Physical, Chemical and Sensory Characterization of the Thai-Crispy Pork Rind 'Kaeb Moo'

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ABSTRACT

Crispy pork rind, called Kaeb Moo in Thai, is a typical and very popular food in the northern region of Thailand. It is made from deep frying pork skin, previously cut in slices. There are basically two different types of Kaeb Moo, the first one consisting only of the skin layer and the second one where subcutaneous fat is also present. Kaeb Moo may undergo rapid change of quality, as rancidity, after it has been processed. However, little has been done so far for quality assessments and certification of the Thai crispy pork rind. In this research, investigations on chemical, physical and sensorial aspects of Kaeb Moo were performed in order to determine the quality parameters of this product. Samples were purchased from well-known local producers of Chiang Mai province, or prepared in-house. The average hardness of each sample ranged from 15.0 to 40.0 kgf, while moisture and fat contents were 0.3 - 2.3 and 20.0 - 36.5%, respectively. The degrees of lipid oxidation were in the range of 0.10 - 2.57 µg malondialdehyde g^{-1}. Volatile compounds were investigated by headspace-solid phase microextraction technique and GC-MS. The following compounds were found: propanal, hexanal, heptanal, 2-heptanone, 2-pentyl furan, heptane, octane, and 4-methyl octane. Descriptive analysis profiling was used to express the sensorial attributes and 18 important attributes of Kaeb Moo were described by 12 trained panelists. Finally, consumer acceptance test (n = 400) using 9-point hedonic scale was carried out in respect to colour, odour, taste, crispness, and overall-liking.

Key words: Thai-crispy pork rind, Sensory analysis, Rancidity, Food quality, SPME

INTRODUCTION

In the northern region of Thailand, crispy pork rind, called "*Kaeb Moo*", is very popular for consumption and trade. It is served together with northern style chili dip and food. Nowadays, it is also consumed as snack, and becomes more famous over the country. Similar products are also commercialized in Europe, USA and in other Asian countries. In United Kingdom and in USA a similar product to *Kaeb Moo* is sold as snack and it is known as "pork scratchings" or "cracklings". In Australia and New Zealand crispy pork rinds are sold as "pork crackles". Recent investigations showed that in USA, as well as in Europe, the consumption of pork scratchings has become more popular. For instance, in USA sales of pork rinds have grown three times more than the overall snack market from 1997 till 2004, experiencing a "meteoric rise" in 2003 (Severson, 2010). In UK pork crackling is one of the most traditional pub snacks, eaten as an accompaniment to beer. In this country, the consumption grew 8.5% between 1999 and 2001 (Stacey, 2004). In Thailand there are mainly two different types of *Kaeb Moo*, the first one consists only of the skin layer, while in the second one subcutaneous fat is retained with the puffed skin. One peculiarity of *Kaeb Moo* is that no salt is traditionally added after frying, while in other countries pork scratchings are often salted.

In Thailand *Kaeb Moo* is prepared in a two-step process. The first step is the production of pork rind pellets. Pork skin is removed from the carcass, and then marinated in a brine solution at 100°C for 30 seconds (Matz, 1993). The skin is then cut into small slices and rendered for 1-2 h at approximately 110-115°C in vats of lard to remove fat and water. While rendering, the skin is agitated and kept submersed in lard. The resulting defatted and dehydrated pellets of skin with about 50% size reduction are bagged and stored frozen. The second step is the production of crispy pork rind. Pellets of skin obtained from the first step are rehydrated in seasoning sauce or flavoured aqueous solution. Then, they are fried in oil at 200-220°C with continuous agitation until they become puffy, have irregular curl in shape, and light density. The expanded skin can be further air-dried to a brittle-hard texture (Bechtel, 2001). The final crunchy pork rinds lack uniformity in shape and size, with different degree of expansion and variation in composition, while their texture and colour are uniform. A typical crispy pork rind contains zero carbohydrates, approximately 70% protein and 30% fat, ca. half of which is unsaturated (Matz, 1993; Jensen et al., 2005). Quality standards for *Kaeb Moo* are not defined in detail. According to the Thai Community Product Standard for *Kaeb Moo* (2010) this product must have a natural colour, no detection of rancidity, no contaminants (e.g. hairs or pebbles), and must be crispy. However, Thai customers may experience rancidity or low quality *Kaeb Moo* in supermarkets and retailers, resulting from the lipid oxidation or long time storage. Moreover, low quality of the frying oil may strongly affect the shelf life of this product as well as unsuitable packaging and improper storage conditions (Chitsamphandhvej et al., 2008). The aim of this research was to define the most important characteristics of high quality *Kaeb Moo*, which were not previously reported. For this reason the study was performed on several chemical, physical and sensorial characteristics of *Kaeb Moo*. Crispy pork rind without fat was selected, since less complex composition characterizes this product.

MATERIALS AND METHODS

Crispy pork rind samples

Ten samples of crispy pork rind without subcutaneous fat layer were used. Nine samples (K1-K9) were purchased from nine famous producers in local markets of Chiang Mai province, Thailand, and one sample (K10) was prepared at the Division of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University. The K10 sample was produced using vacuum frying technique (Vacuum Fryer, Model VP-10M, Owner Food Machinery, Thailand). The sample was fried in refined palm oil (Morakot Industrial Public Co., Ltd., Thailand) at 140°C for 5 min at 60 Torr. The K1-K9 samples were purchased just after preparation. All samples were either analysed freshly or stored at -18°C until required for analysis.

Moisture, fat and malondialdehyde contents

Moisture content was analysed following the standard AOAC method (AOAC, 2000). Soxhlet apparatus (Soxtec Avanti Model 2050, Auto system, Sweden) was used for evaluation of fat content following the method of AOAC (2000). Petroleum ether (AR-grade, Labscan, Thailand) was used as a solvent for extracting fat in pork rind samples. Samples of extracted fat were dried in an air oven at 100°C for 30 min, cooled in desiccator, and weighed.

Malondialdehyde (MDA) content was carried out according to the thiobarbituric acid reactive substance (TBARS) method (Miller, 1998). Five grams of crispy pork rind sample were extracted using 44 ml of 10% trichloroacetic acid (TCA, AR-grade, Merck, Germany) in 0.02 M phosphoric acid (H_3PO_4, AR-grade, Merck) with 1 ml of 0.2 mg ml^{-1} of butylated hydydroxy toluene (BHT, AR-grade, Fluka, Switzerland), then filtered. Afterwards, each sample was subjected to react with thiobarbituric acid (TBA, AR-grade, Merck), and were kept in darkness for 20 h at room temperature. MDA contents were calculated using a calibration curve established with a standard of 1,1,3,3 tetraethoxypropane solutions (TEP, AR-grade, Sigma-Aldrich, Germany), measured using spectrophotometer (Genesys-10 UV-scan, USA) at 530 nm. Results were reported as microgram of MDA per gram of sample.

Texture measurement

Hardness and crispness of pork rind samples were assessed using a texture analyzer (TA-XTplus, Stable Micro Systems Ltd., Surrey, UK) equipped with an Ottawa cell extrusion. Multiple pork rind samples, weighing at approximately 5 g, were analysed using a puncture probe. The measurement was conducted under these conditions: pre-test speed, 1 mm s^{-1}; test speed, 2 mm s^{-1}; post-test speed, 10 mm s^{-1}; measurement distance, 40% deformation; and auto trigger force, 5 g. Maximum force was recorded as the resistance to breakage. The average of maximum force and linear distance from ten replicates were reported in kgf and kg.s, respectively. Analysis of variance (ANOVA) was performed to find out if the quality characteristics of crispy pork rind were significant (P<0.05). Duncan's multiple range test (DMRT) was performed for post hoc multiple comparisons using SPSS version 16.0.

Analysis of volatile organic compounds (VOCs)

Volatile compounds of K1-K10 samples of *Kaeb Moo* were studied by headspace solid-phase microextraction and gas chromatography-mass spectrometry (HS-SPME-GC-MS), following a similar method as described by Thakeow et al. (2008). Two grams of sample were placed in a septum-capped vial of 40 ml and left overnight for equilibrium at room temperature. HS-VOCs were sampled by exposing the SPME fibre for 60 min at 25°C using 50/30 µm Divinylbenzene/Carboxen/Polydimethylsiloxane fiber (Supelco, USA). Afterwards, the SPME fiber was directly injected to the injection port of a gas chromatograph - mass spectrometer (GC-MS, 6982N-5973, Agilent Technologies, USA), equipped with a non-polar column HP-5MS (Agilent Technologies), 30 m x 0.25 mm i.d., 0.25 µm film thickness. Desorbed volatiles were run through the column with helium as a carrier gas at a flow rate of 1.0 ml min^{-1}. The temperature program started at 40°C, held for 1.5 min, then heated with a rate of 6°C min^{-1} to 200°C and held at the final temperature for 5 min. The mass spectrometer was operated in the scan mode in a range of 50-300 amu, a source temperature of 230°C, and EI mode at 70 eV. The chromatograms were preliminary interpreted with Enhanced Chemstation version D.02.00.275 (Agilent Technologies), by matching measured and standard mass spectra of the NIST-08 (National Institute of Standards and Technology, Gaithersburg, USA) and Wiley 7th edition (Wiley Registry of Mass Spectral Data, John Wiley & Sons, Inc, New York, USA). Hexanal content was monitored by peak area integration of mass to charge ratio of 56 of hexanal.

Sensory descriptive analysis

The product profile of crispy pork rind without fat was developed using hybrid descriptive analysis method with 150-mm unstructured line scales (Stone et al., 1980; Resurreccion, 1998; Meilgaard et al., 2007). The method comprised of Quantitative Descriptive Analysis (Tragon Corp., Redwood City, CA, USA) and the Spectrum™ Analysis methods (Sensory Spectrum, Inc., Chatham, NJ, USA). The panelists were selected according to ASTM, Committee E-18 (1981). There were twelve panelists that passed a selection. Afterwards, they were trained on the techniques in twelve 3-hour training sessions for a total of 36 h. To generate a descriptive terminology, nine samples of crispy pork rind from local market and one sample produced in house using vacuum frying were presented to panelists. The panel members individually examined the sample, generated descriptive terms, and followed by discussion (Cairncross and Sjöström, 1997; Lawless and Heymann, 2010; Grosso and Resurreccion, 2002). The final list of descriptors used in this study along with their definitions is presented in Table 1. Standard reference intensity ratings used in this study are listed in Table 2. Before evaluating samples, the panels were calibrated using four basic solutions and warm-up samples to increase reliability of ratings (Plemmons and Resurreccion, 1998).

Table 1. Definitions of attributes used by trained sensory panel to evaluate crispy pork rind.

Attribute*	Definition
Appearance	
Brown colour	The intensity of strength of brown colour from light to dark brown
Curve strip	The degree of curve of sample
Roughness	The appearance associated with uneven surface; lack of smoothness
Glossiness	The amount of light reflected from the skin surface
Flavour	
Aroma	
Oil	Aromatic associated with oil
Oxidized	Aromatic associated with oxidized fats and oils
Burnt	Aromatic associated with overheating of sample
Oily	An overall term for the aroma and flavour notes reminiscent of vegetable oil or mineral oil products
Flavour	
Crispy pork rind	Aromatic associated with crispy pork rind product
Soy sauce	Aromatic associated with soy sauce
Oxidized oil	Aromatic associated with oxidized fats and oils
Burnt flavour	Aromatic associated with overheating of sample
Taste	
Salty	The taste on the tongue associated with sodium chloride
Sweet	The taste on the tongue associated with sugar
Umami	Specific chemical feeling factors stimulated by monosodium glutamate (MSG) and certain other nucleotides
Bitter	The taste on the tongue associated with caffeine
Texture	
Crispness	Amount of force needed and intensity of sound (high pitch) generated from chewing a sample with incisors
Hardness	Amount of force needed to compress a food between molar teeth
Chewiness	The length of time in seconds required to masticate a sample at the rate of one chew per second in order to reduce it to a consistency satisfactory for swallowing

*Attributes listed in order perceived by panelists

Table 2. Standard reference intensity ratings used in descriptive tests for crispy pork rind.

Attribute	Reference	Intensity* (mm)
Appearance		
Brown colour	White paper	0
	Cracker	35
	Crispy pork rind	45
	Brown paper	66
	Hershey chocolate	150
Curve strip	Linear	0
	Semicircle	75
	Crispy pork rind	78
	Circle	150
Surface roughness	Vegetable oil	0
	Crispy pork rind	110
	Peanut shell	150
Glossiness	White paper	0
	Crispy pork rind	70
	Vegetable oil	137

Table 2. Continued.

Attribute	Reference	Intensity* (mm)
Odour		
Oil odour	Potato chip-A	10
	Potato chip-B	20
	Vegetable oil	40
	Crispy pork rind	50
Rancidity	Crispy pork rind	10
	Oil vegetable oil	40
Burnt odour	Burnt sugar	85
Flavour		
Oil flavour	Crispy pork rind	25
	Vegetable oil	55
Crispy pork rind flavour	Crispy pork rind	65
Soy sauce flavour	Crispy pork rind	58
	Soy sauce	80
Burnt flavour	Standard solution / Burnt sugar	85
Taste		
Salty	0.2% salt solution	20
	0.35% salt solution	50
	0.5% salt solution	85
Sweet	2.0% sugar solution	20
	5.0% sugar solution	50
	10.0% sugar solution	100
	15.0% sugar solution	150
Umami	Monosodium glutamate solution (2 g l^{-1})	36
Bitter	0.05% caffeine solution	20
	0.08% caffeine solution	50
	0.15% caffeine solution	100
Texture		
Crispness	Pine apple	15
	Cracker	35
	Crispy pork rind	45
	Maize snack	70
Hardness	Crispy pork rind	45
	Peanut	69
	Maize snack	80
Stickiness	Crispy pork rind	7
	Whole wheat bread	10
	Frankfurter sausage	20

*Intensity ratings are based on 150 mm unstructured line scales with anchor at 12.5 and 137.5

Consumer acceptance test

The acceptance of consumers towards crispy pork rind was carried out at the main canteen of Chiang Mai University and Carrefour hypermarket, Chiang Mai. Four hundred people involved in this test were randomly chosen among students and customers. They evaluated the crispy pork rind for overall liking, colour, odour, taste and crispness based on 9-point hedonic scale (1= dislike extremely, 5 = neither like nor dislike, 9= like extremely).

RESULTS

Moisture, fat, and malondialdehyde contents

Table 3 shows the results of moisture, fat, and malondialdehyde contents. The moisture and the fat contents (wet basis) of the ten samples ranged from 0.36-2.30% and 25.60-36.23%, respectively. MDA, a degraded product of lipid peroxidation, is represented by TBARS. The MDA contents of eight samples were in a range of 0.100-0.300 µg g^{-1}, while the values of the other two samples were higher than 2.000 µg g^{-1}. K10 sample showed the lowest MDA content, although it was one of the highest in terms of fat content.

Table 3. Mean values and standard deviation of physical and chemical properties of the ten crispy pork rinds.

Sample	Moisture content (%, wet basis)	Fat content (%, wet basis)	Malondialdehyde content (µg g^{-1})	Hardness* (kgf)	Linear distance* (kg.s)
K1	1.46±0.05	28.27±2.08	0.179±0.028	32.45±5.68 b	131.89±21.09 cde
K2	1.25±0.19	36.14±1.24	0.159±0.000	29.39±9.10 bc	139.28±27.91 cd
K3	0.54±0.06	20.00±1.79	0.159±0.022	26.51±4.74 cd	146.63±24.08 bc
K4	0.89±0.19	33.88±0.65	0.139±0.040	39.50±7.56 a	168.87±12.68 a
K5	0.38±0.10	29.04±0.55	0.131±0.006	21.86±5.17 de	121.35±18.70 def
K6	2.30±0.14	28.61±1.70	2.574±3.193	31.75±4.02 b	163.54±17.77 ab
K7	0.36±0.13	26.49±0.18	1.085±1.121	31.85±3.81 b	145.38±13.86 bc
K8	1.46±0.04	28.69±0.45	0.163±0.007	26.55±5.16 cd	137.55±28.15 cd
K9	0.36±0.11	36.23±1.43	0.258±0.018	19.49±2.56 ef	105.16±17.82 f
K10	0.49±0.04	34.29±0.28	0.102±0.000	14.95±2.16 f	114.58±18.70 ef

*Mean values with different letters are significantly different ($P<0.05$).

Textural properties

The hardness values of the crispy pork rind of the ten samples are reported in Table 3. Results showed a significantly difference ($P<0.05$) in hardness of samples. The highest hardness was in K7 sample with a mean value equal to 39.50 kgf. The sample K10 had the lowest hardness with a mean value equal to 14.95 kgf. Crispness values of the ten samples were measured in terms of linear distance. The highest crispness value was found in K4 sample (168.87 kg.s), and lowest value was found in K9 sample (105. 16 kg.s).

Volatile organic compounds

Direct headspace solid-phase microextraction technique was used to investigate the volatiles released from crispy pork rind samples. Totally eight volatile compounds were characterized (Table 4). Those belonged to groups of aldehydes (propanal, hexanal, and heptanal), ketone (2-heptanone), furan (2-pentyl furan), and hydrocarbons (heptane, octane, and 4-methyl octane). In K6 all eight volatiles were detected, while in K10 only three volatiles of heptane, octane, and 4-methyl octane were detected. Heptane, octane, hexanal and 4-methyl octane were found in all samples. Hexanal, responding for oxidative off-flavour of fried and oil-containing food, was present in every sample as illustrated in Figure 1. Its quantities were higher in two samples (K1 and K6), while the other eight samples showed slight differences, as monitored by peak area. K10 sample contained the least amount of hexanal.

Table 4. Headspace volatiles of ten crispy pork rinds identified using HS-SPME-GC-MS technique.

No.	LRI	Volatiles	Odour (Reference)	Presence of volatiles in crispy pork rinds									
				K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
1	<700	propanal	solvent, pungent [a]	+	-	-	-	-	+	+	+	-	-
2	730	heptane	alkane [a]	+	+	+	+	+	+	+	+	+	+
3	809	octane	alkane [a]	+	+	+	+	+	+	+	+	+	+
4	814	hexanal	grass, tallow, fat [a]	+	+	+	+	+	+	+	+	+	-
5	866	4-methyl octane	N/A	+	+	+	+	+	+	+	+	+	+
6	902	2-heptanone	cheesy [b]	-	-	-	-	-	+	-	-	-	-
7	909	heptanal	fat, citrus, rancid [a]	+	-	-	-	-	+	-	-	-	-
8	992	2-pentyl furan	buttery, green bean-like [c]	+	-	-	-	-	+	+	-	-	-

LRI: linear retention index, - not detected; +, detected, N/A: data not available.
[a] http://www.flavornet.org
[b] http://www.thegoodscentscompany.com
[c] http://www.pherobase.com

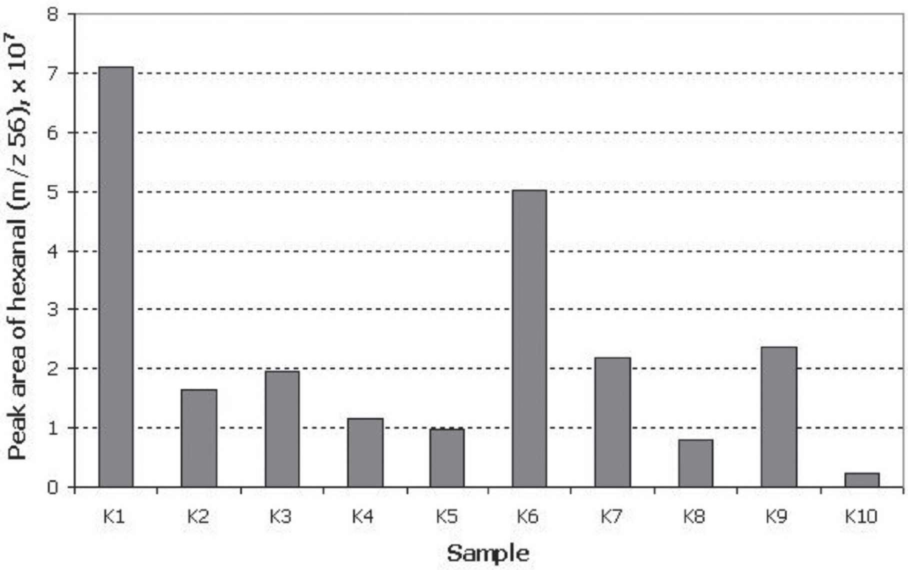

Figure 1. Peak area of hexanal (m/z 56) released from crispy pork rind samples.

Sensory descriptive analysis

Sensory attributes and average intensity ratings of descriptive analysis are shown in Figure 2. There were totally 18 attributes of freshly prepared crispy pork rind. It can be seen that the important characteristics, i.e., hardness, crispness, salty, soy sauce flavour, crispy pork rind flavour, oil odour, surface roughness, and curve strip, were characterized by higher intensity rating (>4). While the negative characteristics were rated close to zero, for example, stickiness, bitterness, sweetness, oil flavour, burnt odour, and rancidity.

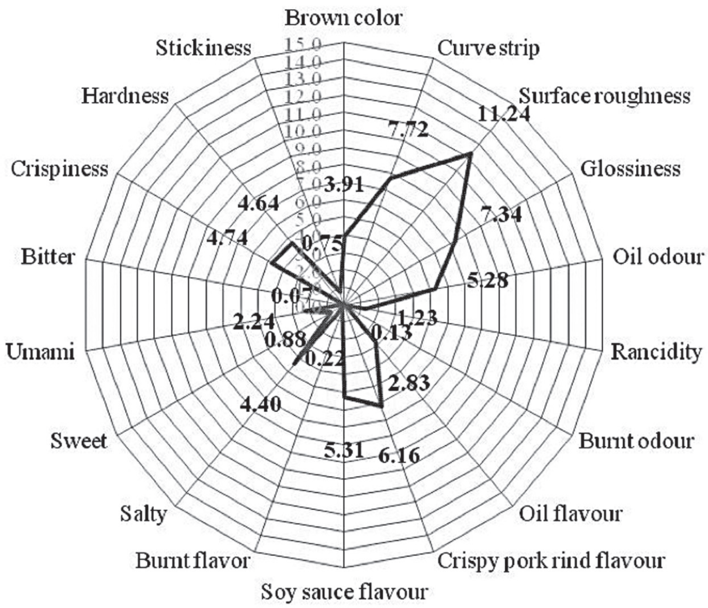

Figure 2. Sensory profiling of different attributes of crispy pork rind from average mean ratings of the 10 samples.

Consumer acceptance test

Nine-point hedonic scale was used for evaluation of consumer acceptance towards the ten crispy pork rind samples. The test results are shown in Table 5. All samples were rated from like slightly to like moderately (6-7 points). All attributes of colour, odour, taste, and crispness play important role in consumer acceptance, but odour and crispness contributes in consumer acceptance less than the other characteristics.

Table 5. Means of consumer rating and standard deviations of ten crispy pork rind samples based on 9-point hedonic scale (n = 400).

Sample	Overall liking	Colour	Odour	Taste	Crispness
K1	6.1±1.6 c	6.4±1.5 cd	5.1±2.0 ef	5.9±1.8 d	6.7±1.7 b
K2	5.6±2.0 d	6.0±1.8 e	5.0±2.1 f	5.4±2.6 e	6.3±2.0 c
K3	6.9±2.0 a	6.8±1.6 a	6.2±1.8 ab	6.7±1.7 ab	7.2±1.6 a
K4	6.4±1.6 b	6.7±2.4 ab	6.0±1.8 bc	6.5±2.2 bc	6.7±2.5 b
K5	6.7±1.5 a	6.7±1.5 a	6.2±1.7 abc	6.8±1.6 a	7.2±1.5 a
K6	6.1±1.8 c	6.4±1.6 cd	5.3±2.0 e	6.0±1.9 d	6.4±1.8 c
K7	6.1±1.7 c	6.5±1.9 bc	5.8±1.8 d	6.0±1.9 d	6.7±1.7 b
K8	6.3±1.7 c	6.4±1.7 cd	6.0±1.9 cd	6.3±1.9 c	6.5±1.9 c
K9	6.7±1.7 a	6.8±1.5 a	6.3±1.8 a	6.8±1.7 a	7.0±1.7 a
K10	6.4±1.7 b	6.3±1.9 d	6.0±1.9 bc	6.4±1.9 c	7.1±1.6 a

The different letters in the same column are significantly different ($P<0.05$) by Duncan's Multiple Range Test (DMRT)

DISCUSSION AND CONCLUSION

Crispy and fried products are in favour of consumers because of their crunchiness and typical aroma. *Kaeb Moo* product is also highly accepted and its market is expanding in many countries. Consumers may consider this kind food as an unhealthy product because of frying production process. In fact, crispy pork rind contains zero carbohydrate and a high amount of proteins, equal to 70%. Fat content is ca. 30% but at least half of it is represented by unsaturated fat, most of that is oleic acid, the same healthy fatty acid found in olive oil. Another 12% is stearic acid, a type of saturated fatty acid that is considered harmless, since it does not raise cholesterol levels (Matz, 1993; Jensen et al., 2005).

Our results showed that there were many important sensory attributes linked with *Kaeb Moo*, i.e. hardness, crispness, salty, soy sauce flavour, crispy pork rind flavour, oil odour, surface roughness, curve strip, stickiness, bitterness, sweetness, oil flavour, burnt odour, and rancidity. These features were rated at different intensities, where the intensities of the attributes rated higher than 4 are positive characters, while the ones rated close to zero are negative characters (Martinez et al., 2011). Among those, crispness and taste prominently contribute to the overall liking. In potato chips texture properties are related to the overall sensory quality and consumer acceptance (Jaworska and Hoffmann, 2008). However, texture properties are important only when flavour and odour are fully accepted by consumers. Our findings of consumer acceptance test clearly showed this relationship. When consumers gave low points to the overall liking of a specific *Kaeb Moo* sample, they also gave low points to odour and taste attributes.

The physical and chemical properties can be used for monitoring the quality of crispy pork rind. The moisture contents of the investigated product, ranging from 0.36-2.30%, did not show pronounced effects on the overall liking of consumers. However, samples with higher moisture contents were less-liked by consumers (Table 3 and 5). This is in agreement with the finding that a snack does not appear to be brittle or crisp if it has high moisture content (Mazumder et al., 2007). Crispness of the fried products can be measured with linear distance value; the higher linear distance indicates more crispness (Nalesnik et al., 2007). Moreover, crispness of a product is linked with its hardness (Shih et al., 2010). In our experiment, the consumers liked mostly the crispy pork rind when linear distance and hardness ranged from 105 to 121 kg.s and from 19 to 27 kgf, respectively. An exception was represented by K3 that it was included in the highest group of overall liking (with K5 and K9, Table 5), and in the highest group of crispness acceptance (with K5, K9 and K10). However, its linear distance (146.63 kg.s, Table 3) was higher than the ones recorded for all the other samples of the highest overall liking group and similar to the linear distance found in the samples of less liked group. K3 had a hardness value similar to the ones found in the highest overall liking group. Therefore, these results showed that consumer preference is rather a complex evaluation and measuring only one parameter, as crispness or hardness, may not reflect the choice of consumers. It was reported that product thickness and frying temperature also affected the product hardness (Abong et al., 2011). In addition, no significant variation of hardness was found between vacuum and atmospheric frying (Da Silva and Moreira, 2008). Besides these reasons, microstructure or cellular structure of products influences their hardness and crispness (Mazumder et al., 2007; Saeleaw and Schleining, 2011). Therefore, investigation of *Kaeb Moo* morphology is necessary to better understand product crispness and hardness.

Lipid oxidation can be monitored by investigation of MDA content. In addition to the MDA content, hexanal is used as an indicator of the degree of oxidation and product quality deterioration (Jensen and Risbo, 2007; Chitsamphandhvej et al., 2008). In our experiment, the MDA content varied among all samples, ranging from 0.102 $\mu g\ g^{-1}$ in K10 to 2.574 $\mu g\ g^{-1}$ in K6 (Table 3). The more MDA is present, the higher rancidity is noticed. The results of headspace hexanal revealed similar trend of MDA content, where hexanal was high in samples with high quantity of MDA. An exception was K1 sample, where MDA content was moderately low (0.178 $\mu g\ g^{-1}$, Table 3) but hexanal content was the highest (Figure 1). In all samples rancidity attribute was considered very low by trained panelists and consumers (Figure 2), although a variation of MDA and hexanal contents were detected. The higher value of rancidity attribute was given to K6, followed by K1 (data not shown). This was in agreement with the fact that these samples had higher hexanal content (Figure 1). On the other hand, MDA content seemed not to reflect rancidity attribute, as in the case of K1, which had a low MDA content but had a higher value of rancidity attribute. K1 and K6 were the only samples containing heptanal, which also contributes to rancid odour (Vinaixa et al., 2005; Chitsamphandhvej et al., 2008; Alvarez, 2009).

This research is the first work describing the physical, chemical, and sensory properties of crispy pork rind *Kaeb Moo*. The results of our investigation can be used to establish specific parameters for product quality and product development. However, more experiments should be performed to establish the exact minimum and maximum values here described of each parameter. Further research could focus on improvement of quality and shelf life extension of *Kaeb Moo*.

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