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Chemical compositions, volatile compounds and sensory property of salted shrimp paste (*Kapi*) produced from *Acetes* vulgaris and *Macrobrachium lanchesteri*

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Received: March 2017 Accepted: October 2017

Keywords: Acetes vulgaris, Macrobrachium lanchesteri, Kapi, Volatile compounds, Sensory properties

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Introduction

Salted or fermented krill or shrimp pastes are widely consumed in many Asian countries including Thailand (Kapi), Indonesia (Terasi Udang), Malaysia (Belacan), **Philippines** (Bagoong-alamang) or Vietnam (Mam ruoc), etc (Hajeb and Jinab, 2015). It is often used to enhance palatability of many foods by providing desirable flavor and salty or umami taste. In general, raw material, shrimp krill/salt ratio, fermentation process and time can be varied, depending on regions or countries. The different characteristics and properties of those products were reported (Peralta et al., 2008).

Kapi, traditional salted shrimp paste of Thailand, is traditionally made from planktonous krill (*Mesopodopsis*

orientalis). Since the last decade, krill stocks have drastically dropped by 3% per year (Meland and Willassen, 2007). Two species of small shrimps: Acetes vulgaris and Macrobrachium lanchesteri became potentially alternative sources for Kapi production, because their high availability throughout the years, especially in the southern part of Thailand. To produce salted shrimp paste, shrimps are mixed with salt and ground into a fine paste. Then, salted shrimps are sun-dried to reduce their moisture content, followed by fermentation at room temperature approximately for month (Pongsetkul et al., 2014). During fermentation, the protein hydrolysis occurs and is mediated by the action of indigenous and microbial proteases. These phenomena yield short chain

peptides and free amino acids, which enhance the flavor and taste of final product (Pongsetkul et al., 2015a, b). Kim et al. (2014) reported that short chain peptides and free amino acids of Korean shrimp paste significantly during fermentation increased the period and could be responsible for the unique flavor of the product. The formation of Maillard reaction products (MRPs) was also observed throughout fermentation of Philippine fermented shrimp paste and related with the darker/browner color of the final product (Peralta et al.. 2008). Moreover, some fermented shrimp products exhibited the strong antioxidant activities (Faithong et al., 2010; Kleekayai et al., 2015).

Flavor or aroma is one of the most important factors in Kapi quality (Phithakpol, 1993). The characteristic flavor and aroma are primarily due to protein and lipid degradation autolytic and bacterial enzymes during fermentation, governed by different raw material, process employed, as well as strains of microorganism involved (Saisithi et al., 1966). Several volatile components of shrimp paste products were associated with their flavors (Cha and Cadwallader, 1995; Wittanalai et al., 2011; Kang and Baek, 2014; Pongsetkul et al., 2014). Nevertheless, a little information regarding chemical compositions, especially volatiles as well as sensory property of Kapi, produced from A. vulgaris and M. lanchesteri has been reported. Therefore, this investigation aimed to comparatively characterize Kapi produced from both shrimps.

Furthermore, relationship between volatile compounds and sensory properties of both *Kapi*, and commercial *Kapi* was also studied using principal component analysis (PCA).

Materials and methods

Sample collection

Shrimps (*A. vulgaris* and *M. lanchesteri*) were caught from the coast in Ko-yo and The-Pha in Songkhla province, Thailand, respectively. After capture, shrimp were transported in ice with a shrimp/ice ratio of 1:2 (w/w) in a polystyrene container to the Department of Food Technology, Prince of Songkla University, Hat Yai, Thailand, within approximately 2 h.

Preparation of Kapi

Shrimps were mixed with salt at the ratio of 5:1 (w/w) and transferred into the basket, covered with the cheese cloth. The mixture was kept at room temperature (28-32°C) overnight. Then, the drained samples were mashed or pounded thoroughly and spread out on fiberglass mats to dry with sunlight. The drying step was continued until samples disintegrate and turned from pink to dark purplish brown (with the moisture content of 35-40%). Subsequently, samples were transferred into earthen jars, covered with plastic bag tightly (close system), and allowed to ferment at room temperature. After 30 days of fermentation, Kapi were collected and referred to as KA (Kapi produced from A. vulgaris) and KM (Kapi produced from M. lanchesteri). The obtained samples were subjected to analyses.

Characterization of Kapi produced from A. vulgaris and M. lanchesteri pH and water activity (A_w)

The pH of samples was measured according to the method of Nirmal and Benjakul (2009) using a pH meter (Sartorius, Gottingen, Germany). Aw of *Kapi* was determined using a water activity analyzer (Thermoconstanter, Novasina, Switzerland).

Proximate composition

Moisture, ash, fat, protein and carbohydrate contents of *Kapi* were determined according to AOAC method (2000) with the analytical No. of 35.1.13, 35.1.14, 35.1.25, 35.1.15 and 35.1.16, respectively.

Salt content

Salt content was determined as per AOAC (2000) with the analytical number of 35.1.18 and was expressed as %NaCl.

Color

The color of samples was determined using a colorimeter (ColourFlex, Hunter Lab Reston, VA) with the CIE system. L^* (lightness), a^* (redness/greenness), b^* (yellowness/blueness), ΔE^* (total difference of color) and ΔC^* (the difference in chroma) were recorded as described by Pongsetkul $et\ al.\ (2014)$.

Browning products

Preparation of water extract

Kapi (1 g) was mixed with 25 ml of distilled water. The mixtures were homogenized at a speed of 11,000 rpm for 2 min, followed by centrifugation at $8,500 \times g$ for 15 min at room temperature. The supernatant was collected and adjusted to 25 mL using distilled water before analyses.

Measurement of browning products

After being diluted, the water extracts were measured for browning intensity (A_{420}) and Maillard reaction products $(A_{280} \text{ and } A_{295})$ using the UV-1601 spectrometer (Shimadzu, Kyoto, Japan). The fluorescence intensity at an excitation wavelength of 347 nm and emission wavelength of 415 nm was also determined using a fluorescence spectrophotometer RF-1501 (Shimadzu, Kyoto, Japan).

Volatile compounds

To extract volatile compounds, samples (5 g) were mixed with 10 mL of deionized water. The mixture was homogenized at a speed of 13,000 ×g for 1 min to disperse the sample. The homogenate was placed in a 20-mL headspace vial (Supelco, Bellefonte, PA, USA) and determined using a solid-phase micro-extraction gas chromatography mass spectrometry (SPME GC-MS) as per the method of Iglesias and Medina (2008) as detailed by Takeungwongtrakul and Benjakul (2013). Volatile compounds identified and expressed in the terms of relative abundance.

Sensory evaluation

The 50 untrained panelists, consumed Kapi regularly, were used for evaluation. The samples were wrapped with aluminium foil and heated in hot air oven at 60°C for 30 min. After cutting into small pieces $(2\times2\times1~\text{cm}^2)$, samples were placed in 15-mL plastic cup, covered with lids and left at room temperature for 30 min before serving. The panelists were asked to open the lid sniff. Between the samples, panelists rinsed their mouth with water or cracker. Scores for appearance, color, odor, flavor, texture and overall likeness using a 9-point hedonic scale were recorded.

Principal component analysis (PCA)

PCA was performed to access the relationship between volatile compounds, odor-liking, flavor-liking and overall-liking score of *Kapi* produced from *A. vulgaris* and *M. lanchesteri*, as well as commercial *Kapi* produced from krill (*Mesopodopsis orientalis*) obtained from different provinces in Thailand, including Krabi, Samut Sakhon and Rayong.

Statistical analysis

Completely randomized design (CRD) was used throughout the study. All experiments were run in triplicate. Data were subjected to analysis of variance (ANOVA), and mean comparisons were carried out by the Duncan's multiple range test. Independent T-test was performed for pair comparison (Steel *et al.*, 1980). Analysis was performed by using SPSS statistic program (Version 10.0) (SPSS, 1.2,

1998). For PCA (Principal Component Analysis), the XLSTAT Software (XLSTAT, 2008, Addinsoft, New York, NY, USA) was used.

Results and discussion

Characteristics and properties of Kapi pH, water activity (A_w) and proximate composition

As shown in Table 1, Kapi produced from A. vulgaris (KA) and lanchesteri (KM) had the neutral pH. KM had the slightly higher basic pH (7.27), compared with KA (7.16)(p<0.05). The slightly basic pH might be caused by the basic degradation products generated during postmortem storage of raw material or the formation of volatile base compounds such as ammonia during fermentation samples (Pongsetkul et al., 2014). The pH of Korean dried shrimp paste was in the range of 6.83-7.23 (Cho and Kim, 2010), while Fillipino fermented shrimp paste had pH of 7.50 (Montano et al., 2001). The pHs of those shrimp pastes were similar to those of Kapi in the present study. Both samples had no differences in water activity (A_w) (p>0.05). A_w of both *Kapi* was in the range of 0.6-0.7, which could be classified as an intermediate moisture food (Fennema, 1996). This associated with the prolonged shelf-life of this product due to the lowered growth of food pathogens and spoilage microorganisms (Chirife, 1989). Low A_w of Kapi samples were in agreement with the low moisture content. There was no difference in moisture content between KA (33.93%)(34.28%) (p>0.05). No differences in carbohydrate, ash and salt contents were found between KA and KM (p>0.05). KM had the higher protein content (28.48%), compared with KA (26.20%) (p<0.05). Conversely, KA had the higher fat content (3.91%) than KM (2.36%) (p<0.05). KA and KM had a high salt content (22.45-22.88%), related with their low Aw. The large amount of salt was added. The presence of inorganic substances in the shell of shrimp used as raw material resulted in the high ash content in both samples (33.13-32.94%). It could be inferred that different shrimps yielded Kapi with different compositions.

Color

KA and KM had different color characteristics as depicted in Table 1. KA showed the lower L^* -value but and ΔE^* -value b*. ΔC^* (p<0.05). However, no difference in a*value between both samples was observed (p>0.05). The result suggested that KA showed browner and more yellowish color than KM. Differences in color of both samples might be due to the different amount and type of pigments in raw material (A. vulgaris and М. lanchesteri). In general, carotenoids, especially astaxanthin, provide the desirable reddish-orange color in crustaceans (Higuera-Ciapara et al., 2006). During fermentation, free amino acids and small peptides could undergo Maillard reaction, thereby contributing to the brown color development (Lopetcharat et al., 2001). Lipid oxidation was also associated with browning mediated by Maillard reaction (Yarnpakdee et al., 2014). The carbonyl groups of aldehydes and ketones, the oxidation products, could react with amino groups of free amino acids or peptides generated during hydrolysis, leading to yellow or brown color development (Yarnpakdee *et al.*, 2014).

Browning and Maillard reaction products

Non-fluorescent fluorescent and intermediate products Maillard reaction as well as browning intensity of both water extracts of KA and KM are presented in Table 1. A₂₈₀ and A₂₉₅ have been used to determine the formation of non-fluorescent intermediate compounds of the Maillard reaction (Binsan et al., 2008). There were no differences in A_{280} and A_{295} between both samples (p>0.05). However, the differences in fluorescent intermediate products were observed. had the higher fluorescence intensity (403.91), compared with KM (315.88) (p<0.05). The result was in accordance with the higher browning intensity (A_{420}) found in KA. The relationship between browning intensity and fluorescence intensity suggested that a large proportion of fluorescent intermediate products were converted into brown polymers. Jing and Kitts (2002) reported that the development of fluorescent compounds occurred in the Maillard reaction prior to the generation of brown pigments. Generally, both non-fluorescent and fluorescent intermediates are formed and turn into brown pigments in the Maillard reaction (Binsan et al., 2008). Benjakul (2005) revealed that et

fluorescent intermediate was more reactive in formation of brown color than non-fluorescent compounds. The higher browning intensity of KA sample was in agreement with the browner color of this sample (Table 1). Thus, the differences in browning could affect the color and acceptability of *Kapi* to some degrees.

Table 1: Chemical compositions and characteristics of *Kapi* produced from *Acetes vulgaris and Macrobrachium lanchesteri*.

Compositions/Characteristics	KA	KM		
рН	7.16±0.01 ^b	7.27±0.03 ^a		
Water activity (A _w)	0.662 ± 0.00^{a}	0.659 ± 0.01^{a}		
Proximate composition				
Moisture	33.93 ± 0.99^{a}	34.28 ± 0.83^{a}		
Crude protein	26.20 ± 0.54^{b}	28.48 ± 0.63^{a}		
Crude fat	3.91 ± 0.25^{a}	2.36 ± 0.87^{b}		
Ash	32.94 ± 0.99^{a}	33.13 ± 0.12^{a}		
Carbohydrate	2.57 ± 0.55^{a}	1.16 ± 0.69^{a}		
Salt	22.88 ± 1.15^{a}	22.45 ± 1.65^{a}		
Color				
L^*	40.92 ± 0.32^{b}	45.23±0.76 ^a		
a^*	9.53 ± 0.52^{a}	9.17 ± 0.08^{a}		
b^*	18.11 ± 0.14^{a}	16.78 ± 0.04^{b}		
ΔE^*	56.50±0.23 ^a	52.13±0.69 ^b		
ΔC^*	19.55 ± 0.16^{a}	18.56 ± 0.94^{b}		
Browning and Maillard reaction products				
A_{280}	0.90 ± 0.09^{a}	1.01 ± 0.05^{a}		
A_{295}	0.83 ± 0.02^{a}	0.85 ± 0.17^{a}		
Browning intensity (A ₄₂₀)	0.46 ± 0.01^{a}	0.32 ± 0.02^{b}		
Fluorescence intensity	403.91 ± 6.31^{a}	315.88 ± 6.01^{b}		

Values are given as mean±SD (n= 3).

Different lowercase superscripts in the same row indicate the significant difference (p<0.05).

Volatile compounds

Forty-two volatile compounds of KA, KM and three commercial Kapi samples were detected (Table 2). These were classified into 6 main groups including aldehydes (5), ketones (8), alcohols (10), N-containing compounds (8), hydrocarbon (5) and others (6). For aldehydes, 3-methyl-butanal, pentanal and benzaldehyde were found in all while hexanal samples, was observed in KA. Among all samples, KC1 showed the highest intensity of

aldehydes (8.47%), followed by KC3 and KC2, indicating that commercial Kapi had the higher amount of aldehydes, compared with KA and KM. The presence of aldehydes and ketones are related with lipid oxidation during fermentation (Pongsetkul et al., 2015a). Eusebio et al. (2010) reported that krill (M. orientalis) contained 4.1-10.6% fat, while the fat contents of A. vulgaris and M. lanchesteri were 4.62 and 3.93% (dry weight basis) as reported by Pongsetkul (2015a)and etal.

^{*} KA, KM: Kapi produced from A. vulgaris and M. lanchesteri, respectively.

Pongsetkul *et al.* (2016), respectively. Krill or shrimp oil was reported to be rich in polyunsaturated fatty acids, which were prone to oxidation (Takeungwongtrakul and Benjakul, 2013). Benzaldehyde was reported to have a pleasant almond, nutty and fruity aroma (Cha and Cadwallader, 1995). 3-methyl-butanal is characterized by a

green and fruity flavor and is generated via Strecker degradation through Maillard reactions of isoleucine (Cha and Cadwallader, 1995). Strecker aldehydes are present and known to be potent odorants in many seafood products (Casaburi *et al.*, 2008).

Table 2: Volatile compounds of Kapi produced from Acetes vulgaris, Macrobrachium lanchesteri

and three commercial Kapi.							
Volatile compounds	Peak area (Abundance) \times 10 ⁶						
·	KA	KM	KC1	KC2	KC3		
3-methyl-butanal	41.73	36.65	45.65	55.35	65.31		
Pentanal	22.02	45.55	26.22	83.54	14.28		
Hexanal	ND	81.12	60.06	14.27	51.11		
Heptanal	44.45	12.03	55.55	ND	45.45		
Benzaldehyde	128.95	44.09	91.02	45.62	133.41		
Total Aldehydes (%)	4.30%	6.06%	8.47%	7.01%	7.06%		
1-phenyl-ethanone	24.43	51.92	209.05	ND	13.34		
1,2-diphenyl-ethanone	ND	58.06	ND	66.97	ND		
1-(2-aminophenyl)-ethanone	55.91	16.32	44.41	29.29	54.41		
2-pentanone	18.08	ND	ND	ND	ND		
2-hexanone	55.12	72.8	22.88	27.77	105.14		
2-heptanone	67.18	65.43	18.84	115.65	105.99		
6-methyl-5-hepten-2-one	ND	12.02	15.65	105.59	16.62		
3-octanone	ND	79.99	105.99	ND	18.84		
Total Ketones (%)	4.00%	9.85%	12.68%	12.18%	7.17%		
Benzenemethanol	152.22	225.09	105.05	24.99	206.12		
2-butyl-ethanol	78.12	22.45	ND	13.38	ND		
2-methyl, 1- propanol	113.13	ND	ND	95.15	22.25		
1-butanol	ND	17.71	103.32	98.45	12.25		
2-butanol	28.26	ND	21.13	33.42	44.78		
3-methyl-butanol	114.95	ND	104.22	95.11	232.26		
1-pentanol	72.28	ND	88.43	22.92	82.22		
1-penten-3-ol	105.32	77.62	ND	140.15	125.11		
5-methoxy-1-pentanol	622.1	620.53	102.34	ND	14.22		
2,4-dimethyl-3-pentanol	ND	71.4	ND	11.41	ND		
Total Alcohols (%)	23.31%	29.59%	15.95%	18.87%	16.86%		
Methyl-pyrazine	225.25	205.55	99.55	104.52	351.12		
2-ehtyl-6-methyl-pyrazine	338.11	113.95	ND	ND	11.08		
3-ethyl-5-methyl-pyrazine	198.11	113.95	214.55	258.29	137.11		
2,3-diethyl, 5-methyl-pyrazine	26.62	ND	44.13	ND	11.34		
2,5-dimethyl-pyrazine	634.88	85.39	211.35	142.72	330.11		
2,6-dimethyl-pyrazine	310.42	197.32	142.77	105.92	299.76		
3-ethyl-2,5-dimethyl-pyrazine	505.55	313.14	225.57	129.99	146.52		
2-ethyl-3,5-dimethyl-pyrazine	408.22	118.23	213.99	198.14	555.11		
Total N-containing Compounds (%)	47.98%	31.71%	35.04%	33.15%	42.01%		
2,6,10,14-tetramethyl-pentadecane	98.15	19.75	ND	ND	ND		
3-tetradocene	24.46	5.51	ND	43.35	ND		
2,3-butanediene	13.22	ND	28.01	28.01	ND		
2-undecane	9.11	55.46	ND	44.13	79/82		
Hexadecane	ND	6.63	102.22	18.83	ND		
Total Hydrocarbon (%)	2.63%	2.41%	3.96%	4.74%	1.82%		
Propanoic acid	12.28	ND	ND	ND	118.18		

Table 2 continued:					
Butanoic acid	49.52	39.61	22.28	105.55	105.16
Methyl-ester-butanoic acid	104.35	23.35	50.05	48.71	12.22
Pentatonic acid	ND	0.95	99.41	ND	13.38
Phenol	209.55	510.01	505.93	455.15	705.66
1H-Indole	605.55	199.34	108.11	72.28	145.55
Total Others (%)	17.78%	21.37%	23.90%	24.05%	25.09%

ND: non-detectable

Ketones found in all samples included 1-(2-aminophenyl)-ethanone, 2hexanone and 2-heptanone. Park et al. (2014) revealed that 2-hexanone and 2heptanone were produced by oxidation or pyrolysis of polyunsaturated fatty acids and were involved in a nasty smell in seafood. KM had the higher intensity of ketones (9.85%), compared with KA (4.00%), but lower than all commercial Kapi samples (7.17-12.68%).

Among 10 alcohols found in Kapi, only benzene-methanol was obtained in all samples. This compound gives the almond-like odor in seafood (Park et al., 2014). Michihata et al. (2002) noted that normal and branched alcohol, especially butanol derivatives, might be formed by microbial fermentation or the degradation products from lipid oxidation. The higher amount of 5methoxy-1-pentanol was obtained in KA compared and KM, commercial samples. The type and abundance of individual alcohol found in Kapi seemed to vary with different raw materials used for production. However, alcohols might not have a paramount impact on Kapi flavor because of their high flavor thresholds (Cha and Cadwallader, 1995).

All Kapi samples contained N-containing compounds as dominant

volatiles. KA highest had the abundance (47.98%), followed by KC3 (42.01%)and KC₁ (35.04%),respectively. Major pyrazine found compounds in all samples included methylpyrazine, 3-ethyl-5methylpyrazine, 3-ethyl-2,5-dimethylpyrazine, etc. These compounds contributed to prawn, roasted, nutty and dried seafood like odors, which were the desirable odor in dried fermented food (Jaffres et al., 2011). Rodríguez-Bernaldo et al. (2001) reported that pyrazine compounds were generated in samples dried using conditions i.e. spray drying and tray drying. The drying step with sunlight during Kapi production more likely contributed to the formation of these compounds. Pyrazines was thermally generated via Maillard reaction through Strecker degradations from various nitrogen sources such as amino acids in thermally processed foods (Rodríguez-Bernaldo et al., 2001). Furthermore, the presence of pyrazine indicated that browning reaction mediated by Maillard reaction occurred in Kapi during fermentation. **Pyrazine** derivative compounds were the major volatiles found in many fermented products including Ishiru (Japanese fish (Michihata al.. sauce) et2002). Noucmam (Vietnamese fish sauce)

^{*} KA, KM: *Kapi* produced from *A. vulgaris* and *M. lanchesteri*, KC1, KC2, KC3: Commercial *Kapi* from Krabi, Samut Sakhon and Rayong, respectively.

(Lopetcharat *et al.*, 2001), fermented dried shrimp (*Acetes chinensis*) (Lu *et al.*, 2011) as well as *Kapi* (Cha and Cadwallader, 1995; Pongsetkul *et al.*, 2015a). This compound might contribute to flavor, color as well as antioxidative activity of *Kapi* to some extent.

Low abundance of hydrocarbons (1.82-4.74%) was obtained in *Kapi*. Those included 2,6,10,14-tetramethylpentadecane, 3-tetradocene, butanediene, etc. Latorre-Moratalla et (2011) noted that the al. hydrocarbons, alkanes and alkenes, are mainly formed from lipid oxidation of fatty acids released from triglycerides. Additionally, some acids were found in some Kapi samples. Propanoic acid, which found in KA and KC3, mainly contribute to oily notes in foods (Chung et al., 2005). Butanoic acid and methyl-ester-butanoic acid were noticeable in all samples. These acids are known to have cheesy notes including cheesy, sharp, rancid, sweaty, and pungent (Chung et al., 2005). Additionally, phenol and 1H-indole were also obtained in all samples. Cha and Cadwallader (1995) reported that phenol give an undesirable aroma in seafood. Indole is the degradation product from tryptophan and has been used as the index for shrimp spoilage (Casaburi et al., 2008). Based on volatile compounds, Kapi produced different shrimps from contained varying amount and type of volatile compounds. This might be associated with different flavors and acceptability of various Kapi.

Sensory evaluation

Likeness scores of KA, KM, as well as three commercial Kapi are shown in Table 3. Generally, KC3 had the highest likeness score for all sensory characteristics including appearance, color, odor, texture, flavor and overallliking score (p<0.05). There were no differences in appearance-liking score between all samples (p>0.05). The highest color-liking score was obtained for KC1 (7.30), while KM had the lowest color-liking score (6.57).Pongsetkul et al. (2015a) suggested that Kapi with browner or darker color was more desirable. Lower L^* but higher b*-value of KA (Table 1) indicated higher intensity of color, especially more vellowish or browner, than KM. This led to the higher color-liking score of KA. Furthermore, the lowest odor and flavor-liking scores were found in **KM** (p < 0.05). In general. differences in sensorial characteristics of fermented food could be influenced by raw material used, ingredients, fermentation process and conditions (Beriain et al., 2000). Therefore, it was likely that differences in compositions as well as autolysis in raw material contributed to varying likeness scores of Kapi. In the present study, odor and flavor mainly affected the sensory quality (overall-liking) of this product. Based on overall-liking score, KA and KC1 had the highest overall-liking score, compared with others (p<0.05). The result indicated that A. vulgaris seemed to have high potential to become an alternative raw material for Kapi production.

Principal component analysis (PCA)

Relationships between volatile compounds of different Kapi samples including KA, KM and commercial Kapi and sensory score (odor, flavor and overall-liking score) were studied using PCA (Fig. 1). The first two principal components could be described as 87.26% of the variations in the data set. It was noticed that the first principal component, which was the direction of the maximum explained variance (47.96%), demonstrated a useful separation between groups of volatiles. From the loadings, samples placed to the right along PC1 (KA and KC3) were characterized by higher intensity of N-containing compound, associated with the higher odor, flavor as well as overall-liking score. In contrast, samples placed to the left along PC1 (KM, KC1 and KC2) were described as higher intensity of other groups of volatiles including

aldehydes, ketones, etc. Moreover, PC2, which explains a lower variance percentage (39.30%), revealed that commercial Kapi contained the higher intensity of aldehydes, ketones as well as hydrocarbons, compared with KA and KM. The total separation of high amount of alcohols in KM was also observed. However, alcohols seemed to have less effect on sensorial scores. Based on PCA results, it was possible to confirm that flavor-liking score was closely correlated with overall-liking score of Kapi. The highest overallliking score in KA and KC3 samples (Table 3) might be caused by higher intensity of N-containing compounds. This result confirmed that A. vulgaris showed higher potential alternative raw material for production of Kapi, in comparison with M. lanchesteri.

Table 3: Likeness score of *kapi* produced from *Acetes vulgaris*, *Macrobrachium lanchesteri* and three different commercial *Kapi*.

Sample -	Attributes					
	Appearance	Color	Odor	Texture	Flavor	Overall
KA	7.27±1.07 ^a	7.10±1.03 ^b	7.25±1.02 ^a	7.10±0.97 ^a	7.30±0.80 ^a	7.43±0.22 ^a
KM	7.23 ± 1.11^{a}	6.57 ± 1.05^{c}	6.95 ± 0.44^{b}	7.33 ± 0.49^{a}	6.83 ± 1.05^{bc}	6.85 ± 0.77^{c}
KC1	7.10 ± 0.96^{a}	$7.30{\pm}1.22^{a}$	7.30 ± 0.55^{a}	6.53 ± 2.05^{b}	7.03 ± 1.01^{b}	7.05 ± 0.87^{b}
KC2	7.25 ± 1.13^a	7.03 ± 0.54^{b}	7.25 ± 0.63^{a}	6.95 ± 0.67^{ab}	7.10 ± 1.12^{b}	7.10 ± 0.22^{b}
KC3	7.15 ± 1.05^{a}	$7.20{\pm}0.98^{ab}$	7.35 ± 1.01^{a}	7.10 ± 0.58^{a}	7.40 ± 0.22^a	7.40 ± 0.53^{a}

Values are given as mean \pm SD (n = 3).

Score are based on a 9-point hedonic scale (1: Dislike extremely, 5: Neither like nor dislike, 9: Like extremely). Different lowercase superscripts within the same column indicate the significant differences (p<0.05).

^{*} KA, KM: *Kapi* produced from *A. vulgaris* and *M. lanchesteri*, KC1, KC2, KC3: Commercial *Kapi* from Krabi, Samut Sakhon and Rayong, respectively.

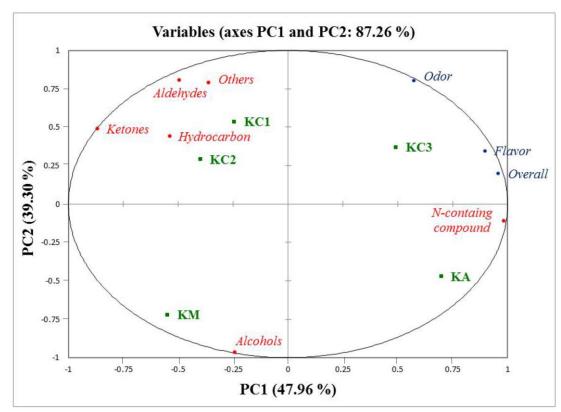


Figure 1: PCA score (samples, in bold) and loading (Groups of volatile compounds and sensorial characteristics, in italic) plots of *Kapi* produced from *Acetes vulgaris*, *Macrobrachium lanchesteri* and three commercial *Kapi* samples.

*KA, KM: *Kapi* produced from *A. vulgaris* and *M. lanchesteri*, respectively. KC1, KC2, and KC3: Commercial *Kapi* from Krabi, Samut Sakhon and Rayong, respectively.

Kapi produced from *A. vulgaris* and *M.* lanchesteri had different chemical compositions, physical and sensory properties. Kapi produced from A. vulgaris with browner color showed higher fat content, but lower protein content, compared with Kapi produced from M. lanchesteri. The former had higher likeness score that the latter. Volatile compounds of both samples also different. N-containing compounds, which were predominant volatiles in Kapi, played a profound role in likeness of this product. Thus, Kapi could be prepared from A. vulgaris with comparable sensory property to commercial products.

Acknowledgement

This research was supported by Prince of Songkla University and the Grant-in-Aid for dissertation from Graduate School, Prince of Songkla University, Thailand.

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