therefore it can be difficult to explain significant differences among chocolate. However, using commercial samples has the advantage that these are products that are actually consumed by consumers and are therefore known to have a minimum of preferred attributes.

Further research can be performed in finding correlations between the sensory attributes for aroma and flavour for commercial chocolate and instrumental measurements.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

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