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Sensory description of dark chocolates by consumers

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ABSTRACT

The Free Choice Profiling technique was applied to examine the analytical abilities of consumers ($n = 39$) from two different locations (Vienna, Austria, and Dresden, Germany) to characterize plain dark chocolate. The cocoa content of the chocolate samples investigated in the study ranged from 60% to 75%, and General Procrustes Analysis and subsequent Principal Component Analysis were used for data analysis. Despite the different local background, both panels used an identical vocabulary for describing the samples; on average, only five descriptors (range: 3–13) were chosen by each assessor. Twenty nine different descriptors were generated by the Vienna panel, and 41 descriptors by the Dresden panel. Although differently assigned to Principal Components (PC) 1 and 2 which, together with PC3, accounted for approximately 85% of the total variance, the panels distinguished between the samples on a comparable level and used a comparable terminology with respect to type and frequency of the descriptors. A combined data evaluation revealed that the easily perceivable taste descriptors were useful for sample separation, whereas flavor descriptors only supported these data. With respect to mouthfeel, chocolate with a lower cocoa content was characterized as melting and creamy, whereas the product with the highest cocoa content was characterized as dry, mealy and sticky.

1. Introduction

Although annual consumption of chocolate in central Europe (approximately 10 kg/head; Alberts & Cidell, 2006) did not change significantly in the past years, there is a continuous and increasing trend towards high-priced dark chocolate and delicacies without milk solids and a high cocoa content. In 2006, dark chocolate accounted for approximately 15% of the German market, and dark chocolate production increased for approximately 23% from 2005 to 2006. Alberts and Cidell (2006) and Cidell and Alberts (2006) also pointed on specific consumer's attitudes in central Europe where chocolate is regarded as a serious food, which undoubtedly affects marketing strategies.

Apart from indulgence, other factors must be considered in context with chocolate consumption: consumption-induced emotional changes (e.g., reduced hunger, or elevated mood) are stronger than those induced by other foods (Macht & Dettmer, 2006), and chocolate is associated with joy and pleasure, potentially being stimulant, relaxant, euphoriant, or antidepressant (Parker, Parker, & Brotchie, 2006). Macht and Mueller (2007) demonstrated that chocolate immediately affects negative mood but shows a low impact on neutral or positive moods, with "palatable" products (milk chocolate, dark with low cocoa) being more effective than "unpalatable" (85% or 99% cocoa) chocolate. It was also shown that negative emotions may be controlled by eating (Macht, Haupt, & Ellgring, 2005), especially by an increased intake of sweet foods (Pollard, Steptoe, Canaan, Davies, & Wardle, 1995; Striegel-Moore et al.,1999). Additionally, subjects with increased appetite usually choose sweeter foods, among them chocolate, and healthy eating habits decrease under stress (Kandiah, Yake, Jones, & Meyer, 2006).

Chocolate is frequently mentioned as the most commonly craved food and, for most chocolate cravers, non-chocolate substitutes are inadequate (Drewnowski, Kurth, Ho, & Saari, 1992; Weingarten & Elston, 1991). Rozin and Michener (1998) showed that chocolate craving cannot be eliminated by ingesting white chocolate or pills containing pharmaceutically active constituents of chocolate; these constituents may contribute to the genesis of craving but, for decreasing their craving symptoms, "chocoholics" definitely need the sensory experience of the real product.

Recently, emphasis has been placed on nutritional benefits arising from chocolate consumption. In the European and American diet cocoa solids represent a significant source of polyphenols (Vinson et al., 2006), which are discussed for being beneficial in heart and vascular protection through their antioxidative activity (Arifdjohan & Savaiano, 2005; Ding, Hutfless, Ding, & Girotra, 2006; Engler & Engler, 2006). There are new approaches for the production of flavonoid-enriched products (Tomas-Barberan et al., 2007),

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and manufacturers are – despite some indications that healthfulness might be irrelevant in the case of chocolate products (di Monaco, Ollilla, & Tuorila, 2005) – trying to improve the image of dark chocolate through transporting health benefits.

It is surprising that the literature on sensory properties of dark chocolate is rare. Several authors (Husson & Pages, 2003; McEwan, Colwill, & Thomson, 1989; Pages & Husson, 2001) used chocolate as a reference for methodical comparisons, whereas the work of Januszewska and Viaene (2001a, 2001b, 2002) mainly focused on cross-cultural effects and preferences in two European countries with a different history in chocolate consumption. Free Choice Profiling (FCP), initially applied to port (Williams & Langron, 1984), is an interesting tool for evaluating sensory properties of foods from the consumer's point of view (Delarue & Siefferman, 2004; Lawless & Heymann, 1999). As regards sensory descriptions, the language of a consumer is more global, not analytical and less accurate than the language of experts, which differs because of the exhaustive definition of the sensory attributes of a particular product (Sune, Lacroix, & Huon de Kermadec, 2002). FCP can easily be performed with consumers, who develop an individual vocabulary in their own, non-scientific language during judging a set of products, and who score the products by using this vocabulary; it is further assumed that the sensory character of a product is perceived similarly by the panelists, who use an idiosyncratic vocabulary (Narain, Paterson, & Reid, 2003). As both the descriptors between individuals and the number of descriptors per assessor may differ largely, it is necessary to refer to special multivariate methods to compare different data matrices (Dijksterhius, 1997). After deriving a consensus product space by Generalized Procrustes Analysis (GPA; Gower, 1975), it is possible to gain information on the way how consumers differentiate between the items under study (Jack & Piggott, 1992).

The aim of the present study was to identify sensory key attributes of consumers for the discrimination of dark chocolate by applying Free Choice Profiling. A second aim was to evaluate whether sensory panels in two locations with a different cultural and language background differentiate the products in a similar or different way.

2. Materials and methods

2.1. Chocolate samples and their preparation

Six formulations of dark chocolate, purchased in a local supermarket in Dresden, were used in the study. The samples had to meet the following requirements: plain products in bars (without any fillings), intermediate cocoa content (i.e., 60–75%), package size 80–120 g, different manufacturers, production in Germany (both East and West). The composition of the samples, taken from the package labels, is given in Table 1. Each sample was from one single production lot and stored at 5 °C until analysis.

Table 1
Sample coding, cocoa content and ingredients of the chocolate samples

Sample code	Cocoa content	Ingredients
SH	60	Cocoa mass, sugar, cocoa butter, sweet whey powder, soy lecithin, vanillin
RS	65	Cocoa mass, sugar, low-fat cocoa powder, cocoa butter, soy lecithin, polyglycerol polyricinoleate, vanillin
L	70	Cocoa mass, sugar, cocoa butter, vanillin
BS	70	Cocoa mass, cane sugar, low-fat cocoa powder, soy lecithin
K	72	Cocoa mass, sugar, cocoa butter, low-fat cocoa powder, canola, lecithin, aroma
RT	75	Cocoa mass, cane sugar, cocoa butter

Specimens with a size of 20 × 20 mm were separated from the chocolate bars with a hot wire cutting device; the initial sample height was similar and remained unaffected. The brand name on the chocolate was eliminated by means of a warm spoon. For sensory analysis, the samples were equilibrated to room temperature (22 ± 1 °C) and served in Petri dishes encoded with random three-digit numbers, generated by the Fizz software (Biosystèmes, Couternon, France). All assessments were done in individual booths of sensory laboratories under white light illumination (color temperature: 6500 K).

2.2. Assessors

The assessors in Vienna and Dresden were students of the respective departments. Selection criteria were availability for the assessments, interest to participate in the study, the absence of aversions, allergies or intolerance against dark chocolate, normal perception abilities, and no chocolate craving. None of the panelists had a specific training in sensory evaluation of chocolate, nor previous experience with FCP. Fifteen persons (11 female, four male) contributed to the experiments in Vienna, and 24 (15 female, nine male) contributed to the experiments in Dresden.

2.3. Free-Choice Profiling

In the first of two sensory sessions, the assessors were given a brief introduction into the methodology and the procedure of FCP (Anonymous, 2003). In single sessions, they were then confronted with the six encoded chocolate samples at once, asked to taste the samples and to use their individual vocabulary for describing sensory characteristics and key features (taste, flavor, and mouthfeel) of the products. The participants were also instructed to refer only to objective attributes and not to use hedonic terminology. Lukewarm tap water and matzo bread were served for mouth-clearing.

Based on the descriptors used by the panelists in the preliminary session, individual score cards were prepared. These score cards were sheets of paper (21 × 10 cm), labeled with the name of the assessor, with the particular descriptor, and line marking scale of a length of 10 cm (Deliza, MacFie, & Hudderley, 2005). Endpoints were labeled with the attributes "nicht vorhanden" (not at all) and "stark ausgeprägt" (extremely). In this session (on average, 3–4 days after session 1), the samples were served monadically, and the serving order of the six samples was randomized (Fizz software). During judgement, it was up to the assessors (a) to eliminate the one or other descriptor if it came to their mind that it had become irrelevant, or (b) to join two descriptors into a new one.

2.4. Statistical analysis

The data from Free Choice Profiling, i.e., the intensities of each attribute as evaluated by the assessors, were analyzed using the GPA tool in the Senstools V.3.0.11 software (OP & P Product Research BV, Utrecht, The Netherlands). Each of the 39 individual matrices (15 from Vienna, and 24 from Dresden) had six rows and a different number of columns, which corresponds to the number of descriptors elaborated by each assessor. After deriving a consensus matrix from the individual data sets, Principal Component Analysis (PCA) reduces the dimensionality of the matrix with a minimum loss of variation (Lachnit, Busch-Stockfisch, Kunert, & Krahl, 2003). The dimensions (principal components) of the obtained space were interpreted by considering the descriptors most highly correlated with each dimension for each assessor (Costell, Trujillo, Damasio, & Duran, 1995; Gains & Thomson, 1990).

Table 2
Free Choice Profiling attributes (in German, and English translation) used for describing taste and flavor of chocolate

Vienna panel ($n = 15$)		Dresden panel ($n = 24$)	
#[a]	Descriptor (translation)	#	Descriptor (translation)
11	Bitter (*bitter, tart*)	21	Bitter (*bitter*)
10	Süß (*sweet*)	15	Süß (*sweet*)
6	Sauer (*acidic*)	10	Sauer (*acidic*)
6	Kakaogeschmack (*cocoa*)	7	Bitterer Nachgeschmack (*bitter aftertaste*)
4	Nussig (*nutty*)	6	Fruchtig (*fruity*)
2	Hantiger Nachgeschmack (*harsh aftertaste*)	6	Kakaoaroma (*cocoa*)
2	Ranzig (*rancid*)	5	Schokoladig (*chocolate-like*)
2	Schokoladig (*chocolate-like*)	5	Modriger Nachgeschmack (musty aftertaste)
2	Zitronig (*citrus-like*)	4	Herb (*tart*)
1	Angebrannt (*burnt*)	3	Kaffeeartig (*coffee-like*)
1	Buttrig (*buttery*)	2	Ölig (*oily*)
1	Fruchtig (*fruity*)	2	Kräuterartig (*herb-like*)
1	Herb (*tart*)	2	Nussig (*nutty*)
1	Karamellig (*caramel-like*)	1	Alkoholisch (*alcoholic*)
1	Metallisch (*metallic*)	1	Anhaltend (*persistent*)
1	Ölig (*oily*)	1	Aromatisch (*aromatic*)
1	Pflaumengeschmack (*plum-like*)	1	Ausgeglichen (*harmonic*)
1	Puddingartig (*pudding-like*)	1	Citronat (*canded lemon peel*)
1	Salzig (*salty*)	1	Erdig (*earthy*)
1	Storck Riesen	1	Nach Essig (*vinegar-like*)
1	Zimtgeschmack (*cinnamon-like*)	1	Fremdnote (*weird note*)
		1	Holzig (*woody*)
		1	Minzig (*minty*)
		1	Olive (*olive*)
		1	Salzig (*salty*)
		1	Stechend (*pungent*)
		1	Vanillearoma (*vanilla*)
		1	Würzig (*spicy*)

[a] Frequency of occurrence.

3. Results and discussion

3.1. Identification of sensory key attributes of dark chocolate

In Free Choice Profiling, the assessors generated between three and 13 attributes for the sensory characterization dark chocolate, with the median value being five attributes for both the Vienna and the Dresden panels. In a couple of cases, assessors commented that it was difficult to generate other descriptors than the standard vocabulary, comprising terms such as bitter, sweet, acidic, cocoa, or melting. The average number of descriptors per panel member is in fact lower than the corresponding number observed in studies on milk chocolate (McEwan et al., 1989), and also lower than in many FCP studies on other foods wherein a considerable number of attributes was elicited (Deliza et al., 2005; Diaz-Maroto, Gonzalez Vinas, & Cabezudo, 2003; Lachnit et al., 2003; Narain et al., 2003). This is also consistent with a previous descriptive study on milk chocolates, which showed only a few aroma descriptors but revealed that taste and mouthfeel were the most significant sensory categories for describing the products (Dürrschmid, Albrecht, Schleining, & Kneifel, 2006). As regards taste and flavor descriptors, the Vienna panel delivered a total of 57 responses for 21 attributes, and the corresponding figures for Dresden were 102 responses and 28 attributes (Table 2). Eight and 13 descriptors related to mouthfeel properties were mentioned with a frequency of 22 and 37 in the experiments in Vienna and Dresden, respectively. In neither descriptor category, the inspection of the attributes revealed eye-catching disparities in the use of the vocabulary by the different panels as might be expected on the basis of a previous study (Rohm, Jaros, Lailach, & Fischer, 1994); only the Viennese colloquial speech expression “hantig” (harsh) was used by two assessors.

3.2. Panel-specific differentiation of dark chocolate

For the Vienna panel, the PCA on the consensus matrix obtained from the Generalized Procrustes Analysis of the FCP data revealed that the first three principal components account for 83.2% of the variance (PC1, 41.0%; PC2, 30.0%; and PC3, 12.2%). The corresponding values obtained for the Dresden group were 45.8%, 23.1% and 16.2%; hence, PC1–PC3 accounted for 85.1% of the total variance. Table 3 summarizes the attributes which were chosen by the panelists to describe dark chocolate in terms of flavor, taste and mouthfeel, and whether these attributes were correlated with PC1, PC2 or PC3.

It is evident from the group average plots for the taste descriptors in the PC1–PC2 space (Fig. 1), which also show the location of the chocolate samples, that both panels were able to distinguish clearly between the products. The coordinates of the products in the PC1–PC2 space reflect the correlations outlined in Table 3. Exemplary, for the Vienna panel, the descriptor sweet, which was used by 10 panel members, is exclusively associated with PC1 whereas, for the Dresden panel, sweet showed nine times

Table 3
Taste, flavor and mouthfeel descriptors and their correlations with principal components (PC) 1, PC2 and PC3

Vienna panel				Dresden panel			
Descriptor	PC 1[a]	PC 2	PC 3	Descriptor	PC 1	PC 2	PC 3
Taste and flavor							
Bitter	6	5		Bitter	14	7	
Sweet	10			Sweet	9	6	
Acidic	2	4		Acidic	2	5	3
Cocoa	1	2	3	Bitter aftertaste	4	3	
Nutty	2	2		Fruity	2	3	1
Harsh aftertaste		1	1	Cocoa	3	2	1
Rancid	1	1		Chocolate-like		4	1
Chocolate-like		2		Musty aftertaste	1	2	2
Citrus-like		2		Tart	4		
Burnt	1			Coffee-like	1		2
Buttery			1	Oily	2		
Fruity			1	Herb-like		2	
Tart	1			Nutty		2	
Caramel-like			1	Alcoholic			1
Metallic			1	Persistent	1		
Oily	1			Aromatic			1
Plum-like		1		Harmonic			1
Pudding-like	1			Canded lemon peel			1
Salty			1	Earthy	1		
Storck Riesen			1	Vinegar-like		1	
Cinnamon-like	1			Weird note			1
				Woody	1		
Mouthfeel				Minty			1
Melting	2	5		Olive			1
Mealy		4		Salty	1		
Dry	4			Pungent		1	
Grainy	2			Vanilla		1	
Sticky	1	1		Spicy			1
Adstringent	1						
Burning		1		*Mouthfeel*			
Fine	1			Melting	8	2	3
				Creamy	2	2	2
				Mealy	2	1	
				Dry	1		1
				Coarse	1	1	
				Sticky		1	1
				Rough	1	1	
				Mouth-coating	1	1	
				Burning		1	
				Fine		1	
				Grainy	1		
				Dense		1	
				Scratching	1		

[a] Figures in the cells refer to the number of times a particular descriptor was correlated with the corresponding principal component.

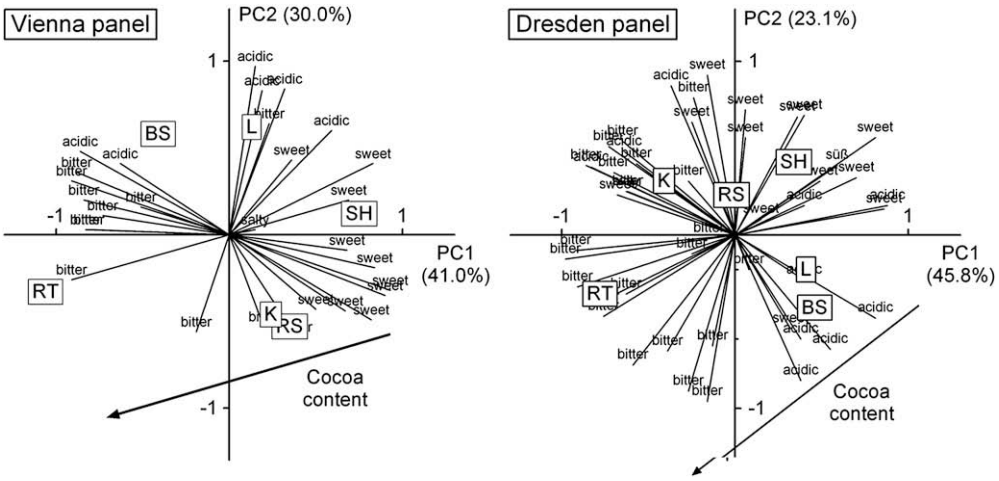

Fig. 1. GPA group average plots for taste descriptors as delivered by the Vienna panel ($n = 15$) and the Dresden panel ($n = 24$). For sample encoding, see Table 1.

the highest correlation with PC1 and six times with PC2. Chocolate RT is clearly separated from all other products and resides in a bitter domain, and the samples BS and L as well as K and RS appear to be closely related. SH is closer to K and RS for the Dresden panel but separated from the K/RS and the BS/L product cluster for the Vienna panel. The location of chocolate SH in the sweet domain and the location of RT in the bitter domain of the plot appears to be clearly linked to the cocoa content of these samples, which was 60% and 75%, respectively, and to the different sugar content which decreases with increasing cocoa. Similar findings were evident from the GPA group average plots for the flavor descriptors and for the mouthfeel properties (data not shown).

The different grouping of the chocolates with respect to the virtual axis orthogonal to the cocoa content axis can be explained by the fact that GPA and PCA resulted in panel-specific sample loadings for PC1, PC2 and PC3 (Fig. 2). Exemplary, the chocolate samples BS and L were distinguished along PC1 by the Vienna panel, whereas almost identical loadings were observed for the Dresden panel; these two samples were, however, differentiated along the PC2 axis by the Dresden panel. The similarity of the lists of sensory descriptors obtained by the two panels (see Table 2) and the likewise grouping of the chocolate samples in the PC1–PC2 plots indicate that there is no difference in the sensory response to the products under study. Therefore, it is justified to combine the FCP data of the two panels for a global analysis.

3.3. Sensory key characteristics of dark chocolate

After performing GPA and PCA for the entire data from 39 panelists (i.e., 39 sets with 3–13 columns/descriptors) the group average plots were, for the sake of clarity, separated with respect to descriptor category: the taste descriptors are shown in Fig. 3, the flavor descriptors are shown in Fig. 4, and the mouthfeel descriptors in Fig. 5. As regards taste, bitter is positively associated with PC1, whereas acidic and sweet are reflected by negative loadings on PC1 and positive and negative loadings on PC2, respectively. Samples SH, RS and K (60%, 65%, and 72% cocoa) show a similar sweetness, higher than those of samples RT, L and BS (75%, 70%, and 70% cocoa). RT, the product with the highest cocoa content, is unequivocally the one with the highest bitterness, and followed in bitterness by RS and K. Samples BS and L are obviously the most acidic products.

Although the grouping with respect to taste categories is also reflected by some of the flavor descriptors (Fig. 4), there is apparently no possibility for a reliable flavor grouping because of the lack of intersubjectivity in flavor perception, which is responsible for the resulting inconsistency in the use of descriptors. Intersubjectivity, introduced by Davidson (2001), is used in psychology and philosophy to describe the strategy of human beings to use consensual codes of communication about subjective perceptions. Nevertheless, it is obvious that fruit-related descriptors such as citrus or lemon, plum, and fruity only occur in the acidic group (see Fig. 3). Associated with the bitter group are descriptors such as bitter/harsh aftertaste, tart, cocoa, coffee, and nutty, and descriptors such as vanilla or chocolate solely appear in the vicinity of the sweet cluster. As regards mouthfeel descriptors, the samples separate along an axis from melting and creamy to dry, sticky and mealy. Chocolate SH with a cocoa content of 60% according the product label had the highest score on melting/creamy whereas sample RT with a cocoa content of 75% had the highest score on dry/sticky/mealy.

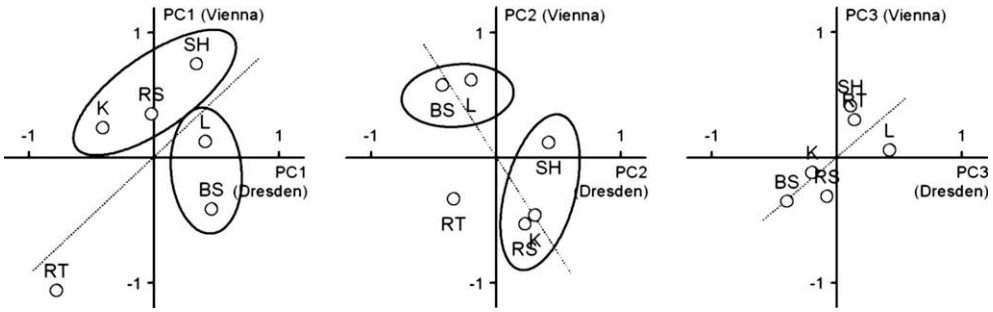

Fig. 2. Comparison of the component loadings for the Vienna panel ($n = 15$) and the Dresden panel ($n = 24$).

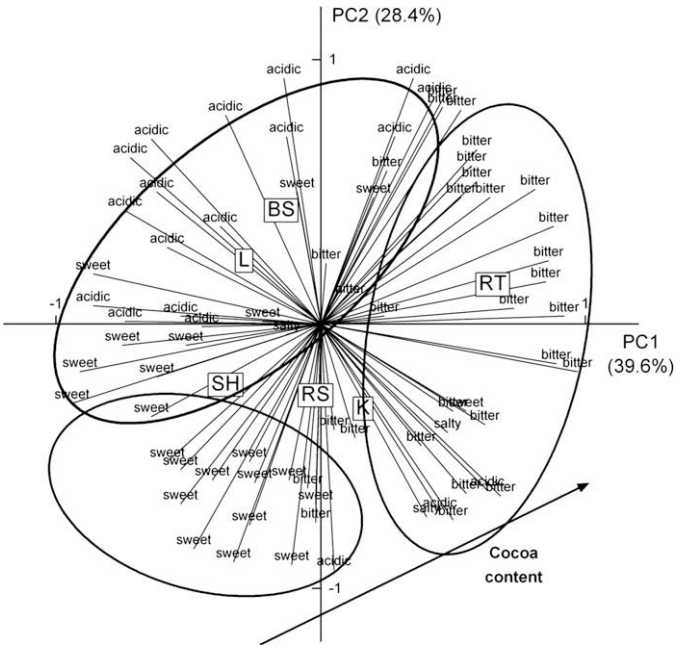

Fig. 3. GPA group average plots for the taste descriptors and the combined panel ($n = 39$). For sample encoding, see Table 1.

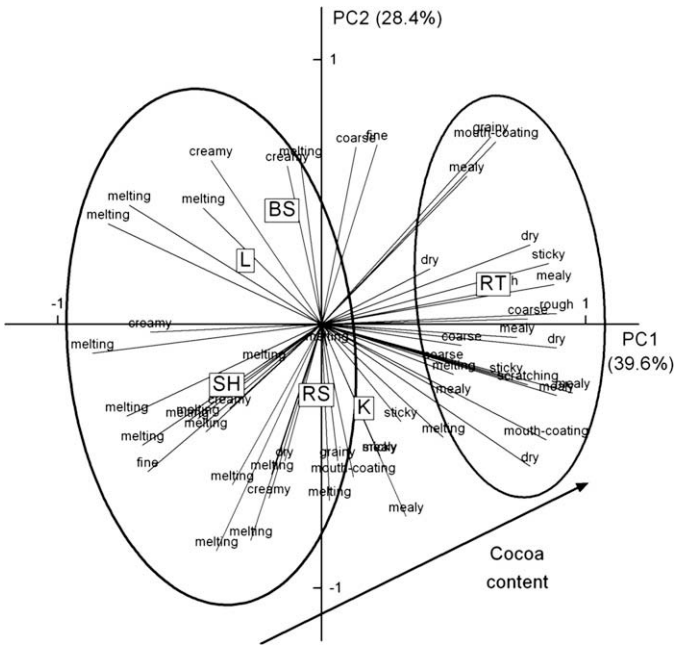

Fig. 5. GPA group average plots for the mouthfeel descriptors and the combined panel ($n = 39$). For sample encoding, see Table 1.

4. Conclusions

Despite the effort of the manufacturers to create unique products, consumers appear to be very limited in their vocabulary to describe the sensory properties of dark chocolate. This is corroborated by the fact that two panels from different countries, having the same mother tongue but significant differences in colloquial speech expressions, did not differ in the descriptors used in the assessment of the products. In both locations, key descriptors were bitter, sweet, acidic, cocoa, and melting. As regards taste and mouthfeel, the grouping of the samples based on sensory data showed a distinct correlation with the cocoa content of the products under study; flavor descriptors can, however, only be considered as auxiliary tools for distinguishing between the samples. Our data do also indicate that the panelists obviously apply a particular strategy for finding and describing sensory properties. First, they construct a sensory frame of easily perceivable sensory properties which are, in the case of chocolate, the basic tastes sweet, sour, and bitter. In a second step, they try to identify further and more subtle properties and descriptors of aroma and flavor perceptions which fit into this frame and which are based on their sensory memory and their actual sensory experience. Some panelists get as far as giving very subtle sensory descriptions, whereas some others remain at a very low descriptive level.

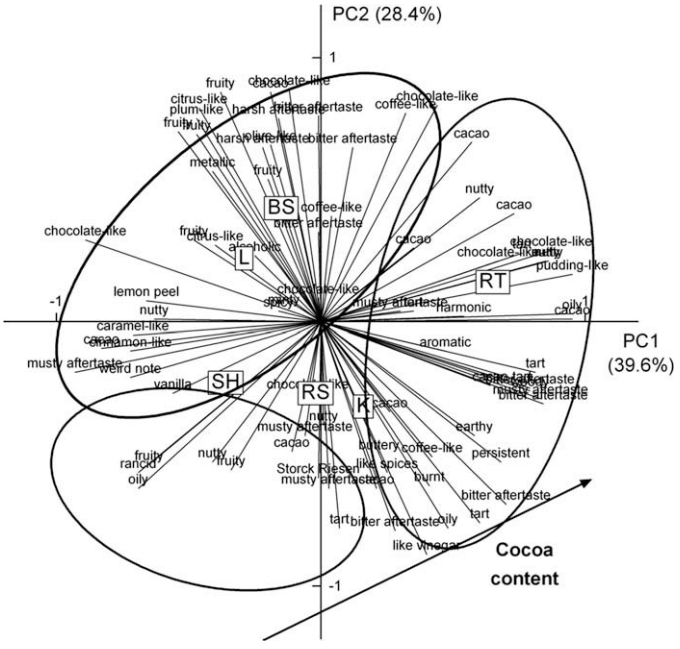

Fig. 4. GPA group average plots for the flavor descriptors and the combined panel ($n = 39$). For sample encoding, see Table 1.

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