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6 **SENSORY LEXICON DEVELOPMENT USING TRAINED PANELISTS IN THAILAND**

7 **AND THE UNITED STATES: SOY SAUCE**

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13 Running title: Lexicon Development by two panels for Soy Sauce

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1 **ABSTRACT**

2 Twenty soy sauce products were presented to two sensory panels, one in Thailand and one in the  
3 U.S. Both panels had extensive training conducting descriptive sensory studies. Neither group  
4 had tested soy sauce previously; however, they had different familiarity with soy sauce. Each  
5 group separately evaluated samples during the same time period; then met, in Thailand, to  
6 compare and discuss their generated lexicons. Most attributes listed by each group of panelists  
7 provided similar definitions and references. Although, a few attributes were not used by one or  
8 the other panel because that term either does not exist in both languages (e.g., “cured” is not a  
9 term for the Thai panel), represented an uncommon characteristic (e.g., “roaches” for the  
10 American panel), or were complex concepts (e.g., “brown”), the panelists used references to  
11 assist their understanding of unclear attributes. After discussion, both panels agreed on 59  
12 attributes with definitions and references for a soy sauce lexicon. The paper presents attributes  
13 in English and Thai.

14 **PRACTICAL APPLICATIONS**

15 A universal lexicon developed by different groups of trained panelists could reduce confusion  
16 and make the lexicon more understandable. A universal lexicon would help researchers in other  
17 countries to understand product quality. Additionally, the developed lexicon allows researchers  
18 to conduct studies with the same standard method in different laboratories enabling comparable  
19 results.

20 **Keywords:** lexicon, descriptive analysis, soy sauce, trained panel

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1 **INTRODUCTION**

2 The sophisticated method of descriptive sensory analysis captures a product's characteristics  
3 (i.e., aroma, appearance, flavor, texture, aftertaste, and sound) by using sensory panelists to  
4 evaluate and quantify perceived sensory attributes (Murray and others 2001).

5 A crucial step in the research process for a product's descriptive analysis includes lexicon  
6 development (Chambers *et al.* 2006). A well-developed set of lexicons for describing a product's  
7 sensory characteristics can provide accurate and reproducible results for descriptive sensory  
8 analysis. A trained panel can generate a set of lexicons or researchers may adopt and/or obtain  
9 lexicons from previous studies developed by other panels (Murray *et al.* 2001). However, Chung  
10 and Chung (2007) and Drake *et al.* (2005) determined that two panels, especially if they are from  
11 other countries, may use terms differently from one another when evaluating samples. The  
12 deviation occurs because of: 1) difficulties understanding and interpreting the previously  
13 established terms (Murray *et al.* 2001); 2) culture and familiarity affecting panelist's perception  
14 and interpretation of specific attributes, e.g., when the description is linked to cultural  
15 experiences or background (Risvik *et al.* 1992; Blancher *et al.* 2007; Chung and Chung, 2007;  
16 Yang *et al.* 2012); or 3) the adopted sensory attribute established in one culture does not exist in  
17 other cultures (Risvik *et al.* 1992; Blancher *et al.* 2007; Chung and Chung 2007). Hunter and  
18 McEwan (1998) suggested that panelists use standard references to assist them with fully  
19 understanding sensory characteristics, and therefore solve the problem.

20 Different researchers conducted several cross-cultural studies on descriptive analysis to  
21 validate lexicons and compare results from different cultures/countries panelists on a product  
22 category familiar, more or less, to each culture (Risvik *et al.* 1992; Hunter and McEwan 1998;  
23 Drake *et al.* 2005; Blancher *et al.* 2007; Chung and Chung 2007; Yang *et al.* 2012). Panelists

1 provided similar responses when products were distinctively different from one another;  
2 however, when the products were similar, panelists provided responses that were less similar  
3 because other familiarities with a product occurred (Drake *et al.* 2005; Chung and Chung 2007).

4 To date, no research exists where sensory panels from different cultural backgrounds with  
5 different familiarity levels on one product category come together and develop a lexicon.  
6 Therefore, researchers conducted this study by using Thai and American panelists with different  
7 familiarity levels toward the specific product category of soy sauce, a staple condiment and  
8 ingredient throughout East Asia.

9 Soy sauce is a salty, brown liquid often used for stir-frying or as a dip. In general,  
10 fermenting and aging a mixture of cooked soy beans and grains (e.g., wheat, barley, or rice), salt  
11 and water creates soy sauce (Hui and others 2003; Hui 2007). Adding acid to decompose soy  
12 protein and starch is another manufacturing method for making soy sauce. This method takes  
13 only few days to produce, while traditional soy sauce ages for several months (Steinkraus, 1989).  
14 The different ratio of soy bean to grains, as well as manufacturing process and flavoring  
15 ingredients are responsible for qualities and various types of soy sauce, especially sensory  
16 properties.

17 Several studies on the sensory properties of soy sauce exist; however, most focus on tastes;  
18 salt and umami tastes (Lioe *et al.* 2007; Lioe *et al.* 2010), and aroma/flavor characteristics (Otero  
19 *et al.* 1998; Steinhaus and Schieberle 2007). Studies by Jeong *et al.* (2004) and Chung and  
20 Chung (2007) conducted research providing a full spectrum of sensory characteristics of soy  
21 sauce samples. However, their research focused on only Japanese and Korean soy sauce  
22 products, even though soy sauce products are manufactured throughout East Asia. Additionally,  
23 several researchers conducted studies on volatiles compounds in soy sauce (Yokotsuka 1961;

1 Steinhaus and Schieberle 2007; Zhang *et al.* 2010) and indicated that some flavor attributes were  
2 absent from their studies. Therefore, developed lexicons from their studies leave out a wide array  
3 of soy sauce products' sensory characteristics.

4 Understanding a wide range of soy sauce flavor attributes is important because researchers  
5 can use the obtained information to measure and understand flavor quality. Additionally, in order  
6 to provide a universal and understandable lexicon, two different panels with different familiarity  
7 and cultural background working together on lexicon development would assist sensory  
8 scientists in conducting methods with the same standard. Thus, this study's objectives were to: 1)  
9 develop consensus terms, definitions, and references for describing sensory characteristics of soy  
10 sauce products, and 2) cross-culturally compare identical products' lexicons developed by Thai  
11 and US trained panelists with different familiarities toward soy sauce products.

## 12 **MATERIALS AND METHODS**

### 13 **Panelists**

14 Nine trained professional Thai panelists with fair-good English speaking skills from Kasetstart  
15 University Sensory and Consumer Research Center and six trained professional US panelists  
16 from the Sensory Analysis Center at Kansas State University participated in this study. The Thai  
17 panelists were familiar with and use soy sauce products, whereas US panelists were not familiar  
18 with soy sauce products. All panelists were females between 30-65 years old. Both panels had  
19 approximately 120 hours of training in descriptive analysis methodology that emphasized  
20 lexicon development and use and scaling of intensity for a wide range of products . Neither  
21 group had experience in evaluating soy sauce products.

### 22 **Product Screening**

1 Researchers purchased 116 soy sauce samples from grocery stores in Manhattan, Kansas and  
2 Beaverton, Oregon (Appendix 1). Five sensory analysts evaluated all soy sauce samples and  
3 classified samples based on similarity of overall flavor characteristics. The samples sorted into  
4 10 different groups. One to 3 representative samples of each group were selected for the lexicon  
5 development study. A total of 20 soy sauce samples were selected to represent a wide range of  
6 flavor characteristics. The selected samples were manufactured in China, Japan, Singapore,  
7 Korea, Taiwan, Philippines, Hong Kong, and the US. Researchers then sent samples to Thailand  
8 for evaluation.

### 9 **Sample Preparation**

10 All 20 samples were coded with 3-digit random numbers and stored in a refrigerator at 5-7°C.  
11 Samples were removed from the refrigerator about 1 h prior to the evaluation sessions and  
12 allowed to come to room temperature (~ 20C); then 10 mL of each soy sauce sample was  
13 measured and placed in 1 oz clear plastic cups and covered with a lid. One sample at a time was  
14 served in random order.

15 Panelists cleaned their palates between samples with unsalted-top crackers (Unsalted tops  
16 premium saltine crackers, Nabisco, East Hanover, NJ, USA) and reverse osmosis, deionized,  
17 carbon-filtered water.

### 18 **Lexicon development**

19 During the same period of time, Thai and US panels separately evaluated and developed  
20 terminology characteristics presented in the 20 soy sauce samples. Each panel worked in its own  
21 laboratories in Thailand or the U.S. Each evaluation session lasted approximately 1-2 h in the  
22 morning over 5 consecutive days. The panelists had at least a 5-minute break after each sample  
23 evaluation. Panelists individually evaluated each sample and made notes on the descriptors

1 presented. After all panelists finished their evaluations, the panel leader led a discussion to reach  
2 agreement on the identified descriptors. Once the panel agreed on the descriptors, they began  
3 defining the flavor notes more precisely and suggested definitions and potential references  
4 (including food and chemical), which represented soy sauce characteristics. Lexicon  
5 development with evaluation of all 20 products and determination of references took  
6 approximately 40 h for each panel. This is similar to the lexicon development reported in recent  
7 research on other products (Suwonsichon et al., 2012; Leksrisonpong et al., 2012; Bett-Garber  
8 et al., 2012; Vázquez-Araújo et al., 2012; and Adhikari et al., 2011). After establishing the  
9 lexicon for describing soy sauce products, four of the six US panelists went to Thailand for  
10 discussion, comparison, and finalization of the lexicons previously generated by each panel  
11 group.

12 A Thai sensory analyst who lived and worked in the U.S. moderated the final lexicon  
13 selection sessions. The sessions were conducted 2 sessions per day, 3 hr in the morning and 3 hr  
14 in the afternoon over 4 consecutive days. Sessions were held in both the morning and afternoon  
15 to reduce travel expenses for the US panelists. During the lexicon selection, researchers  
16 provided additional samples and references to panelists upon request.

#### 17 Product Testing and Analysis

18 The 20 plain soy sauce samples (1mL) were scored for each attribute by the panel and the  
19 scores for each attribute were mapped using principal components analysis (PCA) to determine  
20 how well the attributes described the products and to ensure that the products represented a  
21 broad cross-section of products in the category.

22

## 23 **RESULTS AND DISCUSSION**



1 Most attributes listed by each group of panelists provided similar definitions and references.  
2 Both panels agreed on 59 useful terms for describing sensory characteristics of soy sauce for the  
3 final lexicon (Table 1). The two panels discussed for clarity some attributes due to the unfamiliar  
4 characteristics, unfamiliarity, or ambiguousness of language.

5 The finalized 58 terms classified into four aspects: common terms, uncommon terms,  
6 uncommon characteristics, and complex characteristics (Table 2). The frequencies of each  
7 characteristic found in the 20 samples evaluated also are shown (Table 2).

8 Common terms: both panels generated terms such as *alcohol*, *animalic*, *beany*, *bitter*,  
9 *chemical*, *chocolate*, etc. Almost identical definitions for each term were created by both panels.

10 Uncommon terms: the Thai panel had difficulties understanding and interpreting several  
11 terms developed by the US panel. The Thai panel did not use these terms because the term either  
12 does not exist in the Thai language (i.e., *brown*, *dark brown*, *brown sweet*, *brown spice*, *caramel*,  
13 and *cured*) or no appropriate word was found for a specific characteristic, instead Thai panelists  
14 came up with a phrase to represent a characteristic (i.e., *acrid*, *briny*) or applied the English terms  
15 (i.e., *brown*, *caramel*, and *cured*).

16 Uncommon Characteristic: a term occasionally was not common or known to panelists. The  
17 US panelists originally did not define *roaches*, which Thai panelists described as *dirty*, *dusty*,  
18 and *musty characteristics*. The US panelists, who generally do not have roaches in their  
19 environment, would not know this characteristic based on their experience and cultural context  
20 (Severiano-Pérez et al., 2012; Risvik et al. 1992; Blancher et al. 2007). After the US panel was  
21 introduced to *roaches* they were able to identify this specific term.

22 Complex characteristics: Thai panelists had difficulties describing and understanding some  
23 terms such as *brown* and *musty*.

1 The Thai panelists had difficulty differentiating the terms *brown*, *caramel*, and *dark brown*  
2 created by US panelists. Thai panelists perceived these three characteristics to be the same as  
3 *brown* and rated the intensity by the degree of *brown* (i.e., low was *brown*, medium was *caramel*,  
4 and high was *dark brown*). However, the US panelists suggested these terms be separate because  
5 a soy sauce product may have different intensities for each “brown level.”

6 Both panelists had difficulties identifying and selecting appropriate terms related to *dusty*,  
7 *moldy*, *earthy*, and *musty*. The panels were uncertain how to differentiate these characteristics  
8 once they tried to classify the terms into specific characteristics (e.g., *earthy-damp*, *dusty*, and  
9 *moldy-damp*). However, chemical references, based on those recommended by Chambers *et al.*  
10 (1998), solved the confusion when these references were provided.

11 Another discussion created by both panels removed some redundant terms, and both panels  
12 agreed on eliminating these terms. For example, the original list of flavor terms contained such  
13 characteristics as *smoky*, *acid*, and *acid smoke*, but after discussion, the panels eliminated *acid*  
14 *smoke* because it was a combination of *acid* and *smoky* attributes in soy sauce samples. Some  
15 attributes were combined even though they represent slightly different flavors because  
16 individually no contribution was made to overall differences in soy sauce. For example,  
17 *medicinal*, *band-aid*, and *iodine* are different flavor attributes. However, the panel combined  
18 these three attributes because no differential contribution to understanding the flavor of soy  
19 sauce was made individually. Additionally, panelists found these attributes infrequently and at  
20 near-threshold levels.

21 The results were illustrated on a PCA map to show the product space (Fig. 1) on the first two  
22 PCs which represented only 30% of the explained variability. Due to the diversity of flavor

1 characteristics in soy sauce, it would take 18 PCs to explain approximately 99% of the  
2 variability.

3 The map demonstrated that the selected samples represented a broad cross-section of the soy  
4 sauce category. The developed attributes were successfully used to describe the product  
5 diversity.

6

## 7 **CONCLUSIONS**

8 This study suggested that familiarity of products does not affect trained panelists'  
9 performance in developing sensory terms for soy sauce products. However, language and culture  
10 were the factors that limit the ability to describe certain attributes. These limitations could be  
11 solved by using standard references to help the panelists to understand sensory characteristics of  
12 products across cultures.

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14

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- 16  
17

1 **TABLE 1. DEFINITION AND REFERENCE STANDARDS OF SOY SAUCE FLAVOR**

2 **CHARACTERISTICS DEVELOPED BY THAI AND AMERICAN PANELS**

3 (คำจำกัดความและตัวอย่างมาตรฐานกลิ่นรสของซอสถั่วเหลืองพัฒนาโดยผู้ทดสอบชาวไทยและอ

4 เมริกกัน)

Term	Definition	Reference
Acrid แหลม ฉุน	Sharp/acid, burnt flavor note associated with something over baked or excessively browned in oil	Grandma's molasses
Alcohol แอลกอฮอล์	Colorless pungent chemical-like aromatic associated with distilled spirits of grain products	1-penten-3-ol
Animalic/ barnyard สาบสัตว์	Combination of aromatics associated with farm animals and live animal habitation, including manures	Tincture of civet
Ashy sooty เถ้า	Light smokey/ashy aroma associated with burning tobacco, such as cigarette smoke.	Camel filters (Turkish and domestic blend) cigarette smoked filter
Astringent ฝื่อน	Drying, puckering, or tingling sensation on the surface and/or edges of the tongue and mouth	Alum solution
Bacon เบคอน	Aromatic reminiscent of smoked, brown, cured pork	Betty crocker Bac-os
Beany ถั่ว	Aromatics characteristic of beans; most include green, pea pod, nutty, brown, soy; also include starchy, musty/earthy, musty/dusty, sour aromatics, powdery feel, and one or more of the characteristics	1-octen-3-ol Kroger great northern bean
Bitter ขม	Fundamental taste sensation of which caffeine is typical	Caffeine solution
Briny น้ำเกลือ	Aromatic associated with salty and moist, such as salt water, ocean water, ocean air, or seaweed.	Dried seaweed (Kelp)
Brown น้ำตาล	Rich, full aromatic impression always characterized as some degree of darkness, generally associated with other attributes (can be found in nuts, brown sugar, coffee, coco).	2,3-dimethylpyrazine Diamond pecan halves
Brown (Dark) น้ำตาลเข้ม	Sharp, almost burnt aromatic, nice/deep intense flavor that is dry, round, and crisp (meat, bouillon cube, e.g., Knorr, dark brown sugar)	Wyler's beef bouillon
Brown fruity ผลไม้แห้งที่มีสีเข้ม	Aromatics associated with dried brown fruit	Prunes juice
Brown spices เครื่องเทศสีเข้ม	Aromatics associated with a range of brown spices such as cinnamon, nutmeg, allspice	McCormick allspice, cinnamon, and nutmeg in

		water
Brown sweet กลิ่นหวาน	A rich full-bodied dark brown sweet aromatic	1-2 Cyclo-hexenedione C & H golden brown sugar
Burnt ไหม้	Scorched dark brown aromatic that may be somewhat sharp and acrid; produced by over-heating.	AFF's wheat cereal
Caramel คาราเมล	A round, full bodied, medium brown aromatics associated with brown sugars and some other carbohydrates	Ethyl maltol C&H golden brown sugar
Cheesy ชีส	Perception of aromatics commonly associated with or identified as cheese; may be described as dairy sweet, dairy sour, butyric and/or goaty.	Joan of arc brie de luxe cheese
Chemical สารเคมี	Aromatic impression associated with a broad range of compounds, generally known as chemical	Borneol Carvacol
Chocolate ช็อกโกแลต	Aromatics associated with cocoa bean, powdered cocoa, and chocolate bar; a dark brown, sweet, often musty aromatic	Hershey's chocolate bar
Coffee กาแฟ	A distinctly roasted brown, slightly bitter aromatic characteristic of brewed coffee; additional descriptors may/may not include woody, oily, acidic, and full bodied; these notes may occur at varying intensities	Folger's coffee
Cured ถนอมอาหาร (เนื้อ)	Overall aromatic impression of preserved meat which includes sweet, salty, smoky and the impression of nitrite	Guaiacol Oscar meyer smoked, cooked ham
Cooked Fruit ผลไม้ความร้อน	Aromatic impression associated with a cooked fruit rather than fresh, uncooked fruit	Motts apple juice
Dry แห้ง	Dry is the term for the odor-effect, achieved through processing such as drying or dehydrating of a product.	Gensoy; soy protein powder
Dusty อับแห้ง	Dry, musty, papery	2,3,4- trimethoxybenzaldehyde
Earthy/damp ดินอับชื้น	Musty, damp, wet soil	2-methylisoborneol
Fermented หมัก	Sweet, overripe, rotten, musty. Sweet, slightly brown, overripe aromatics associated with fermented fruits, vegetables, or grains; can have a yeasty notes	Great lakes sun dried tomato
Fishy คาวปลา	Aromatic associated with fish oil as found in mackerel, canned sardines, or cod liver oil	Dried bonito shaving, Katsuobushi
Fruity	Aromatic blend which is sweet and/or sour	Welch white grape juice



ผลไม้	reminiscent of a variety of different fruits	
Green เขียว	Sharp slightly pungent aromatics associated with green plant/vegetable matter such as asparagus, Brussels sprout, celery, spinach, etc.	Dried seaweed (kelp)
Hay-like หญ้าแห้ง	Slightly sweet dry, dusty, aromatic with a slight green character associated with dry plant material	Dried parsley
Heavy oil / petroleum ปิโตรเลียม	Aromatics associated with a petroleum product; described as clean, heavy, and oily	Vaseline petroleum jelly
Meaty เนื้อ	Aromatic impression associated with meat extracts and/or broth; may or may not have a brown character (if the meat protein can be specifically identified, it will be)	Wyler's beef bouillon granules
Medicinal ยา	A clean, sterile aromatic characteristic of antiseptic-like products such as Band-Aids, alcohol, and iodine	Listerine
Metallic โลหะ	Flavor aromatics described as the flat associated with iron, copper, and silver spoons	Chunk pineapple
Molasses กากน้ำตาล	Dark caramel top notes, which may include slightly sharp, acrid, sulfur like of molasses notes characters	Grandma's molasses
Moldy/damp อับ/ชื้นรา	Musty, damp basement-like, earthy, moldy	2,3,5,6-tetrachloroanisole
Numbing ความรู้สึกลบ	A feeling of a decrease or loss of sensation in the mouth or tongue	Pepsi
Nutty ถั่ว	A total of the nutty characteristics; these nutty characteristics are: sweet, oily, light brown, slightly musty and/or buttery, earthy, woody, bitter (nuts, wheat germ, whole grains)	Kretschmer wheat germ
Oily impression กลิ่นน้ำมัน	Overall perception of heated oil aromatics commonly associated with products containing oil or fat; may include fat from pepperoni, utter fat from cheese, or oil in sauce or crust	Ritz cracker
Pungent ฉุน	Sharp aromatics with a physically penetrating sensation in the nose	McCormick dry mustard
Roasted คั่ว	Dark brown impression characteristic of products such as coffee, meat, and nuts- cooked at a higher temperature than toasted for a longer period of time); does not include bitter or burnt notes	Folgers classic roast ground coffee 2-isopropyl-3-methoxypyrazine
Roaches สาบ	Dirty, musty, insect-like aromatics associated with insects or roaches and their nests	Hydratrophic aldehyde
Rodent หนู	Dirty, animal hair-like aromatics, associated with rodents and rodent nests, sometimes accompanied by urine and/or rodent feces	Methylpentanoic acid
Salty	Fundamental taste factor of which sodium	Sodium chloride solution

เค็ม	chloride in water is typical	
Seaweed สาหร่าย	Aromatics associated with shell fish, fresh fish, and ocean vegetation	Jin Han international dried laver
Sesame งา	Woody, nutty, brown, buttery, musty aromatic characteristic of sesame seeds	Raw spice hunter sesame seeds
Smoky ควัน	A sweet, brown pungent aromatic which may be slightly ashy, sooty, dusty, or woody	Dried bonito shaving, Katsuobushi
Sour aromatics กลิ่นเปรี้ยว	Sour, astringent, slightly pungent aromatics associated with vinegar	5% white vinegar in water
Sour เปรี้ยว	A fundamental taste sensation of which citric acid is typical	Citric acid solution
Spicy เผ็ด	Blend of aromatics associated with a variety of products commonly known as spices: an overall intensity evaluation of what may be a combination of spice aromatics, which may/may not include allspice, fennel, dry mustard, paprika, black pepper, and ginger	Hillshire farms lit'l beef smokies
Sulfur ซัลเฟอร์	Slightly sweet acrid, pungent, harsh irritating aromatic reminiscent of matches, cap guns, and gun powder	Grandma's molasses
Sweet Aromatics กลิ่นหวาน	Aromatics and flavor notes associated with the impression of all sweet substances	Lorna doone cookie
Sweet หวาน	Fundamental taste sensation of which sucrose is typical	Sucrose solution
Umami ผงชูรส	Flat, salty flavor enhanced, naturally occurring in some mushrooms.	Mushroom broth
Urinous คล้ายปัสสาวะ	Combination of sour, somewhat sweet, pungent, slightly ammonia-like aromatics; associated with urine-soiled diapers	Choline chloride
Wet animal hair ขนสัตว์เปียก	Aromatic reminiscent of wet animal hair; tends to be pungent, musty, and somewhat sour; sometimes described as goaty	d-Xylose
Woody ไม้	Flat, dark dry aromatics associated with the bark of a tree or wood by-products.	Popsicle stick 4-ethyguaiacol
Yeasty (dough) ยีสต์ (แป้งหมัก)	Sour, fermented aromatic commonly associated with yeast	Wonder bread slice

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1 **TABLE 2: CLASSIFICATION OF TERMS FOR DESCRIBING SOY SAUCE**  
 2 **CHARACTERISTICS DEVELOPED BY US AND THAI PANELS AND FREQUENCY OF**  
 3 **EACH CHARACTERISTIC FOUND IN SELECTED SAMPLES.**

<b>Common Terms</b>			
Alcohol (20)	Cooked fruit (1)	Numbing (2)	Spicy (1)
Animalic-barnyard (2)	Dry (1) (1)	Oil Impression (1)	Sulfur (2)
Ashy-sooty (1)	Fermented (20)	Petroleum (1)	Sweet (20)
Bacon (1)	Fishy (3)	Pungent (18)	Sweet aromatics (17)
Astringent (20)	Fruity (11)	Roasted (2)	Umami (20)
Beany (20)	Green (1)	Rodent (1)	Urinous (3)
Bitter (20)	Hay (1)	Salty (20)	Wet animal hair (1)
Burnt (8)	Meaty (20)	Seaweed (2)	Woody (9)
Cheesy (1)	Medicinal (7)	Sesame (1)	Yeasty (2)
Chemical (3) (3)	Metallic (1)	Smoky (10)	
Chocolate (2) (2)	Molasses (5)	Sour (20)	
Coffee (1) (1)	Nutty (2)	Sour Aromatics (20)	
<b>Uncommon Terms</b>			
Acrid (3)	Briny (20)	Brown Sweet (6)	Brown spice (1)
Brown fruity (8)	Cured (19)		
<b>Uncommon Characteristics</b>			
Roaches (1)			
<b>Complex Characteristics</b>			
Brown (12)	Caramel (6)	Dark brown (20)	Dusty (6)
Earthy-Damp (8)	Moldy-damp (3)		

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 6 **APENDIX 1: A LIST OF ONE HUNDRED AND SIXTEEN SOY SAUCE COLLECTED**  
 7 **FOR PRODUCT SCREENING PROCESS**

<b>Country of Manufacture</b>	<b>Brand</b>	<b>Information</b>
China	<b>Lee Kum Kee*</b>	<b>Seasoned Soy Sauce for Seafood</b>
	<b>Lee Kum Kee*</b>	<b>Mushroom Flavored Dark Soy Sauce</b>
	<b>Lee Kum Kee*</b>	<b>Soy Sauce</b>
	Zhu	Dark Soy Superior Sauce
	<b>Zhu*</b>	<b>Light Superior Soy Sauce</b>

	Lee Kum Kee	Premium Dark Soy Sauce
	Lee Kum Kee	Chili Soy Sauce
	Lee Kum Kee	Double Deluxe Soy Sauce
	Tomo Foods	Soy Sauce
	<b>Maggi*</b>	<b>Seasoning</b>
	Pearl River Bridge	Superior Light Soy Sauce
	Lee Kum Kee	Lite Soy Sauce (50% Less Sodium)
	Lee Kum Kee	Premium Soy Sauce
	Pearl River Bridge	Seasoned Soy Sauce for Seafood
	Pearl River Bridge	Mushroom Flavored Superior (Dark Soy Sauce)
Hong Kong	<b>Koon Chun*</b>	<b>Black Soy Sauce</b>
	Amoy	Superior Light Soy Sauce
	Amoy	Dark Soy Sauce
	Amoy	Light Soy Sauce
	Amoy	Reduced Salt Soy Sauce
Indonesia	ABC	Sweet Soy Sauce
	ABC	Kecap Asin Salty Soy Sauce
Japan	<b>Kikkoman*</b>	<b>Organic Soy Sauce</b>
	<b>Kikkoman*</b>	<b>All-Purpose Seasoning (Maroyaka Soy Sauce)</b>
	Uminosei Shoyu Kokusan	Shoyu
	Usukuch	
	Kikkoman	Kikkoman Organic Soy Sauce
	Kikkoman	All-Purpose Seasoning (Umakuchi Shoyu; Flavor Enhanced Soy Sauce)
	Yamasa	Yamasa Soy Sauce
	Kikkoman	Marudaizu Oni Konbu Shoyu
	Eden Organic	Tamari Soy Sauce
	Kikkoman	Tamari Soy Sauce
	Yamasa	Marudaizu Shoyu
	Ohsawa	Nama Shoyu Unpasteurized Soy Sauce
	Mitoku	Johsen Organic Shoyu
	Eden Organic	Shoyu Soy Sauce (Reduced Sodium)
	Yamasa	Shinmi
	Wadakan	Soy Sauce
	White Soy Sauce	White Soy Sauce
	Yamasa	Soy Sauce (Less Salt)
	Mitoku	Organic Yaemon Tamari (Wheat Free)
	<b>Ninben*</b>	<b>Tsuyu No Moto (Seasoning Sauce Triple Strength)</b>
	<b>Marukin*</b>	<b>Soy Sauce</b>
	<b>Eden Organic*</b>	<b>Tamari Soy Sauce-Naturally Brewed</b>
	Wadakan	Soy Sauce with Seaweed
	Eden Organic	Shoyu Soy Sauce (Whole Wheat)

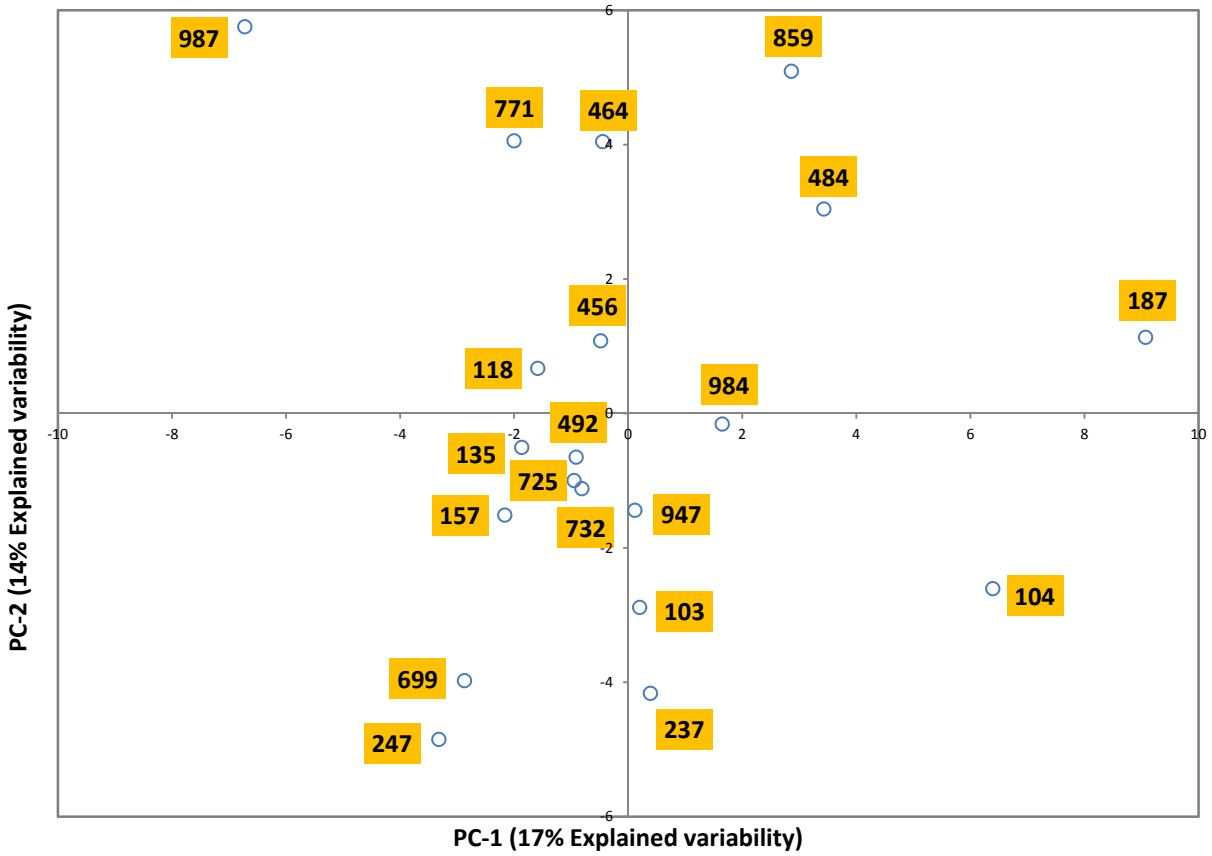
	Yamasa	Less Salt Soy Sauce
	White soy sauce	White Golden Tamari (Premium)
	Tomoechan	Soy Sauce with Seaweed
	Yamasa	Yamasa Tokusen Yuki Shoyu
	Eden Organic	Shoyu Soy Sauce (Organic Wheat)
	Nittojyozo Mikawa Shiro	Tamari
Korea	Assi	Sea Tangle Soy Sauce
	Chung Jung Won	Soy Sauce
	Chung Jung Won	Soy Sauce (Jorim)
	Sempio Foods	Soy Sauce for Soup
	Assi	Kelp Soy Sauce (5% Kelp)
	Sempio Foods	Soy Sauce Light (25% Low Sodium)
	Monggo Sun	Soy Sauce
	CJ	Dasima Ganjang (Soy Sauce, Sea Tangle Flavor)
	CJ	Traditional Korean Soy Sauce (for Soup)
	Sempio	Soy Sauce Jin S
	Assi	Authentic Flavor Soy Sauce
	Sempio Foods	Soy Sauce Charcoal Filtered
	Sempio Foods	Brewed Soup Soy Sauce Premium
	<b>CJ*</b>	<b>Naturally Brewed Soy Sauce (Yangjo)</b>
Philippines	<b>Silver Swan*</b>	<b>Special Soy Sauce</b>
	<b>Coconut Brand*</b>	<b>All-purpose Seasoning</b>
	Datu Puti	Soy Sauce
	<b>Marca Pina*</b>	<b>Soy Sauce</b>
	Datu Puti	Soy Sauce
Singapore	<b>Wei-Chuan*</b>	<b>China Light Soy Sauce</b>
	Wei-Chuan	China Dark Soy Sauce
	Kimlan	Soy Paste
	Kimlan	Kimlan Sang Chau (Grade-A, Light Soy Sauce)
	O'Long	Premium Black Bean Soy Sauce
	Kimlan	All-Purpose (40% Less Sodium)
	Kimlan	Authentic (Less Salty, More Flavor)
	Kim Ve Wong	Sang Chau (Premium Soy Sauce)
	Tung-I	Soy Sauce (Four Seasons)
	Kimlan	Kimlan Lou Chau (Dark Soy Sauce)
	Wan Ja Shan	Soy Sauce (Paste)
	Kimlan	Kimlan Sang Chau (Light Soy Sauce)
	Kimlan	Aged Soy Sauce
	Kim Ve Wong	Anka Soy Sauce
	Kim Ve Wong	Thick Soy Sauce
	Wan Ja Shan	All Purpose Seasoning
	Wei-chuan	Low-Salt Soy Sauce
	Kim Ve Wong	Soy Sauce for Vegetarians

	Kwong Hung Seng	Thin Soy Sauce (White Soy Sauce)
	Kwong Hung Seng	Sweet Sauce
	Healthy Boy	Thin Soy Sauce (White Soy Sauce)
	Golden Mountain	Seasoning Sauce
	Maekrua Gold Label	Yellow-Green Label (Premium)
	Kwong Hung Seng	Dark Soy Sauce
	Maekrua Gold Label	Yellow Label
	Chay	Seasoning Sauce
Thailand	<b>Maggi*</b>	<b>Cooking Soy Sauce, Taste of Asia</b>
	San J	Organic Shoyu
	Kikkoman	All-Purpose (37% less sodium)
	Best Choice	Lite Soy Sauce (50% less sodium)
	Yamasa	Premium Soy Sauce
	San-J	Tamari Premium Soy Sauce (Reduced Sodium)
	Great Value	Soy Sauce
	Aloha	Lower Salt Content
USA	<b>Best Choice*</b>	<b>All-Purpose Seasoning</b>
	<b>Kikkoman*</b>	<b>All-Purpose</b>
	Wan Ja Shan	Aged Soy Sauce
	Kikkoman	All-Purpose Milder Soy Sauce (40% Less Sodium)
	Aloha	Soy Sauce
	Kikkoman	Premium Quality Sushi and Sashimi
	La Choy	All Purpose
	Bluegrass	Soy Sauce
	San-J	Tamari Premium Soy Sauce
	San J	Organic Tamari (Wheat Free)
	La Choy	Lite Soy Sauce (50% Less Sodium)
	<b>San-J*</b>	<b>Organic Tamari (Reduce Sodium and Wheat Free)</b>

1 \* Samples were selected for lexicon development in this study

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2 **FIG. 1.** PRINCIPAL COMPONENT ANALYSIS MAP OF SOY SAUCE PRODUCTS

3 EVALUATED BY TRAINED PANEL USING DEVELOPED LEXICONS

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