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Sensory Properties of Thai Fish Sauces and Their Categorization

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ABSTRACT

Sensory characteristics of Thai fish sauces is one of the most important factors of consumer perception. This study aims to characterize sensory properties of Thai fish sauces, and to categorize Thai fish sauces based on the sensory properties. Twenty samples composing of 12 commercial Thai fish sauces (P) and 8 commercial Thai mixed fish sauces (M) were collected. Generic descriptive quantitative analysis with twelve trained panelists was used to determine and compare the sensory characteristics of samples. The results showed that there were fifteen sensory descriptors which were brown color, five aromatics (sweet, caramelized, fermented, fishy, and musty), four tastes (sweet, salty, bitter, and umami), and five aftertastes (sweet aftertaste, salty aftertaste, bitter aftertaste, caramelized flavor, and fishy flavor). P samples had significant difference in all of sensory characteristics from M samples ($p<0.05$). In addition, principal component analysis (PCA) could reduce those sensory attributes into two independent principal components, which accounted for 55.14% of the total variance, and could categorize samples into four groups. The first principal component (PC1) separated samples into two groups which high and low degree of fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste. The second PC also separated samples from PC1 in another two groups which high and low degree of caramelized aromatic, sweet taste, sweet aromatic, salty taste, salty aftertaste, musty aromatic and fermented aromatic.

Key words: fish sauces, descriptive analysis, principal component analysis (PCA)

INTRODUCTION

Fish sauce is a clear brown liquid hydrolysate from salted fish and is commonly used as a flavor enhancer or salt replacement in various food preparations. The nutritional value is limited due to the high salt content, but daily consumption of fish sauce renders it one of the main protein sources in some regions where carbohydrates are the fundamental part of diet (Amano, 1962). During the fish sauce fermentation, fish proteins are hydrolyzed both by endogenous protease through autolysis and exogenous ones of microbial origin. The resulting product has a distinctive odor and flavor, which develops progressively as the fermentation progresses (Fukami *et al*., 2004). These characteristics are significantly factors in consumer acceptability of fish sauce products.

Sensory analysis is one of the methods that can describe the qualities of fish sauces. Generic descriptive analysis is a much used tool in sensory analysis which provides the most detailed or complete description of products and/or product categories. This technique adapted from the trademarked named "Quantitative Descriptive Analysis (QDA®)" and "Sensory Spectrum"

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(Lawless and Heymann, 1998). Stone *et al.* (1974) subdivided three major contributing factors (ammonical, cheesy, and meaty), which describe the fish sauce odor into eight attributes as the descriptors for QDA®. They were burnt, fishy, sweaty, feacal, rancid, cheesy, meaty, and ammonical notes. Fukami *et al.*(2002) reported that 2-methylpropanal, 2- methylbutanal, 2-pentanone, 2-ethylpyridine, dimethyl trisulfide, 3-(methylthio)-proppanal, and 3-methylbutanoic acid were principal contributors to the distinctive odor of fish sauce.

The analysis of sensory descriptive analysis data is usually done by means of analysis of variance on the individual attributes. When there are many samples and many attributes the comparison of profiles becomes cumbersome, either graphically or by means of analysis of variance on all the attributes. In that case, principal component analysis (PCA) in combination with a biplot can be a most effective tool for the exploration of the data (Vandeginste *et al*., 1998). Many researchers applied PCA to the sensory properties of food products such as sausage (Ellekjaer *et al*., 1994), carrot (Rosenfeld and Nes, 2000), cheese (Bertaud *et al*., 2000), strawberries (Han *et al*., 2005).

PCA is one of variable-directed techniques for forming new variables which are linear composites of the original variables. The objective of the PCA is to reduce the dimensionality of the data set. It involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables that are called principal components (PCs). The values of new variables are called principal components scores (Sharma, 1996; Johnson, 1998). The most reason for performing a PCA is to use it as a tool for screening multivariate data. An examination of the results graphical display used PC scores as input often reveal abnormalities and outliers in the data set. In addition, the PC scores can be analyzed individually to see whether distributional assumptions such as normality of the variables and independence of the experimental units hold. PCA is also helpful to researchers who want to partition experimental units into subgroups so that similar experimental units belong to the same subgroup (Johnson, 1998).

In Thailand, there are many factories producing fish sauces for domestic consumption and export (Fisheries Economics Division, 2002). Thai fish sauces can be categorized in to three types based on the production process, raw material, and quality according to the Notification of the Ministry of Public Health (2000). These three types of Thai fish sauce are: 1) pure fish sauce, fish sauce in which fermentation is derived from fish and fish residue, 2) fish sauce made from other animals, fish sauces where fermentation is derived from marinating other types of animals rather than anchovy fish, and 3) mixed fish sauce, fish sauces obtained by fish sauce that added with non-hazardous additive or flavoring agent.

This study aims to investigate on Thai fish sauce of type 1 (pure fish sauce) and type 3 (mixed fish sauce) with the following objectives: (1) to characterize sensory properties of Thai fish sauces, and (2) to categorize Thai fish sauces based on the sensory properties.

MATERIALS AND METHODS

Samples

The fish sauce samples consisted of pure Thai fish sauces and mixed Thai fish sauces were purchased from the markets around Kasetsart University, Bangkok, Thailand. A total of 20 fish sauces, produced during the same period of January 2006, were available used in this study. According to their labels, 12 samples were pure fish sauces (P) and the remaining of 8 samples were mixed fish sauces (M). All samples were transferred to tightly plastic bottles, sealed and stored at 4 °C before measure their sensory

properties.

Panelists

Twelve panelists (aged 22-28 years) from Department of Product Development, Faculty of Agro-Industry, Kasetsart University, participated in this study. These panelists had been trained on the Generic quantitative descriptive analysis method. They had some experience on descriptive tests and ability to perceive difference between test samples. The sensory panelists were selected according to guidelines in ISO (1993).

Sensory evaluation

All 20 Thai commercial fish sauces were examined during the orientation session to develop terms and definitions for describing sensory characteristics of Thai fish sauces. The final list of the 15 sensory attributes and their definitions are given in Table 1. Panelists were trained in the

Table 1 Descriptive attributes and their definitions used in the descriptive analysis of Thai fish sauces.

Attributes[1]	Definitions
Color	
Brown intensity	The intensity or strength of the brown color from light to dark.
Aromatics	
Sweet aromatic	The aromatic associated with sugar perceived by smell.
Caramelized aromatic	The aromatic associated with brown sugar perceived by smell.
Fermented aromatic	The aromatic associated with fermented fish perceived by smell.
Fishy aromatic	The aromatics or volatiles which are derived from fish products perceived by smell.
Musty aromatic	The aromatic associated with closed air spaces that are perceived by smell such as attic and closets.
Basic tastes	
Sweet taste	The fundamental taste factor associated with a sucrose solution perceived by tongue.
Salty taste	The fundamental taste factor associated with a sodium chloride solution perceived by tongue.
Bitter taste	The fundamental taste factor associated with a caffeine solution perceived by tongue.
Umami taste	The fundamental taste factor associated with a monosodium glutamate (MSG) solution perceived by tongue.
Aftertaste	
Sweet aftertaste	The fundamental taste factor associated with a pure refined sugar in solution remaining after swallowing the sample.
Salty aftertaste	The fundamental taste factor associated with a sodium chloride solution remaining after swallowing the sample.
Bitter aftertaste	The fundamental taste factor associated with a caffeine solution remaining after swallowing the sample.
Caramelized flavor	The characteristic aroma of natural brown sugar in solution perceived by tasting and smelling during swallowing.
Fishy flavor	The characteristic aroma of fish products perceived by tasting and smelling during swallowing.

[1] Attribute listed in order perceived by panelistes.

definition of the attributes for 16 hours before testing samples. Five sessions were held for sample evaluation. Four samples were presented monadically in random during each session. Each panelist was served approximately 20 mL of a fish sauce sample in a 60-mL plastic cup with cover slip at room temperature (25°C). Panelists evaluated intensities and scores of each attributes on a 15-point numerical scale divided into 0.5 increments, with 0 meaning none and 15 meaning extremely strong. Panelist cleaned their palates with mineral water and unsalted crackers between sample evaluations. Ten minute break was taken between sample analyses. A randomized complete block design with 2 replications was used in this study.

Data analysis

Analysis of variance (ANOVA) was performed to determine significant differences in sensory quality between fish sauces samples. The mean scores of the fish sauce samples were considered. Two factors, the panelist and type of Thai fish sauce, were studied. Cluster analysis was applied to the sensory attribute scores which significantly discriminated between samples. The attributes were also analyzed, standardize, by Hierarchical cluster analysis with Euclidean distance and averages between groups linkage. This analysis was carried out in order to identify clusters of samples having a similar sensory profile. ANOVA and cluster analysis were performed using SPSS®. Consequently, principal component analysis (PCA) of mean rating for each sensory attribute was used to illustrate the relationships among variables and samples. PCA was performed by the Unscrambler® software, ver. 8.3: CAMO AS, Norway. Full cross-validation was used to validate the model (Martens and Naes, 1986). The sensory attributes were standardized prior to the analysis by weighing variables by their standard deviations.

RESULTS AND DISCUSSION

Sensory characteristics of Thai commercial fish sauces

The mean values for the sensory attribute ratings of pure fish sauce and mixed fish sauce samples from the descriptive analysis are presented in Figure 1. The analyses of variance for each attributes were assessed independently at a

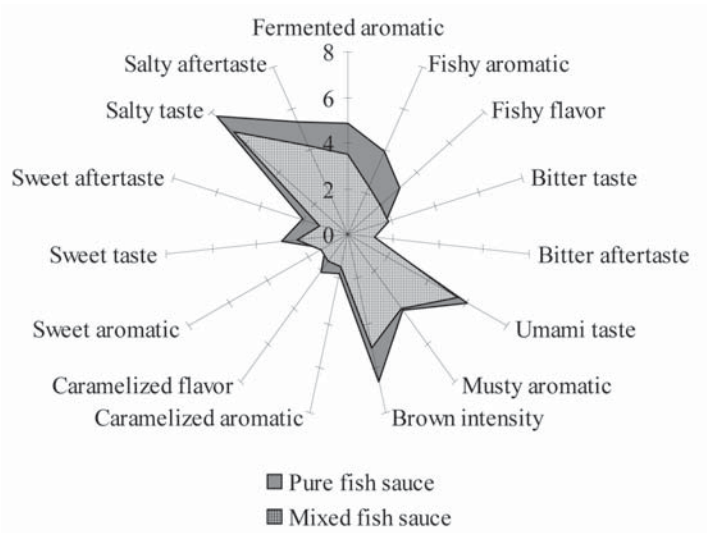

Figure 1 The sensory profiles of Thai pure fish sauces based on generic quantitative descriptive analysis test.

significance level of 5%. The two factors, panelist and sample, were studied. Table 2 shows the sensory attributes and results of ANOVA. At the 5% level, the sample effect was significant for all attributes while the panelist effect was not significant. This can be indicated that the intensity of sensory attributes differs among samples.

Cluster analysis

Cluster analysis was performed using sensory scores of fifteen sensory attributes as predictor variables. Prior to cluster analysis, all sensory attributes were converted to Z-scores to standardize and normalize the sensory scores. The dendrogram obtained by the Euclidian distance partly classified samples according to types (Figure 2). Four clusters each mainly composed of P, P, M and P+M were observed. It can be seen that the sensory characteristics of some samples in pure fish sauces (P) group similar to mixed fish sauces (M). Although the branches of the dendrogram represent the distance between the samples or clusters, no information is provided by the dendrogram on the specific attribute differences among the samples. The final output does not provide the reason why two types of fish sauces were grouped together. Therefore, other test results, such as principal component analysis, need to be inspected to explain the clustering (Muñoz *et al*., 1996).

Categorization and describing of Thai commercial fish sauces

Principal component analysis (PCA) was applied to the fifteen sensory attributes of twenty fish sauce samples to investigate the relevant and interpretable structure in the data. It indicated that the dimensionality of the data was reduced from fifteen variables to four uncorrelated components, which explained a total of 79.88% of the variation.

To simplify and visualize the data, the score plot (the map of fish sauce sample scores) and loading plot (the map of sensory attribute loadings) on the first two principal components are shown in Figure 3 and 4, respectively. The score plot can be used to detect sample patterns,

Table 2 Analysis of variance on 15 sensory attributes rated for fish sauce samples.

Attributes	Panelist effect		Sample effect	
	F-ratio	*p-value*	*F-ratio*	*p-value*
Brown intensity	0.05	1.00	64.37	0.00*
Sweet aromatic	0.28	0.93	15.73	0.00*
Caramelized aromatic	1.03	0.40	14.28	0.00*
Fermented aromatic	0.30	0.91	16.96	0.00*
Fishy aromatic	0.23	0.95	19.48	0.00*
Musty aromatic	0.28	0.92	16.38	0.00*
Sweet taste	0.36	0.88	17.82	0.00*
Salty taste0.07	1.00	33.69	0.00*	
Bitter taste	0.25	0.94	7.02	0.00*
Umami taste	0.58	0.72	7.47	0.00*
Sweet aftertaste	0.29	0.92	14.26	0.00*
Salty aftertaste	0.13	0.99	30.31	0.00*
Bitter aftertaste	0.71	0.61	4.38	0.00*
Caramelized flavor	0.57	0.72	8.57	0.00*
Fishy flavor	0.56	0.73	11.66	0.00*

The *p-value* followed by * are significant at $p<0.05$.

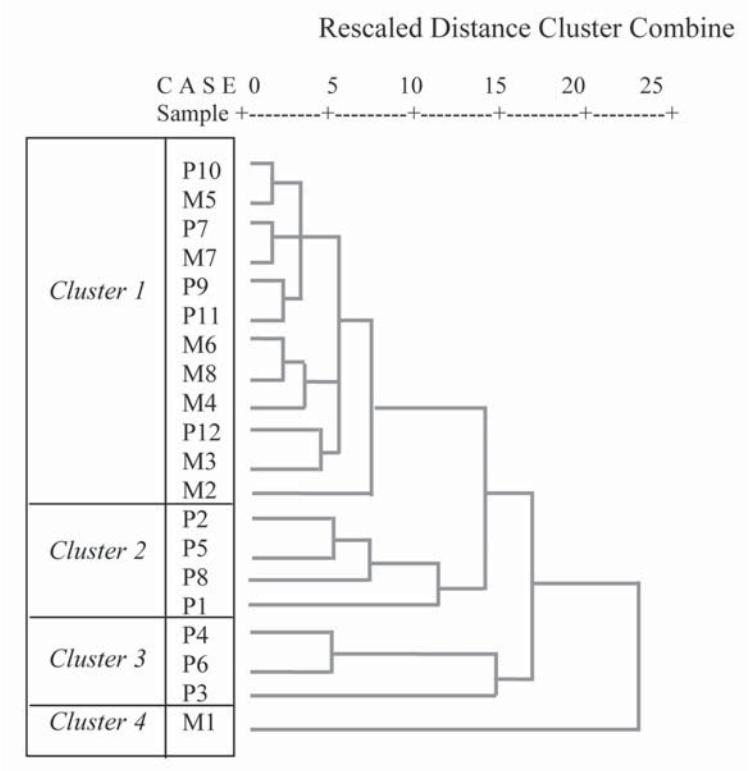

Figure 2 Clustering of 20 fish sauces based on their sensory properties. P1-P12 are pure fish sauce samples and M1-M8 are mixed fish sauce samples.

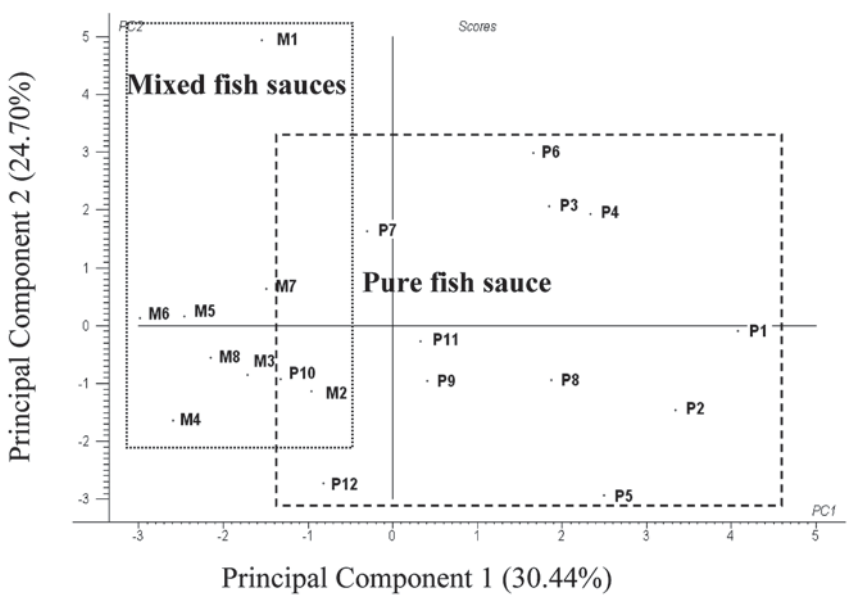

Figure 3 PCA score plot of the 20 Thai fish sauce samples performed by sensory data. P1-P12 are pure fish sauce samples and M1-M8 are mixed fish sauce samples.

grouping, similarities or differences, whereas the loading plots can be used to show how much each variable contributes to the meaningful variation in the data and interpret variable relationships (Rosenfeld and Nes, 2000).

Figure 3 shows the PCA score plot of fish sauce sample scores on the first two principal components. Principal component 1 (PC1) described 30.44 % of the total variance, while PC2 described 24.70% of the total variance. P samples (P1 to P12) and M sauce samples (M1 to M8) distinguished well on this plot. There is clear distinction of the scores from the two types of fish sauce on PC1. The P samples are somewhat more shifted towards the higher values of PC1 than the M samples

Table 3 shows the first four principal components explained 79.88% of the total variation. PC1 accounted for 30.44% of the variation and highly correlated to *fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste*, which will be referenced as fishy component. PC2 explained an additional 24.70% of the variation and highly correlated to *caramelized aromatic, sweet taste, sweet aromatic, salty taste, salty aftertaste, musty aromatic and fermented aromatic*, which will be referenced as caramelized and sweet component. PC3 explained an additional 15.66% of the variation and could be taken as an index of bitterness, as the attributes *bitter taste and bitter aftertaste* were highly correlated to this PC. The fourth PC explained another 9.37% of the variation and was mostly related to the variation in *brown color*.

The map of the sensory attribute loadings on the first two principal components is shown in Figure 4. Principal component 1 (PC1) described 30.44 % of the total variance, while PC2 described 24.70% of the total variance. The PC1 is mainly positively related to *fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste*. The attributes of *caramelized aromatic, sweet taste, sweet aromatic, salty taste, salty aftertaste, musty aromatic and fermented aromatic* were mainly represented by the PC2. Accordingly, *sweet aromatic, caramelized aromatic and sweet taste* were positively correlated with the PC2, contrary to the other sensory attributes. The total

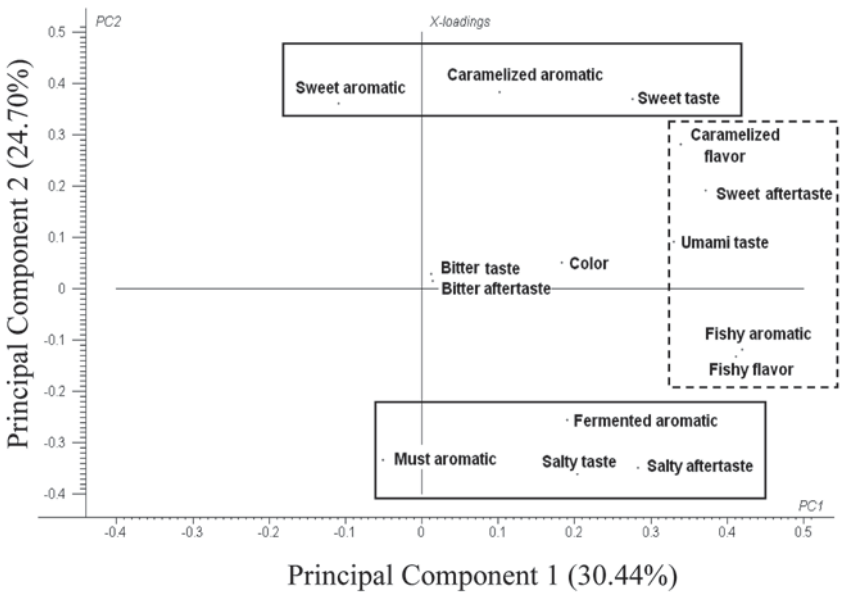

Figure 4 Sensory map of the first two principal components for describing 15 sensory attributes of Thai fish sauces.

amount of variance that was explained by the first two PCs was 55.14%.

Besides demonstrating the associations among the attributes, PCA can be used to display the relative "locations" of the samples with respect to each other and their characterizing attributes (Meilgaard *et al.*, 1999). The sensory data were analyzed to identify relationships and difference between samples and sensory attributes using biplot analysis. Based on cluster analysis, fish sauce samples could be categorized into four clusters and were grouped together in the PCA biplot map as shown in Figure 5. According to *fishy component* (PC1) which explained 30.44% of the total variance, the samples in cluster 2 and 3 were identified by higher degrees of *fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste* than the samples in cluster 1 and 4. It can be seen that pure fish sauce samples (P) and mixed fish sauce samples (M) distinguished well on this PC. There is clear distinction of the scores from the two types of fish sauce on PC1. The pure fish sauce samples (P) is somewhat more shifted towards the higher values of PC1 than the mixed fish sauce samples (M). These results indicated that pure fish sauces had higher degree of *fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste* than mixed fish sauce samples. Considering the *caramelized and sweet component* (PC2) which explained an additional of 24.70% of the variation, the samples in cluster 3 and 4 had higher degree of *sweet aromatic, caramelized aromatic and sweet taste* than the samples in cluster 1 and 2. A summary of the characteristic of fish sauces classified by principal component 1 and 2 is shown in Table 4.

CONCLUSION

This study has demonstrated the potential of PCA for describing the sensory properties of

Table 3 Explained variance for the first four principal components (PCs) from the principal component analysis (PCA).

Sensory attributes	Explained variance (%)			
	PC1	PC2	PC3	PC4
Brown intensity	15.37	0.97	6.86	**45.29**
Sweet aromatic	5.47	**48.40**	0.55	9.89
Caramelized aromatic	4.74	**54.42**	10.55	2.41
Fermented aromatic	16.54	**24.16**	2.08	21.56
Fishy aromatic	**80.21**	5.19	0.24	3.20
Musty aromatic	1.18	**41.17**	11.40	18.18
Sweet taste	34.70	**50.38**	5.71	0.42
Salty taste	18.97	**48.26**	2.01	5.47
Bitter taste	0.06	0.30	**88.65**	4.07
Umami taste	**49.83**	3.10	0.01	11.06
Sweet aftertaste	**62.91**	13.52	7.82	4.51
Salty aftertaste	36.64	**44.91**	0.66	8.78
Bitter aftertaste	0.09	0.10	**88.36**	0.02
Caramelized flavor	**52.64**	29.21	2.90	1.13
Fishy flavor	**77.30**	6.42	1.94	5.29

Figures in bold represent attributes responsible for the most variation between fish sauce samples on four significant principal components.

Thai commercial fish sauces from different types. The study revealed significant difference in the fifteen sensory properties of pure fish sauces and mixed fish sauces. These properties were brown color, 5 aromatics (sweet, caramelized, fermented, fishy, and musty), 4 tastes (sweet, salty, bitter, and umami), and 5 aftertastes (sweet aftertaste, salty aftertaste, bitter aftertaste, caramelized flavor, and fishy flavor). PCA reduced the fifteen sensory properties to the first four principal components, which explained a total of 79.88% of the variation. The samples were distinguished well using PC1, which explained 30.44% of the total variance. The pure fish sauces (P) showed higher degree of fishy aromatic, fish flavor, sweet flavor, caramelized flavor and umami taste than mixed fish sauces (M) on this PC.

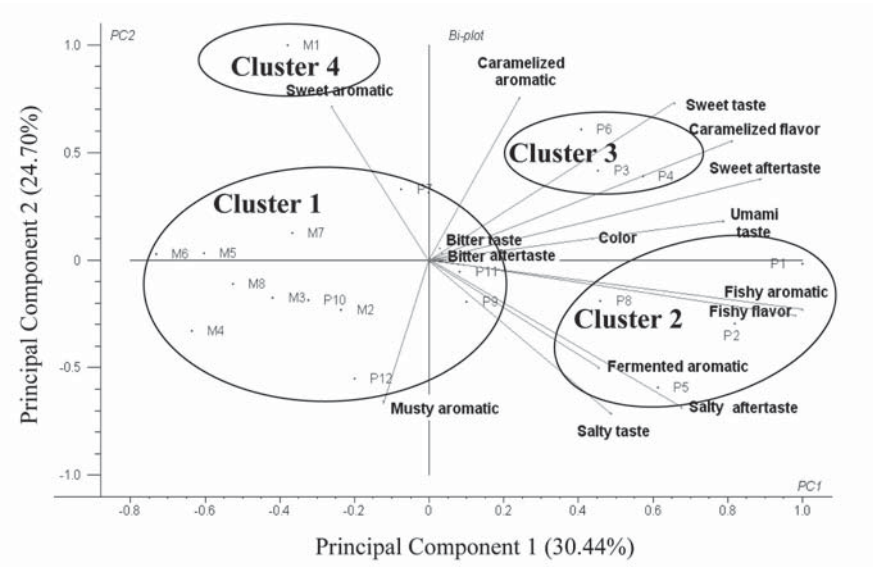

Figure 5 Biplot of the first two principal components for describing sensory attributes and grouping Thai fish sauces. P1-P12 are pure fish sauce samples and M1-M8 are mixed fish sauce samples.

Table 4 Four clusters of Thai fish sauce samples classified by principal component analysis (PCA)

Cluster	Principal component 1*		Principal component 2**		Sample in this cluster
	High	Low	High	Low	
1		√		√	P7, P9, P10, P11, P12, M2, M3, M4, M5, M6, M7, M8
2	√		√		P3, P4, P6
3	√			√	P1, P2, P5, P8,
4		√	√		M1

P1-P12 are pure fish sauce samples and M1-M8 are mixed fish sauce samples.

* Principal component 1 (PC1) explained 30.44% of the variation and positively related to *fishy aromatic, fishy flavor, sweet aftertaste, caramelized flavor and umami taste*.

** Principal component 2 (PC2) explained an additional 24.70% of the variation. PC2 is positively related to *caramelized aromatic, sweet taste and sweet aromatic*, which contrary to the other sensory attributes of *salty taste, salty aftertaste, musty aromatic and fermented aromatic*.

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