WHAT IS MOUTHFEEL?

SENSORY-RHEOLOGICAL RELATIONSHIPS IN INSTANT HOT COCOA DRINKS

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ABSTRACT

Fourteen samples of instant cocoa drinks with different compositions of main ingredients (cocoa, milk, sugar) and stabilizer content were evaluated by a trained sensory panel. Fifteen sensory attributes concerning appearance, odor, texture and flavor were evaluated with focus on the complex term mouthfeel. The sensory properties of the cocoa drinks were related to measured physical, chemical and rheological properties by means of Partial Least Squares Regression. A high positive covariation was revealed between sensory and rheological measured viscosity properties. Mouthfeel in cocoa drinks was found to depend on both viscosity and flavor properties. These findings suggest that in addition to the prevailing ISO definition of mouthfeel, which is limited to a description of tactile characteristics, interaction with flavor may be included. Both stabilizer and main ingredients were shown to have distinct effects on the sensory properties. A consumer test showed a negative correlation between mouthfeel and consumer preference, within the range of cocoa drinks studied.

INTRODUCTION

Mouthfeel is a property of great importance for the sensory impression of many foods and is thus associated with consumer acceptability. In the 1960's and 70's much attention of sensory research concerned texture and mouthfeel properties of various food products. Alina Szczesniak, among others, studied the sensory

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dimensions of the term mouthfeel (Szczesniak 1979). She investigated mouthfeel properties of 33 beverages asking 103 untrained persons to name as many terms as they could think of describing how the beverages felt in the mouth. From the results she concluded that mouthfeel is effected by 11 categories of underlying properties as shown in Table 1.

TABLE 1.
CLASSIFICATION OF SENSORY MOUTHFEEL PROPERTIES FOR BEVERAGES (SZCZESNIAK 1979)

CATEGORY	TYPICAL WORDS
Viscosity-related terms	Thin, thick, viscous
Feel on soft tissue surfaces	Smooth, pulpy, creamy
Carbonation-related terms	Bubbly, tingly, foamy
Body-related terms	Heavy, watery, light
Chemical effects	Astringent, burning, sharp
Coating of oral cavity	Mouthcoating, clinging, fatty, oily
Resistance to tongue movement	Slimy, syrupy, pasty, sticky
Afterfeel-mouth	Clean, drying, lingering, cleansing
Afterfeel-physiological	Refreshing, warming, thirst-quenching, filling
Temperature-related	Cold, hot
Wetness-related	Wet, dry

Mouthfeel seems to be a complex property with several definitions suggested. The ISO-standard 'Sensory analysis-Vocabulary' (ISO 5492: 1992) defines mouthfeel as: *"The tactile sensations perceived at the lining of the mouth, including the tongue, gums and teeth."* In the first of two Canadian definition proposals to revise the ISO-standard, mouthfeel is defined as: *"Related to the perception of moisture and fat content of a food by tactile receptors in the mouth cavity and may also be concerned with the lubricating properties of the product"*, and in the second Canadian proposal as: *"A mixed experience derived from sensations in the mouth that relate to physical (e.g density, viscosity, particulate) or chemical (e.g astringency, cooling) properties of a stimulus. Trained panelists differentiate the physical sensations as texture properties and the chemical*

sensations as flavor properties." Especially the last of the Canadian proposals, is descriptive and divides mouthfeel into a number of underlying properties including both texture and flavor, and thereby renders the term mouthfeel multivariate. Other definitions of mouthfeel used in the literature appear to be more limited, e.g. *"Sensation detected in the mouth that may be due to an oily coating or a feeling of drying"* (Civille and Lyon 1996) and *"The degree of thickness when eating the yoghurt"* (Skriver *et al.* 1999). Bertino and Lawless (1993) illustrated the multidimensionality of mouthfeel attributes encountered in oral healthcare products.

From the definitions of mouthfeel it appears that the sense of touch is most important for the perception of mouthfeel. Studies have shown that the organs involved in perception of mouthfeel (mouth, tongue and lips) have the second most discriminative sense of touch of the body (Kandel and Jessel 1991). In recent years little attention has been paid to the effect of texture and mouthfeel properties on the sensory impression of foods. However, a recent review of Guinard and Mazzucchelli (1996) indicated a renewed interest in this field.

The present paper investigated the sensory properties of instant cocoa drinks with special focus on mouthfeel, and how the sensory impression was affected by the composition of the three main ingredients and by the stabilizer xanthan gum. Furthermore, possible relationships between the sensory properties and the physical, chemical and rheological properties were studied. Consumer preference as affected by the mouthfeel and other sensory characteristics were also investigated. The aim of this work is to achieve a greater understanding of the term mouthfeel and which sensory, physical, chemical and rheological properties contribute to the perception of the mouthfeel.

MATERIALS AND METHODS

Samples

The cocoa drinks were prepared adding hot water to an instant mixture consisting of the 3 main ingredients: cocoa (fat reduced), sugar and 'milk ingredient' (skimmed milk powder + non dairy creamer in a constant ratio). This investigation included 7 different compositions of the main ingredients in which the cocoa content was varied between 20 and 40 w/w % of dry matter and the sugar and milk ingredient content were varied between 30 and 50 w/w % of dry matter (Fig. 1).

Each composition of main ingredients was investigated both with and without the stabilizer xanthan gum in the concentration 1 w/w % of dry matter. Thus 14 samples were included in the investigation. Each sample was named with a number from 1 to 7 referring to the composition of main ingredients as shown on the

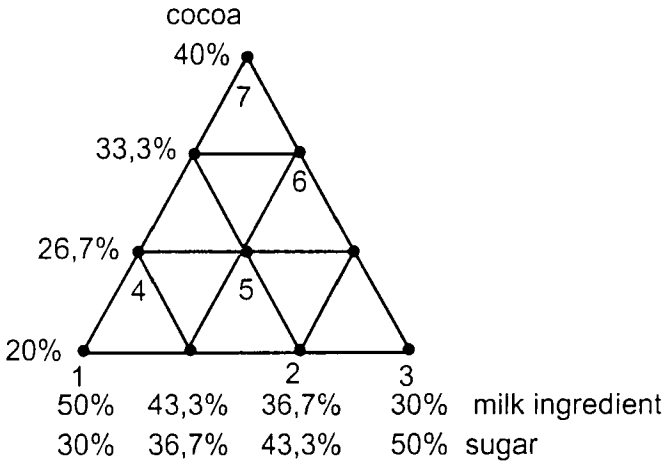

FIG. 1. THE COMPOSITIONS OF MAIN INGREDIENTS

triangle diagram and a suffix (+ or -) referring to whether it contained xanthan gum or not. The indicated compositions were approximations since the mix also contained small amounts of salt, vanilla and TCP (tricalciumphosphate) and since half of the samples also contained xanthan gum. These approximations are allowed since all samples contained equal amounts of salt, vanilla and TCP and since the content of xanthan gum was only 1 w/w %. Samples for the sensory profiling were prepared by adding 75 mL of 80C hot water to 10 g instant mixture and mixing carefully with hand held mixer. Before serving for the assessors, the samples were brought to a temperature of 51-53C. The sample size was approximately 100 mL cocoa drink per sample.

Sensory Profiling

A sensory profiling (Meilgaard *et al.* 1991) was carried out by a trained panel consisting of 4 female and 3 male members varying in age between 25 and 60 years. All sessions took place on weekdays at 11 AM in the sensory laboratory at the University which is arranged according to the ISO standards guidance for the design of test rooms (1988) and ASTM's physical requirement guidelines for sensory evaluation laboratories (1986). During 5 training sessions, the assessors agreed on a position of a reference sample (cocoa drink number 5-) on each attribute scale, and this reference sample was served to the panel at the beginning of each main session. The list of attributes was developed from attributes in the literature (Szczesniak 1979; Guinard and Mazzucchelli 1996) and discussions with cocoa mixture producers and with the panelists. The 15 attributes concerning appearance, odor, texture and flavor appear from Table 2.

TABLE 2.
SENSORY ATTRIBUTES USED IN THE STUDY

Sensory Attributes
Color
Thickness appearance
Cocoa odor
Milk odor
Resistance
Thickness (in mouth)
Smooth
Creamy
Mouthfeel
Astringent
Cocoa flavor
Milk flavor
Sweet
Bitter
Balanced

The intensity of the attributes were evaluated on a 150 mm unstructured scale with two anchor points placed 10 mm from each scale end marked as 'low' and 'high'. For most of the attributes an instruction was given for each anchor point. Two color prints representing the extremes, were used as references for color. 'Thickness appearance' was evaluated visually when pouring a spoonful down from the spoon. 'Resistance' was evaluated when sucking a spoonful into the mouth, while 'balanced' was described as the balance between the taste agents versus dominance by one ingredient.

Fourteen samples were evaluated in 3 replicates. Five samples were evaluated at each session, thus 9 sessions were needed to carry out the profiling. A data system (FIZZ, Biosystems, France) for automatic acquisition of the assessors scores was used. For each session the experimental design was a 5×7 Latin square with cross over design (incomplete) according to the FIZZ system, meaning that all assessors evaluated the same 5 samples in one session but in different orders and with 8-10 min intervals between each sample.

Physical, Chemical and Rheological Measurements

Six classes of physical, chemical and rheological variables were measured in 2 replicates.

(1) Sediment volume in 50 mL cocoa drink samples after centrifugation (Struers Sigma) at 45 g for 270 s (the centrifuge was stopped every 30 s to read the volume, the time included acceleration but not stopping of the centrifuge). The start temperature of the samples was 75C.

(2) The parameters K and n from the Power law: $\sigma = K\ \dot{\gamma}n$ where σ = shear stress (Pa), $\dot{\gamma}$ = shear rate (s^{-1}), K=index of viscosity, n=deviation from Newtonian behavior. The parameters were determined by measuring the flow properties of the cocoa drink at a controlled stress rheometer (Carri-Med CSL100) with a double concentric bup&cup system at 40C. For each sample shear rates were measured as a function of shear stress in 10 points with shear rate varying between 0 and 150 s^{-1}. The resulting flow curves were fitted to model flow curves by the rheometer software. Cocoa drinks without xanthan gum behaved Newtonian, and cocoa drinks with xanthan gum were pseudoplastic. The parameters K and n were chosen to characterize the flow properties of the cocoa drinks.

(3) Apparent viscosities at shear rates of 10, 20, 50 and 100 s^{-1} calculated from the Power law parameters. All four viscosities were similar for the cocoa drinks without xanthan gum since Newtonian liquids have constant viscosity (named VISCOSITY in the data analysis).

(4) The three color parameters L*, a* and b* of the cocoa drinks at 60C were measured using a chromameter (Minolta CR-200).

(5) Fat content (w/w % in dry matter) of the main ingredients was measured by a Roese-Gottlieb fat determination method (Soerensen *et al.* 1978).

(6) Milk ingredient content, cocoa content and sugar content (w/w % in dry matter) were known from the triangle diagram in Fig. 1.

Consumer Test

Sixty untrained persons were presented with 5 cocoa drink samples (number 1-, 3-, 5-, 5+, 6-) in a random order. They were asked to evaluate their liking of the samples on a 0 to 4 point hedonic scale with grade 0 defined as 'dislike very much', and grade 4 was defined as 'like very much'. For each sample it was possible to give comments. The test was carried out at a central location at the University. Although only 5 out of 14 samples were evaluated, this consumer test was still considered representative since the variation in cocoa, sugar and milk ingredient contents and both samples with and without xanthan gum were represented.

Data Analysis

From the sensory measurements a data matrix containing 14 samples × 15 attributes (each value was an average of 7 assessors and 3 replicates) was constructed. This matrix is later referred to as the 'sensory data'. From the physical, chemical and rheological measurements a data matrix referred to as the 'physical/chemical/rheological data' containing 14 samples × 14 variables was constructed. The sensory data matrix was analyzed separately using Principal Component Analysis PCA (Esbensen *et al.* 1996). Relationships between the two matrices were analyzed using Partial Least Squares Regression PLSR (Martens and Martens 1986). The PCA and PLSR analyses were performed with the software Unscrambler 6.11 (Camo ASA, Trondheim, Norway). All the analyses were performed with standardized variables and full cross validation. Only significant components are mentioned in the discussion. Analysis of variance (ANOVA) was performed by using the FIZZ system.

RESULTS AND DISCUSSION

ANOVA

Results from the ANOVA showed significant differences ($p < 0.001$) between the 14 samples for all the sensory attributes. No important interactions between assessors and products were found.

PCA on Sensory Data

This analysis was performed to investigate the systematic structure in the sensory data. The loading plot and score plot of the first two significant principal components (PC) explaining in total 91% of the systematic variation are shown in Fig. 2.

As shown in the loading plot (Fig. 2A) the first PC mainly described a variation in the flavor attributes while the second PC mainly described the texture variation. Mouthfeel was described in both components. The loading plot showed grouping of the attributes, thus the attributes for color, cocoa odor and cocoa flavor formed one group with the attributes bitter and astringent as a subgroup. Another group was formed by the attributes thickness appearance, thickness (in mouth) and resistance, whereas a third group was formed by milk flavor, milk odor and sweet. These three groups are referred to as respectively, the "Cocoa properties", the "Viscosity properties" and the "Milk properties". The score plot (Fig. 2B) showed a distinct structure in the data. The first PC divided the samples after composition of main ingredients (low sample numbers to the left side and high numbers to the right side), i.e. spanning the variation in samples with "milk properties" versus

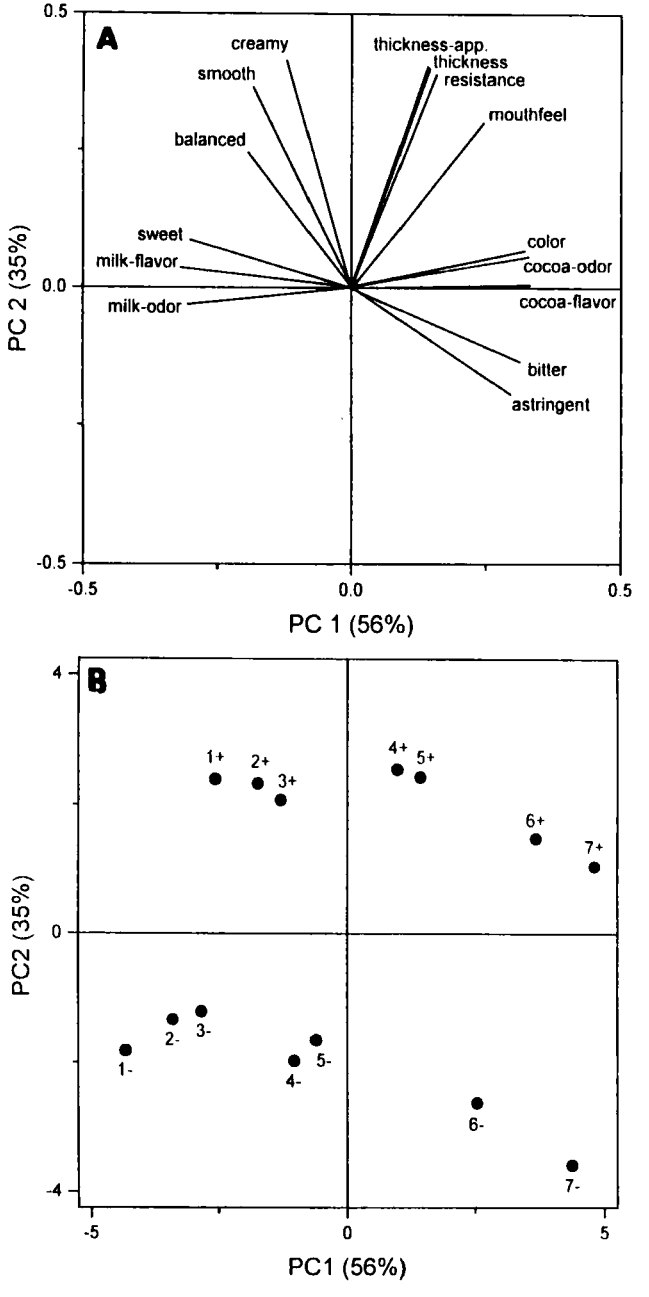

FIG. 2. PCA ON SENSORY DATA, (A) LOADING PLOT- AND (B) SCORE PLOT OF THE FIRST AND SECOND PRINCIPAL COMPONENTS

The composition of samples 1-7 appear from Fig. 1. Samples are with (+) and without (-) stabilizer

"cocoa properties". The second PC divided the samples according to whether they contained xanthan gum (+) or not (-). In a separate analysis on xanthan gum, samples with xanthan gum represented the "viscosity properties" in the loading plot, i.e. xanthan gum was positively correlated with the "viscosity properties" and the mouthfeel. The "cocoa properties" and creaminess, smoothness and partly balanced were also promoted by xanthan gum. These results support that xanthan gum enhances flavor release as mentioned by Whistler and Daniel (1985) when dealing with cocoa flavor. On the other hand, the plot showed that xanthan gum had the opposite effect on the "milk properties" (including sweet) since these were negatively correlated with the xanthan gum content. The fact that increased viscosity decreased the intensity of sweetness was previously reported by Kokini (1987). The present study indicated that the same effect was present for milk flavor. The third significant PC (not shown here) explained 39 % of the variation in balanced, showed that samples number 5+ and 5- were assessed to be more balanced than the extreme samples number 1+, 1- and 7+ and 7-. Lastly, a fourth significant PC explaining 31% of the variation in sweetness, indicated a second type of perceived sweetness different from the "milk properties".

PLSR on Sensory Data (X-matrix) Versus Mouthfeel (y-matrix)

This analysis was performed to explore which sensory attributes showed covariation with mouthfeel. In total 97% of the variation in mouthfeel was explained by the first two PLSR factors. The loading plot (Fig. 3) showed the same grouping of the sensory attributes as seen in the PCA. In the first factor mouthfeel was positively correlated with the "viscosity properties" and the "cocoa properties" and negatively correlated with the "milk properties". The attributes smooth, creamy and balanced contributed to a smaller degree (10%) to the explanation of mouthfeel in the second factor. Thus, mouthfeel in cocoa drinks could be described as a combination of texture and flavor properties, whereof the viscosity-related terms and chemical effects (astringent) were listed as sensory mouthfeel properties for beverages by Szczesniak (1979) in Table 1.

PLSR on Physical/Chemical/Rheological Data (X-matrix) Versus Sensory Data (Y-matrix)

This analysis was performed to investigate the systematic relationships between the 15 sensory and the 8 physical, chemical and rheological variables. Three significant factors were found explaining in total 92% of the sensory variation of which 84% in the first two factors (Fig.4). The loading plot in Fig. 4 showed that the sensory variations of the "viscosity properties" and the "cocoa properties" were positively correlated with the rheologically measured K and apparent viscosity and negatively correlated with n and instrumentally measured color (a*). These variations mainly separated the samples with and without stabilizer, the former

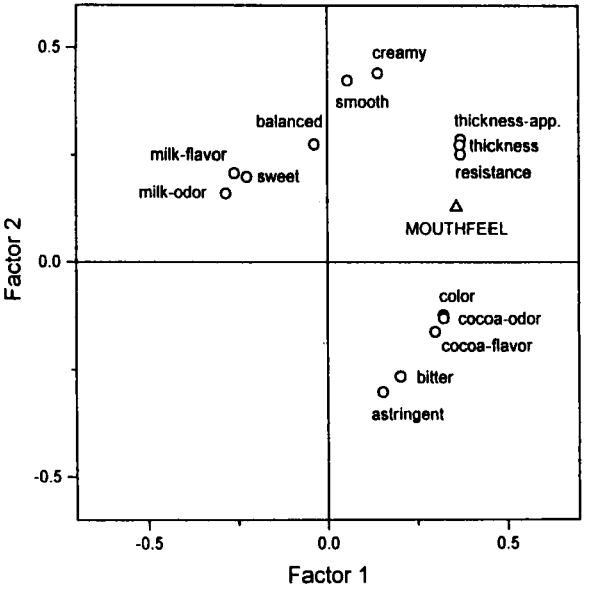

FIG. 3. PLSR ON SENSORY DATA (X-MATRIX) VERSUS MOUTHFEEL (Y-MATRIX), LOADING PLOT OF THE FIRST AND SECOND PLSR FACTORS

being more viscous and intense in perceived color. The second PLSR factor mainly showed that the "milk properties" were positively correlated with lightness (L*) and negatively to the sediment volume, reflecting the variation in samples with high milk content (1+ and 1-) versus samples with high cocoa content (7+ and 7-). These results indicated that the properties L*color, b*color and the milk content should be included in the "milk properties", and the Power law parameter K and apparent viscosity (at all four shear rates) should be included in the "viscosity properties", whereas cocoa content belonged to the "cocoa properties". These three groups of properties represented two dimensions, namely a texture dimension (the "viscosity properties") and a flavor dimension (the "cocoa and the milk properties"). Most of the variation in mouthfeel (91%) was explained by the physical, chemical and rheological variables after two factors. A third significant factor, not contributing to the mouthfeel variation, showed that the fat content (FAT-C) was negatively correlated to the second type of sweetness (as discussed from the PCA results). This is interesting from the viewpoint of the effect of reducing the fat content in cocoa drinks; an issue beyond the scope of this paper.

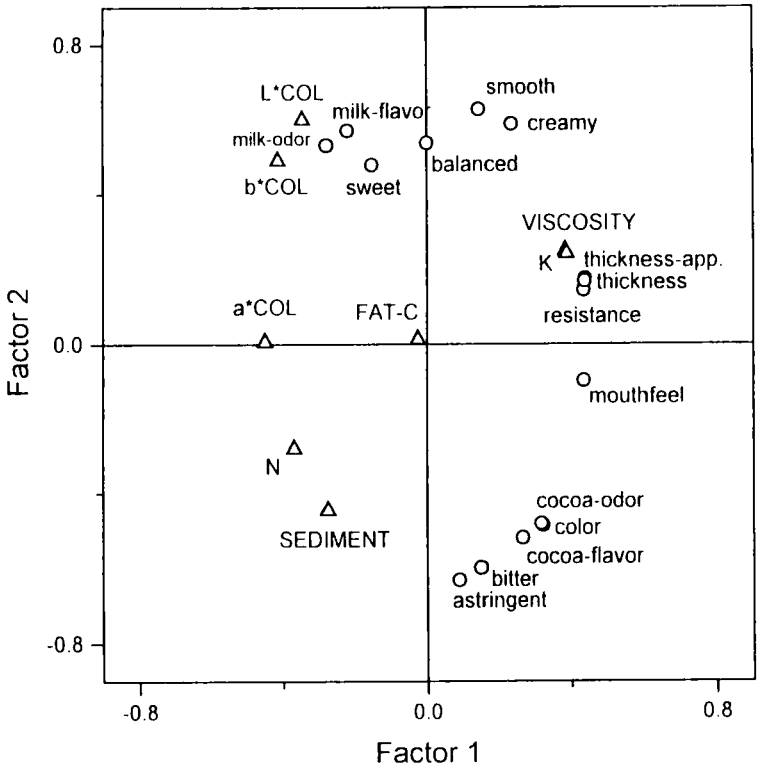

FIG. 4. PLSR ON PHYSICAL/CHEMICAL/RHEOLOGICAL DATA (X-MATRIX) VERSUS SENSORY DATA (Y-MATRIX), LOADING PLOT OF THE FIRST AND SECOND PLSR FACTORS

PLSR on Sensory Data (X-matrix) Versus Composition of Main Ingredients (Y-matrix)

This analysis investigated in more details the relationships between the sensory properties and the three main ingredients. The loading plot of the first two factors explained in total 84% of the Y-variance (Fig.5). Figure 5 shows that the three main ingredients were spread in a triangle shape similar to the triangle diagram shown in Fig. 1. The cocoa content was positively correlated with the "cocoa properties" and with mouthfeel and to a minor extent with the "viscosity properties". Both sugar and milk ingredient content were positively correlated with the "milk properties" including smoothness, creaminess and balanced, whereas these ingredients were negatively correlated with the "cocoa properties". These results mean that the composition of ingredients of the cocoa drinks showed strong relationships to the sensory properties.

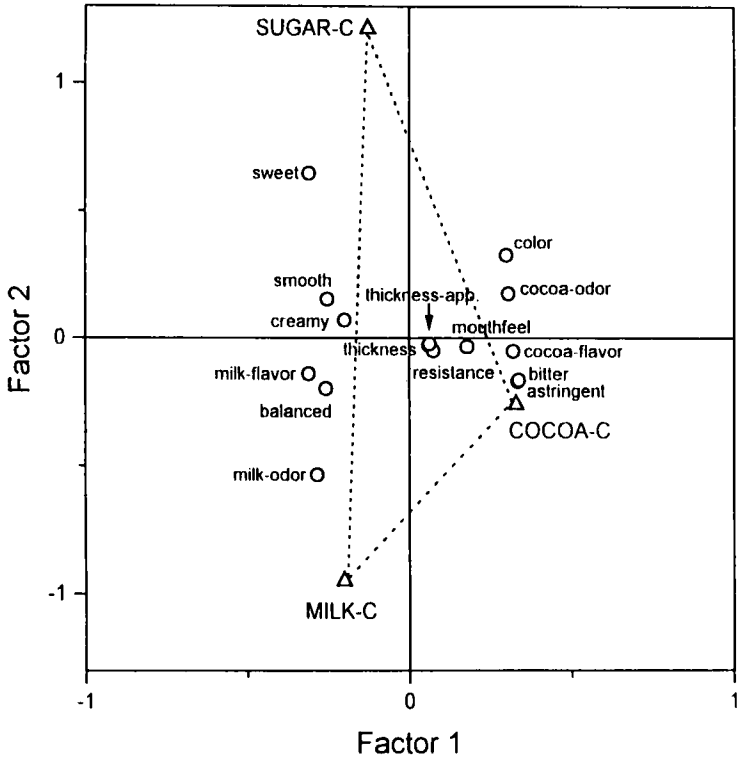

FIG. 5. PLSR ON SENSORY DATA (X-MATRIX) VERSUS COMPOSITION OF MAIN INGREDIENTS (Y-MATRIX), LOADING PLOT OF THE FIRST AND SECOND PLSR FACTORS

PLSR on Sensory Data (X-matrix) Versus Consumer Preference (y-matrix)

This analysis was performed to investigate which analytical sensory properties could be used to predict consumer preference, using five selected samples. The loading plot (Fig. 6) showed that in the first factor 82% of the systematic variation of LIKING was explained. Sweet, milk flavor and milk odor were highly positively correlated, and the "cocoa properties", the "viscosity properties" and mouthfeel highly negatively correlated with LIKING. In factor 2, the second type of sweetness showed a minor positive correlation with consumer preference. Thus the consumers seemed to prefer cocoa drinks with a sweet and milky flavor. Cocoa drinks with a high content of cocoa flavor and thick (stabilized) drinks were not preferred. Among the 5 samples the average consumer panel preferred sample number 3-.

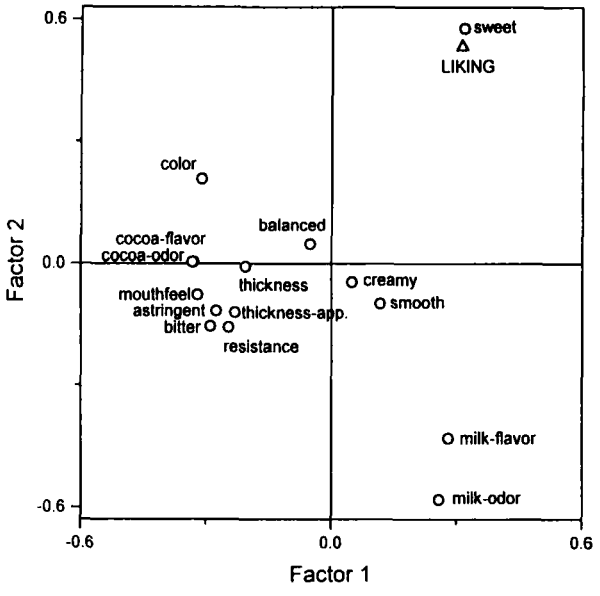

FIG. 6. PLSR ON SENSORY DATA (X-MATRIX) VERSUS CONSUMER PREFERENCE (Y-MATRIX), LOADING PLOT OF THE FIRST AND SECOND PLSR FACTORS

CONCLUSIONS

Mouthfeel in instant cocoa drinks was shown to be positively correlated with two groups of properties, i.e. the "cocoa properties" (cocoa content, cocoa odor, cocoa flavor, color and the subgroup bitter and astringent) and the "viscosity properties" (viscosity, the Power law parameter K, thickness appearance, thickness (in mouth) and resistance). Mouthfeel was negatively correlated with a group of properties which can be called the "milk properties" (content of milk ingredient, milk odor, milk flavor, sweet, b*("yellowness"), and L* ("lightness")). These three groups of properties suggested two main dimensions in the sensory impression of this product, namely a texture dimension and a flavor dimension. Thus it may be concluded that mouthfeel in instant hot cocoa drink depends of both flavor and viscosity properties perceived by the tactile and chemoreceptors in the mouth. The results suggest that mouthfeel in cocoa drinks is better described by the second of the Canadian definition proposals than by the prevailing ISO-standard.

The stabilizer xanthan gum had significant effects on the cocoa drinks. Since it increased the viscosity, it also promoted the mouthfeel. Cocoa odor and cocoa flavor were promoted by xanthan gum whereas sweet, milk odor and milk flavor were subdued. Finally, xanthan gum increased the creaminess, smoothness and

partly the perception of balanced. The three main ingredients had also distinct effects on the cocoa drinks. Thus cocoa promoted the "cocoa properties" whereas both milk ingredient and sugar promoted the "milk properties" and the creaminess, balanced and smoothness. The consumer preference for instant hot cocoa drinks in this study seemed to be sweet and milky products which were neither rich in cocoa flavor nor had a thick consistency.

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