DETERMINATION OF THE SENSORY ATTRIBUTES OF DRIED MILK POWDERS AND DAIRY INGREDIENTS

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ABSTRACT

A standardized descriptive language for skim milk powder and dried dairy ingredients was developed. The lexicon was initially identified from a large sample set of dried dairy ingredients (138). A highly trained descriptive panel (n = 14) refined terms and identified references. Dried dairy ingredients (36) were then evaluated using the developed language. Twenty-one descriptors were identified for dried dairy ingredients. Seventeen flavors and tastes were identified in skim milk powders (27) with nine flavors/tastes observed in all skim milk powders. Dried dairy ingredients were differentiated using the language (P C 0.05). There were flavors common to all dried dairy ingredients while other flavors were specific to particular products.

INTRODUCTION

Worldwide very large amounts of dried milk products are manufactured. The primary dry milk product manufactured in the U.S. is skim milk powder (SMP) although whole milk powder is also produced (ADPI 2000). Over 663,000 tons of SMP and over 50,000 tons of whole milk powder (WMP) were produced domestically in 2000 (ADP! 2000). SMP is mainly produced by spray-drying of fluid pasteurized milk and the finished product composition is not more than 1.5% fat by wt (ADPI 1998), Three basic types of SMP are produced: low heat, medium heat, and high heat (ADPI 1998). Typically, SMP should have a shelf-life (at 25C) of 12-18 months

(ADPI 1998). *Currently, U.S.* SMP production continues to increase while the U.S. has only a 17% share of the world SMP market (Lagrange 2001). The global market for SMP is expected to grow by 20% by the year 2005 (Lagrange 1998).

SMP and other dried dairy ingredients should ideally *have* a clean, *sweet* and pleasant taste free of flavor defects (Bodyfelt *er a!,* 1988). For SMP, cooked flavors may be present and vary according to heat treatment (low, medium, high) of the milk prior to evaporation and spray-drying. Dry milk products must have good flavor characteristics for direct consumption as well as for product applications. The largest outlet for SMP is ingredient application in dairy products. Recommended applications of SMP classification based on preheat treatment vary. Low and medium heat-treated powders are used in fluid milk fortification, *cottage* cheese, yogurt and chocolate dairy drinks because of their high solubility and minimal cooked flavor. However, high heat powders are mostly used in bakery, confectionery, meat products for texture modification, water absorption/binding, emulsification and gelation (Varnam and Sutherland 1996; ADPI 1998). Off-flavors present in SMP and other dried dairy ingredients can carry through to the final end-product and result in poor end-product quality. Therefore, flavor and sensory properties are considered important criteria in grading dry milk powders and other dried dairy ingredients (Bodyfelt *et al.* 1988).

Grading has been used by the industry for many years to evaluate overall quality of milk powders and other dried dairy ingredients but is defect-based, rather than descriptive in nature. These defects are not well-defined, and grades are based on one person's somewhat subjective opinion. Descriptive sensory analysis is traditionally used to identify and quantify flavors in products and can be a powerful tool for describing and differentiating product flavors for research, product development or marketing (Meilgaard *et al.* 1999; Drake and Civille 2003).

Previous research that has addressed flavor of SMP has not used descriptive sensory analysis (Kurtz *et al.* 1971; Driscoll *et al.* 1985). Descriptive sensory analysis has been conducted widely on fluid milk (Lawless and Claassen 1993; Watson and McEwan 1995; Chapman *et al.* 2001; Born Frost *et al.* 2001), as well as ice cream (Prindiville *et al.* 1999, 2000) and defined sensory languages have been developed specifically for cheese (Heisserer and Chambers 1993; Murray and Delahunty 2000; Drake *er al.* 2001). Descriptive sensory flavor research has not been conducted on milk powders or other dried dairy ingredients. Since flavor consistency has reportedly been a problem in SMP and WMP (Dryer 1999), the development of a descriptive sensory language for SMP and WMP would provide a powerful research and quality control tool. The objective of this study was to identify and develop a descriptive sensory language for milk powders and other dried dairy ingredients.

MATERIALS AND METHODS

Milk Powders and Dried Dairy Ingredients

SMP, WMP and other dried dairy ingredients were donated or purchased from producers nationally and internationally. Thirty eight SMP were obtained from U.S. producers (twenty low heat, five medium heat, thirteen high heat) and twenty-four SMP were obtained from international sources in eleven countries (seventeen low heat, four medium heat, three high heat). An additional fourteen SMP (all low heat) were obtained from U.S. universities that varied in age from 3 months to 20 years. Eleven WMP (eight U.S., three international) were obtained. Sixteen whey protein concentrates (WPC) or whey protein isolates **(WP1),** five milk protein concentrates (MPC), and ten caseinates were also obtained from U.S. and international producers. The other dairy ingredients were obtained to get as wide an array of dairy milk

product flavors as possible. Samples were received as 1, 5. 10 or 50 lb samples and were stored at -20C in the dark upon receipt. For sensory analysis, skim milk powders were rehydrated on a 10% solids basis, 10 g SMP/100 mL water (ADPI 2001) and whole milk powders were rehydrated using the formula: 1000/100-dry %fat content of WMP = g of WMP dissolved in 90 g water (IDF 1997). Powders were rehydrated on the percent solids basis with deodorized water (prepared by boiling 4 L of distilled water until its volume was decreased **by** one-third) and blended with an electric hand-held mixer. Eight percent-solution of WPC, WPIs, MPCs and caseinates were rehydrated in warm water (60C) based on their protein amount (Harris 2000).

Language Identification and Development

Rehydrated powders were evaluated for flavor and initial language generation by a group of six individuals experienced (>500 h experience each) with descriptive analysis of products. Rehydrated powders were dispensed into Styrofoam cups with lids (to prevent light oxidation) and allowed to equilibrate to 7C for 1 h prior to evaluation. The initial language is listed in Table 1. The panel also grouped the rehydrated powders based on general flavors for future evaluation and language refinement. [Table 1]

Fine-tuning and Identification of References

Following the roundtable and generation of the preliminary language, a descriptive panel was trained to refine the developed language and to identify references. Fourteen individuals, six male and eight female, 22 to 44 years of age were selected from university staff and students based on availability, interest, and a demonstrated liking of dairy products, including milk. Twelve panelists had prior experience with descriptive analysis. The panel received fifty

hours of training using the Spectrum' method (Meilgaard *et al.* 1999) and the identified language. The rehydrated dairy ingredients initially evaluated and grouped were presented to the panel. Panelists were encouraged to volunteer new descriptive terms and to address existing terms. Panelists received food treats and monthly gift certificates at local restaurants for their participation. During training, panelists were presented with and evaluated potential references (food or chemical) and the panelists selected the best reference(s) to represent the identified descriptive terms [Table 2].

Sample Evaluation

To evaluate the efficacy of the identified language, thirty six samples were selected for examination (Table 3). Some of these products were from the initial sample set used to generate the language, others were newly obtained. The sample set focused on SMP since this was our primary goal. Panelists evaluated each sample in quadruplicate across forty tasting sessions across a 10-week period. Three samples were evaluated per session; samples were presented in a randomized balanced block design within each session. A completely randomized design was used to select samples for each session.

Rehydrated powders were dispensed into Styrofoam cups with lids (to prevent light oxidation) and three digit codes and allowed to equilibrate to 7C for 1 h prior to evaluation. Panelists were presented with a warm-up sample of fluid skim milk and then began sample evaluation. Panelists evaluated the samples using the developed language with a 15-point numerical SpectrumTM scale on paper ballots. Bottled water was provided to cleanse the palate during evaluation.

Statistical Analysis

Significance was established at P<0.05. Statistical analysis was conducted using SAS (version 8.0. Cary, NC). Analysis of variance with means separation (PROC GLM) was conducted to evaluate panel consistency across replication of the same sample and to determine significant differences between samples for each attribute. Principal component analysis (PROC PRINCOMP) and factor analysis (PROC FACTOR) were conducted to determine how the SMP were differentiated and to identify redundant terms. Correlation analysis (PROC **CORR) with** Bonferroni's adjustment was also conducted to determine individual relationships between terms.

RESULTS AND DISCUSSION

Group discussion and evaluation of SMP and other dried dairy ingredients was conducted for each term in the lexicon following initial language identification. The refined language is listed in Table 2. During language refinement, panelists were able to separate several terms that originally were confounded. Caramelized/sweet aromatic/vanillin were originally grouped together, but were separated into caramelized/butterscotch and sweet aromatic/cake mix by subsequent panel discussion and agreement. Animal-type flavors were also separated into animal/banly and animal/wet dog as were fried fattylpainty and fishy. [Table 3]

Definitions and references were also identified for each descriptor (Table 2). In some cases multiple references were identified. The use of more than one reference for a descriptor can help panelists with different perceptions and experiences of a descriptor focus on the particular concept of interest (Civille and Lawless 1986; Ishii and ❑'Mahoney 1991; Drake and Civille 2003).

Chemical references were also identified when possible. Since not all food types are available world-wide, chemical references allow for clarification of flavor lexicons for future use, and/or comparison. In some cases, chemical sources of particular flavors have not been

identified and certainly are an area where future research is warranted. Karagul-Yuceer *et al.* (2001, 2002a) determined aroma-active components of SMP with different sensory properties. They hypothesized that some sensory flavors in SMP were caused by a mixture of two or more chemicals which complicates identification of single chemical references. The term cereal/grassy was one example where chemical references may help clarify concepts. Panelists agreed that this term could potentially be separated into two terms, cereal (dried grain) and grassy (fresh grain, *grass)* but had trouble consistently differentiating the two flavors in samples. The identification of specific chemical anchors may help further subdivide the term in future studies.

Skim milk powders were differentiated using the lexicon (Table 4, Fig. 1, 2). Panelist performance was consistent as evidenced by the consistently small LSD in univariate analysis (Table 4). There was not a replicate effect across the four replications further indicating consistent panel performance *(P7* 0.05). Nine descriptors were found in all 27 SMP (Table 4) evaluated while a few terms were found in one or two SMP (Table 5). Of the SMP in Table 5, both SMP 14 and 18 were *clearly* unusual. SMP 14 was 20 years old and not surprisingly exhibited flavor properties and intensities not observed commonly in SMP. SMP 18 was 3 years old and had been stored at extreme temperatures (35C). Again, it should not be surprising that unusual flavors would be observed in this SMP. SMP 23 was a high heat SMP that was suspected by the company that provided it as being "scorched". The presence of burnt flavor and bitter taste was not surprising given this information. Clearly, some flavors are only occasionally observed in SMP while others are more common. A lexicon with flavors that are commonly observed and additional flavors that are observed less often has also been noted with other foods including Cheddar cheese (Drake *et al.* 2001) and sourdough bread (Lotong *et al.*

2000). Such a lexicon provides a platform to use a smaller number of terms when only a few SMP are evaluated.

Principal components analysis indicated that four principal components (PC's) had Eigenvalues greater than 1 and explained 82% of the variance (Fig. 1, 2, Table 7). PC1 was comprised of the descriptors sweet aromatic with animal/wet dog and potato/brothy inversely associated. Sweet aromatic and animal/wet dog and potato/brothy were also inversely correlated (Table 8). The aromatics animal/wet dog and potato/brothy are likely to overpower the delicate flavor sweet aromatic, hence their inverse correlation. PC2 was comprised of cooked/sulfur with cereal/grass-like and salty inversely associated. PC3 was primarily the chemical feeling factor astringency and PC4 was sweet taste and cardboard inversely associated. Other trends observed by principal components were also confirmed by fluid skim milk including cooked, sweet aromatic, and sweet taste were correlated while flavors not associated with fluid milk such as animal/wet dog, potato/brothy were also correlated with each other. SMP were loosely grouped into three categories upon visual observation of biplots of PC I and 2 (Fig. 1, 2). A group of SMP were characterized by sweet aromatic, sweet taste, and cooked, a group of SMP were characterized by animal/wet dog and potato/brothy flavors and astringency, and a few SMP were characterized by cereal/grassy and cardboard flavors. Ideally, SMP should have flavors similar to fluid skim milk. Results in Fig. 1 suggest that this idea] is possible since a group of SMP were associated in the same sample space as fluid skim milk. At the same time, a large number of SMP, many less than 3 months in age, exhibited flavors unlike fluid skim milk (potato/brothy, animal/wet dog, astringent). The standard shelf-life for ingredient application of SMP is 18 months at 21C (ADP! 1998). Clearly factors in addition to storage age may affect the formation of nonfluid milk types of flavors in SMP and additional research is warranted.

Other dried dairy ingredients were differentiated using the identified language (Fig. 3, 4, Table 6). These products were all dairy ingredients derived in some form from fluid milk so we might expect to see the same basic groups of flavors. Differences in processing and composition provide some of the different types of flavors. Certain flavors are present or are more common in these products than in SMP. For example, milkfat, and fried, fatty/painty flavors were not detected in SMP, but were observed in WMP. These flavors are milkfat-derived flavors. WMP when rehydrated contain 3.5-4.5% fat (w/w) as opposed to 5MP which contain less than 0.5% fat (w/w) so it is expected that fatty flavors would be more prevalent in WMP.

Fishy flavor was not detected in the WMP's evaluated, but was detected in one of the eleven WMP that was evaluated during initial language identification. This WMP was evaluated and discussed by the panel during subsequent training and language refinement. The panel determined that fishy was a distinct and separate flavor, however, that flavor does not appear to be commonly observed in WMP. Heat treatment for WMP is slightly higher than the heat treatment for SMP (Vain= and Sutherland 1996). Cooked and associated flavors such as caramelized flavor can be perceived at higher intensities in WMP.

The whey protein concentrates (WPC) and caseinates exhibited flavors found in SMP but intensities were different. Animal/wetdog flavors and astringency intensities were higher in WPC and caseinates than in SMP *(P<0.05)* (Fig. 3, 4). A "glue-like" flavor has been reported in caseins and caseinates (Ramshaw and Dunstone 1969). It is possible that the glue-like flavor previously reported is the flavor referred to in this study as animal/wet dog since mucilage and gelatin are also used as descriptors of this flavor concept (Table 2). The compound o-aminoacetophenone (o-AAP) was isolated as a possible contributor of "glue-like" flavor (Rarnshaw and Dunstone 1969). The compound was also identified as an off-flavor

compound in micromilled milk powder (Preininger and UIlrich 2001) and a prevalent component of stored milk powders (Karagul-Yuceer *et al.* 2002a). More recent research with caseinates indicates *that* a combination of other volatile compounds including hexanoic acid, indole, guiacol, and p-cresol may be responsible for the prevalent animal/wet dog flavor (Karagul-Yuceer er *al.* 2002b). Metallic and cardboard flavors were also prevalent in WPC and caseinates. [Table 4] [Figure 1] [Figure 2] [Table 5] [Table 6] [Table 7] [Table 8] [Figure 3] [Figure 4]

CONCLUSIONS

A defined and referenced language was identified for SMP and other dried dairy ingredients. Several flavors were common to all dried dairy products while others were more prevalent in specific dried dairy ingredients. The standardized descriptive language will provide a useful tool for research, quality control and marketing.

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INGREDIENTS LANGUAGE

Aromatics
Cooked/sulfurous
Caramelized/sweet aromatic/vanillin
Heated butter
Cereal/grassy
Animal/mucilage/wet dog/barny
Brothy/potato-like
Fried fatty/painty/fishy
Mushroom/metallic
Cardboard/papery
Burnt/charcoal
Vitamin/rubbery
Diacetyl

Tastes
Salty
Sour
Sweet
Bitter
umami

Feeling factors
astringent

TABLE I. INITIAL MILK POWDER AND DRIED DAIRY

INGREDIENTS LANGUAGE.

Descriptor	Reference	Preparation
Cooked/sulfurous	- Heated milk	- heat pasteurized skim milk to 85C for 45 min
Caramelized/butterscotch	- Autoclaved milk - Caramel syrup	- Autoclave whole milk at 121C for 30 min - Dilute a tablespoon of caramel syrup in 400 mL skim milk
Sweet aromatic/cake mix	- Pillsbury-White cake mix - vanillin	- dilute 5 mg of vanillin in skim milk
Cereal/grass-like	- breakfast cereals (corn flakes, oat and wheaties)	- soak one cup cereal into three cups milk for 30 min and filter to remove cereals
Barny	- p-cresol	- 20 ppm in skim milk
Brothy/potato-like	- Kroger-Canned white potato slices - methional	- remove the sliced potatoes from the broth - few drops of 20 ppm methional in methanol in sniffing jars
Animal/gelatin-like/wet dog	- Knox-unflavored gelatin	- dissolve one bag of gelatin (28 g) in two cups of distilled water
Milkfat/lactone	Heavy cream delta dodecalactone	40 ppm on filter paper
Fried fatty/painty	- (E,E)-2,4-decadienal	- 2 ppb in skim milk
Fishy	Fresh fish with skin Canned tuna juice	
Mushroom/metallic	- fresh mushroom	- slice fresh mushroom in skim milk for 30 min and filter to remove mushroom slices
Papery/cardboard	- cardboard paper	- soak pieces of cardboard paper in skim milk overnight
Burnt/charcoal	- over toasted bread slice	
Vitamin/rubber	- Enfamil - liquid Polyvisol vitamins	
Diacetyl	diacetyl	Diacetyl, 20 ppm on filter paper
Earthy/musty	potting soil, odor reminiscent of damp basement	
Sweet taste	- sucrose	- 5% sucrose solution
Salty	- NaCl	- 2% NaCl solution
Sour	- citric acid	- 1% citric acid solution
Bitter	- caffeine	- 0.5% caffeine solution
Umami	monosodium glutamate	- 1% MSG in water
Astringent	- tea	- soak 6 tea bags in water for 10 min

TABLE 2. REFINED LANGUAGE AND PREPARATION OF REFERENCE MATERIALS.

Sample	Source	Heat Treatment	Storage	Age
1. SMP	International	low	2-ply bag	>3mo
2. SMP	U.S. (local store)	low	paperboard	unknown
3. SMP	International	low	2-ply bag	> 3mo
4. SMP	U.S.	low	2-ply bag	>3 mo
5. SMP	International	low	2-ply bag	>3mo
6. fluid skim	U.S. (local store)	n/a	yellow jug	n/a
7. SMP	U.S.	low	2-ply bag	>3 mo
8. SMP	U.S.	low	2-ply bag	>3 mo
9. SMP	U.S.	low	2-ply bag	>3 mo
10. SMP	U.S.	high	2-ply bag	>3 mo
11. SMP	International	low	2-ply bag	>3mo
12. SMP	International	low	2-ply bag	>3mo
13. SMP	U.S.	low	2-ply bag	6 mo
14. SMP	U.S.	low	can	20 yr
15. SMP	U.S.	medium	2-ply bag	6 mo
16. SMP	U.S.	low	2-ply bag	6 mo
17. SMP	International	low	2-ply bag	>3mo
18. SMP	U.S. (local store)	low	paperboard	3 yr
19. SMP	International	low	2-ply bag	6 mo
20. SMP	International	low	2-ply bag	8 mo
21. SMP	U.S.	low	2-ply bag	>3mo
22. SMP	International	low	2-ply bag	>3 mo
23. SMP	International	high	2-ply bag	>3 mo
24. SMP	U.S.	med	2-ply bag	>3mo
25. SMP	U.S.	high	2-ply bag	>3 mo
26. SMP	U.S.	high	2-ply bag	>3mo
27. SMP	U.S.	low	2-ply bag	>3mo
28. WMP	U.S.	n/a	2-ply bag	>3mo
29. WMP	U.S.	n/a	2-ply bag	>3mo
30. WMP	International	n/a	2-ply bag	>3mo
31. Evaporated milk	U.S. (local store)	n/a	can	unknown
32. Caseinate	U.S.	n/a	2-ply bag	>3mo
33. Caseinate	International	n/a	2-ply bag	>3mo
34. WPC34	U.S.	n/a	plastic can[a]	>3mo
35. WPC34	U.S.	n/a	plastic can[a]	>3mo
36. WPC34	U.S.	n/a	plastic can[a]	>3mo
37. WPC80	U.S.	n/a	plastic can[a]	>3mo

[a] sample received in plastic bag within a sealed plastic canister

TABLE 3. SAMPLES EVALUATED USING THE

DEVELOPED LANGUAGE.

sample	cooked	Swtarom	cereal	An/wd	pot	crdbrd	sweet	salty	astrgt
1	2.7	0.9	0.8	3.4	3.0	0.5	1.0	0.3	2.1
2	2.8	2.0	1.0	0.9	1.3	1.5	2.5	0.3	2.0
3	2.8	2.2	1.0	0.9	1.3	1.5	2.6	0.2	1.9
4	3.1	1.3	0.8	2.5	3.0	1.0	2.1	0.3	2.4
5	3.0	1.9	1.0	2.2	1.1	2.0	2.1	0.2	2.1
6	2.3	1.6	1.0	0.0	0.0	0.4	2.2	0.3	1.5
7	2.8	2.0	1.2	0.8	1.5	1.6	2.1	0.3	2.0
8	3.1	1.9	1.0	0.8	2.0	1.4	2.2	0.3	2.0
9	2.7	2.1	1.3	0.5	1.7	1.6	2.6	0.3	1.5
10	2.9	1.6	1.3	1.2	2.3	1.3	2.2	0.3	2.1
11	2.8	1.4	1.8	1.4	2.1	11	2.0	1.1	2.0
12	2.7	1.2	1.0	3.0	2.6	0.6	1.8	0.3	1.9
13	2.8	1.9	1.3	0.7	2.0	2.0	2.1	0.3	2.1
14	2.9	1.3	1.8	0.3	2.5	1.0	1.4	2.3	2.8
15	3.0	1.5	1.3	1.4	2.3	1.9	2.1	0.3	2.1
16	2.8	2.2	1.7	0.5	1.5	1.9	2.3	0.3	2.4
17	2.9	1.6	1.0	0.7	1.7	1.5	2.0	0.2	2.0
18	2.6	0.4	0.4	0.3	0.0	0.6	1.0	0.2	3.1
19	2.7	1.3	1.4	1.4	1.7	1.0	2.4	0.3	1.5
20	2.8	1.4	1.4	0.3	1.0	0.5	2.4	0.3	1.9
21	2.9	1.4	1.0	0.7	2.1	0.4	2.3	0.2	2.0
22	2.5	0.8	1.0	2.4	2.6	1.0	1.5	0.2	2.1
23	2.7	1.0	1.5	0.8	2.0	1.8	2.1	0.2	2.1
24	2.5	0.8	1.8	0.3	1.5	1.0	2.3	0.4	1.5
25	3.2	0.8	1.0	2.1	1.5	0.5	1.1	0.8	2.2
26	3.0	1.0	0.5	1.1	0.5	1.8	1.0	0.4	2.1
27	2.0	3.2	0.0	0.0	0.0	0.0	2.5	0.3	1.0
LSD	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3

[1] flavor intensities observed in three or more skim milk powders

Cooked – cooked flavor, swtarom – sweet aromatic, cereal – cereal, an/wd – animal/wet dog, pot – potato/brothy, crdbrd – cardboard, sweet – sweet taste, salty – salty taste, astrgt – astringent. For complete references, see Table 2.

TABLE 4. INTENSITY SCORES FOR FREQUENTLY

OBSERVED FLAVOR ATTRIBUTES' OF SKIM MILK

POWDERS

Attribute	Sample and Intensity
Caramelized	SMP 10 = 1.8, SMP 14 = 2.2
Burnt	SMP 23 = 1.4
Animal/Barny	SMP 20 = 2.2
Vitamin/rubbery	SMP 18 = 3.9
Free fatty acid	SMP 14 = 1.0
Earthy/musty	SMP 14 = 1.1
Bitter	SMP 23 = 1.4
Sour	SMP 14 = 2.2

TABLE 5. ATTRIBUTES AND INTENSITY SCORES

FOUND IN TWO OR FEWER SKIM MILK POWDERS

Attribute	Sample and Intensity
diacetyl	WPC34 = 1.0
Cereal/grass-like	WMP28 = 2.1
umami	WPC34 = 1.5

[1] Whey protein concentrate (WPC), whole milk powder (WMP), or caseinate

TABLE 6. ATTRIBUTES AND INTENSITY SCORES

FOUND IN FEWER THAN TWO OTHER[1] DAIRY

INGREDIENTS

Attributes	Factor 1	Factor 2	Factor 3	Factor 4
cooked	0.03	**0.66**	0.57	0.04
Sweet aromatic	**0.79**	0.25	0.26	0.05
cereal	0.32	**-0.77**	0.20	-0.17
Animal/wetdog	**-0.80**	0.28	0.13	-0.11
Potato/brothy	**-0.84**	0.13	0.13	0.08
cardboard	0.43	-0.06	**0.65**	-0.52
Sweet taste	0.63	0.26	-0.03	**0.65**
salty	-0.08	**-0.66**	0.32	0.36
astringent	-0.40	-0.15	**0.72**	0.31
% variance explained	31	22	17	12

Numbers in bold are believed to be of primary importance.

TABLE 7. FACTOR LOADINGS FOR SENSORY

ATTRIBUTES OF SKIM MILK POWDERS

	Swe/aro	cereal	An/wd	Potato	cardbrd	sweet	salty	astrgt
Cooked	0.25	-0.31	0.15	0.10	0.34	0.16	-0.13	0.19
Swe/aro		0.08	-0.55*	-0.56*	0.35	0.51*	-0.20	-0.08
cereal			-0.42*	-0.25*	0.24	-0.04	0.04	0.08
An/wd				0.63*	-0.14	-0.42*	0.03	0.28
Potato					-0.30	-0.40*	0.03	0.44*
Cardbrd						0.03	0.02	0.10
sweet							-0.10	-0.16
Salty								0.35

* denotes significant correlation ($P<0.002$)

Cooked – cooked flavor, swe/aro – sweet aromatic, cereal – cereal, an/wd – animal/wet dog, potato – potato/brothy, crdbrd – cardboard, sweet – sweet taste, salty – salty taste, astrgt – astringent. For complete references, see Table 2.

TABLE 8. PEARSON CORRELATIONS BETWEEN TERMS
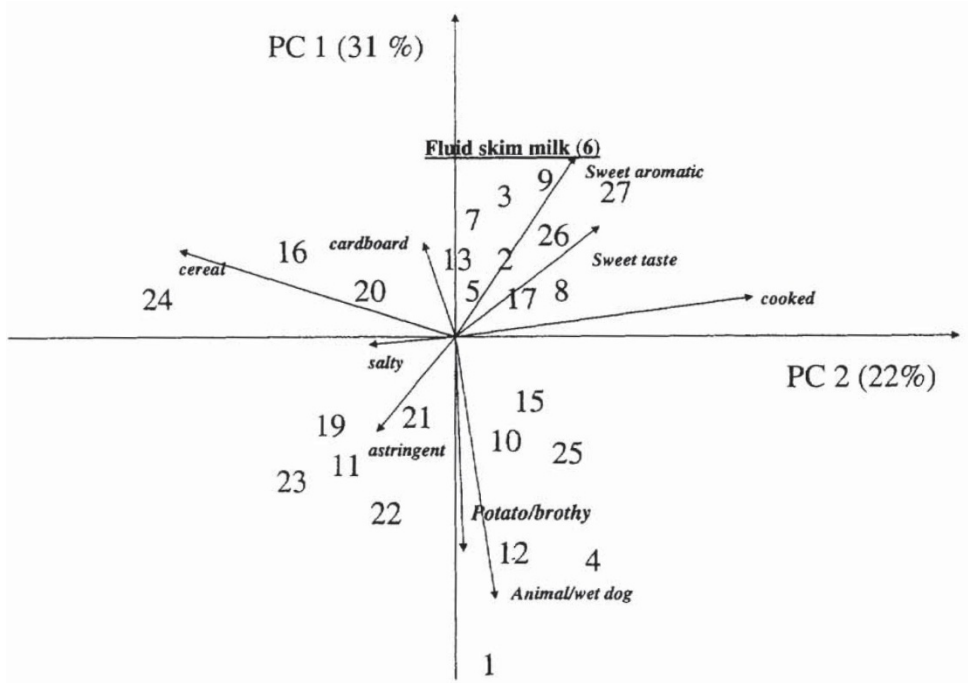
FOR SKIM MILK POWDER EVALUATION.

FIG. 1. PRJNCIPAL COMPONENT BIPLOT OF SMP AS

SEPARATED BY PCl AND PC2

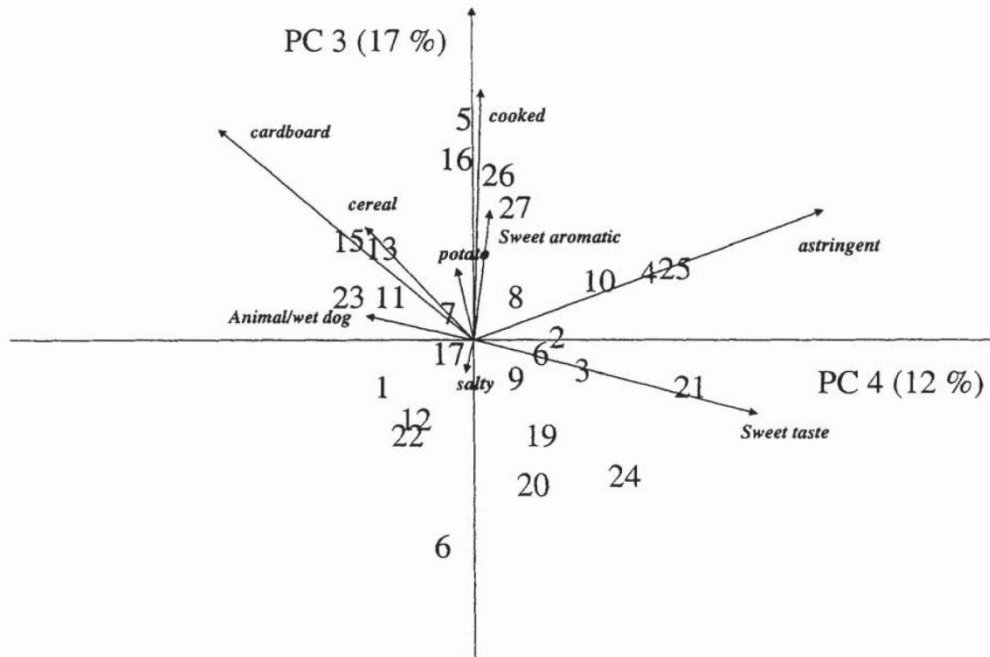SMP are represented by numbers (see Table 3).

FIG. 2. PRJNCIPAL COMPONENT BIPLOT OF SMP AS

SEPARATED BY PC3 AND PC4
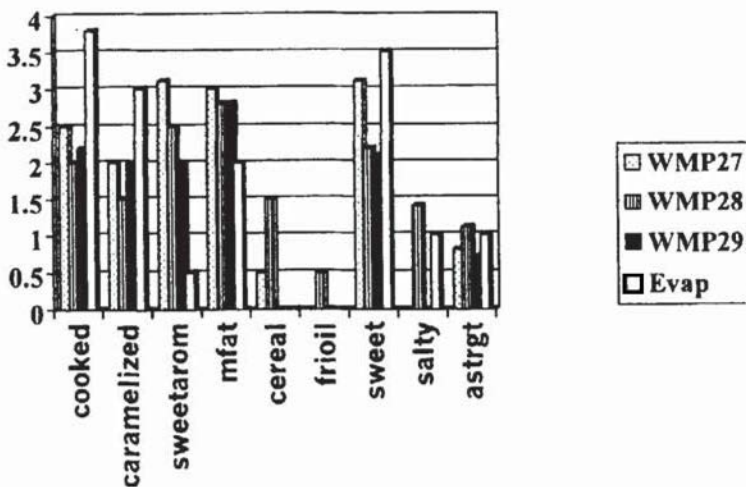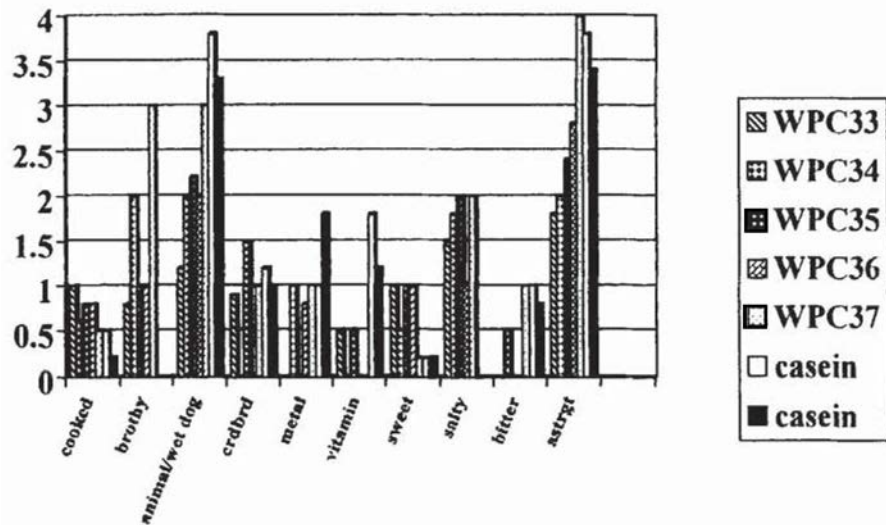
SMP are represented by numbers (see Table 3).

FIG. 3. ATIRIBUTES AND INTENSITIES OF WHOLE MILK

POWDERS AND EVAPORATED MILK

Cooked • cooked flavor, caramelized flavor, sweetarom- sweet

aromatic, mfat- milkfat flavor, cereal - cereal, frioil - fried,

fatty/painty, sweet - sweet taste, salty - salty taste, astrgt-

astringent . For complete references, see Table 2.

FIG. 4. ATTRlBUTES AND INTENSITIES OF CASEINATES

 AND WHEY PROTEIN CONCENTRATES

Cooked- cooked flavor, animal/wet dog - animal/wet dog, brothy

- potato/brothy. crdbrd - cardboard, metal - mushroom/metallic,

vitamin - vitamin, sweet- sweet taste, salty - salty taste, bitter –

bitter, astringent - astringent. For complete references, see

Table:z.