Comparison of sensory properties of freshly harvested and 1-year storage Thai rice

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Abstract

Thailand is a major producer and world supplier of rice, both aromatic and non-aromatic varieties. Rice sold as "new crop" shortly after it is harvested generally commands higher prices. The study compared differences in sensory properties of various aromatic (Khao Dawk Mali 105, RD 15, Pathum Thani 1) and non-aromatic (Chai Nat 1, Phitsanulok 2, Suphan Buri 1) rice varieties and differences in fresh rice and rice stored for 1 year. Floral, popcorn, and sewer/animal flavors were found in both rice samples but jasmine rice had higher intense of floral aroma and was the only aroma that decreased overtime. The texture of jasmine rice samples were more adhere to lips, grain to grain, softer and more intense of cohesiveness of mass than non-aromatic rice. There were three attributes; residual, toothpacking, sweet, from nineteen attributes were not different between jasmine and non-aromatic rice and not changed overtime. Most of the texture attributes were not changed after one year of storage except cohesiveness of mass and starchy mouthcoating that reduced after storage. There were not a significantly differences for most of the flavor attributes except musty flavor between jasmine and non-aromatic rice samples within the same testing year such as grain, straw-like, starch, popcorn flavor, sweet, overall sweet, bitter and metallic. The changes of the flavor like grain and straw-like were decreased from their original intense; while, musty flavor and bitter taste were increased.

Keywords: rice, descriptive analysis, sensory evaluation, aroma flavor

1. Introduction

Thailand is one of the rice export leaders in the market. Even Thailand is now holding the third rank of the world rice exporter; the statistic showed that Thailand exported rice 8,000 million tons in 2012 (Prasertsri, 2012). Quality of Thai rice for exportation was specified in accordance to

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Thai Agricultural Commodity and Food Standard 2003 which including characteristic and size of rice kernel, chemical and physiochemical properties; for instance, moisture content, amylose content and alkali spreading value (gelatinization temperature type) (TACFS 4000, 2003). These chemical and physiochemical properties were used to explain texture and flavor that indicate the eating quality of rice (Perez and Juliano, 1978) using amylose content, rice can be categorized as waxy (0-5%), very low (5-12%), low (12-20%), intermediate (20-25%) and high (25-33%) or it can be either classified as low (less than 20%), medium (21-25%) and high (26-33%) for commercial (Juliano, 1992).

Differences of amylose content in differences rice varieties provide different textural characteristic of cooked rice (Sigh et al., 2003). It was found that amylose content is positively correlated with hardness and negatively correlated with stickiness (Juliano and Pascaul, 1980; Windham et al., 1997). In addition, high amylose rice has higher in roughness of mass; while, low amylose rice has higher tooth-pack, cohesive of bolus, cohesive of mass, and adhesive to lips (Suwannaporn et al., 2007). Protein content also plays an important role in cooked rice texture since the proteins combine with starch granule decrease starch granule swelling that change the viscosity and starch gelatinization rate; as a result, the higher protein content, the harder cooked rice texture (Champagne 1996; Ramesh et al., 1999). However, rice with similar amylose and protein content still have different texture quality, therefore, physicochemical properties still cannot precisely predict the texture of cooked rice (Champagne et al, 1999; Sitakalin et al., 2000). Consequently, there are some studies used descriptive methodology that accomplishable to determine the intensity of the sensory characteristic (Stone and Sidel 1993) and observed the changes of product overtime (Meilgaard et al., 2006). The textural properties of rice including initial starchy coating, slickness, roughness, stickiness, springiness, cohesiveness, hardness, cohesiveness of mass, chewiness, uniformity of bite, moisture absorption, residuals or loose particles, and toothpack (Goodwin et al., 1996; Lyon et al., 1999).

Aroma was considered as an important property of rice that indicates the high quality and price in the market (Paule and Powers, 1989; Ishitani and Fushimi, 1994). Aromatic rice is very popular in South, South East Asia and recently gained wider acceptance in the U.S.A., Europe and East Asia (Holi et al., 1992; Holi et al., 1996). Several aroma attributes were studied in cooked rice; for instance, cold-steam-bread, hot-steam-bread, raw-dough, rice milk, corn, corn-leaf, pear-barley, burnt, fermented-sour, plastic, sulfur, brown rice, and gasoline aroma (Yau and Liu, 1999), tortilla-like, nut-like, popcorn-like, buttery, earthy, bran-like and pandan-like (Paule and Powers, 1989), bland, dusty, rancid, sulfur, popcorn (Chastril, 1990), spicy, cracker, buttery, vegetable, burned, paint-like, sulfur, earthy, musty, smoky, grainy, floral, potato, and white glue (Withycombie et al., 1978). Popcorn aroma, which sometimes described as Pandan-like aroma (Laksamalamai and Ilangantileke, 1993), was contributed by 2-acetyls-1-pyrroline (2AP) in rice. It is the most important aroma since it was used to identify aromatic and non-aromatic rice (Petrov et al., 1996). Rice aromas were classified into five majors groups as green, fruity/floral, roasty, nutty, and bitter. Although, there is no single compound could be responded for the specific cooked rice aroma, a mixture of the compounds in the correct proportions may be responsible for each cooked rice aroma group; for instance, refreshing green/ woody notes were mainly contributed by aldehydes, some alcohol and ketones; sweet floral and fruity notes were mainly contributed by ketones, heptanone and 6-methyl-5-hepten-2-one responded to floral fruity notes, 2-pentyfuran and benzaldehyde provided nutty aromas (Widjaja et al., 1996).

Rice normally requires the amount of time to be delivered from farm gate to the consumer including the time for aging that modify cooking and eating quality (Tran et al., 2005) Moreover; Thai rice market mechanism; especially a lapse of time from the initial rice harvest to rice arriving in the market for consumer purchase, is affected by the government policy to guarantee the reliable and certain income for the farmers by allowing farmers to deposit their rice with the guarantee price set and withdraw it later as the market price increased (Patrawimolpon and Pongsaparn 2006). Therefore, storage is the typical step in the rice system (Tran et al., 2005). During storage, the quality or rice will be changed in accordance to the post harvest condition. The storage time is one of the factors that affect the rice texture, flavor and taste. Most of the change in texture occurred during the first 1 to 2 years. Many research showed that lipid degradation causes the deterioration of rheology of cooked rice since the free fatty acid from the lipid degradation bind with amylose and amylopectin in starch and affect the pasting properties of stored rice by increase the maximum, minimum, final viscosities and break down value that response to the increasing of chewiness and hardness and decreasing stickiness (Tamaki et al., 1993; Tran et al., 2005).

Lipid degradation also causes the aroma change in rice. The oxidation of unsaturated fatty acids, linoleic and linolenic acids, continue the free-radical chain mechanism and create various secondary oxidation products, carbonyl compound, which corresponding to off-flavor and odor development (Villareal et al., 1976; Piggott et al., 1991). Moreover, increasing in fatty acid caused by lipid degradation decreased the pH value in cooking liquid. The decreasing pH in cooking liquid cause the deterioration of the taste of cooked rice since glutamic acid is an important taste substance in rice (Matsuzuki et al., 1992; Tamaki, 1989; Tamaki, 1993).

As the earlier mention that storage is a typical process in rice market mechanism and it causes the changes in the rice sensory properties such as texture and flavor. Accordingly, this study aimed to use descriptive analysis to observe the effect of storage time on sensory profile of different Thai rice varieties.

2. Materials and Methods

2.1 Rice Samples

Six varieties of Thai rice samples were obtained from Rice Research Institute, Department of Agriculture Pathum Thani, Thailand as the milled white rice were used in the study. The six varieties; RD 15, Khao Dawk Mali 105 (KDML 105), Pathum Thani 1, Chai Nat 1, Suphan Buri 1, and Phitsanulok 2 harvested in 2006 were included in the study. Khao Dawk Mali 105 harvested in 2007 was also added into this study in order to confirm Khao Dawk Mali 105 rice sensory profile from different harvest year. The rice samples were packed in Low-density polyethylene bags and kept in plastic boxes. Sensory evaluation was performed in March of 2006 as the new crop samples and after one year of storage at 21°C and 56% relative humidity as the old crop samples.

2.1.1 Sample Preparation for Sensory Analyses

Rinse 200 g rice one time with 320 g of room temperature water and stir in circle with spatula for 4 times then rinse off the water. Add 360 g water and stir in circle with spatula for 10 times then cook in the ZOJIRUSHI NEURO FUZZY® MICOM Rice cooker and warmer using white rice and regular cooking mode (cooking time about 90 min). When the rice is completely cooked, use a spatula to fluff the rice before serving 3-4 times. Serve by measuring about 1/4 cup of cooked rice at 85°C into 8 oz foam cups. Cover each cup with watch glass.

2.2 Panelists

The six highly trained panelists from the Sensory Analysis Center, Kansas State University (Manhattan, KS) participated in this study. All panelists passed the acuity test then they were interviewed in order to observe their attitude, behavior, and personality. The panelists who passed the interview participated in the training program. The training program took 120 h. It included general sensory analysis, descriptive analysis, practicing sessions (lexicon development, referencing system (universal system), use of the references, scaling), and based on the universal reference standard system. Each panelist had completed 120 h of training on general sensory analysis techniques. They have a minimum 1000 h of experience in testing a variety of food product.

2.3 Sensory Evaluation

Descriptive analysis was conducted to evaluate the rice samples. Product testing included two sessions. The new crop session was conducted in March 2006 included new crop of RD 15, KDML 105, Pathum Thani 1, Chai Nat 1, Suphan Buri 1, and Phitsanulok 2. Prior to the evaluation, the panel received three 1.5 h sessions of orientation during they were familiarized with the samples that would be evaluated, and established the sensory attributes of the rice samples. During orientation session, the panel was presented with the different rice samples to help the panelists with terminology development. Another three 1.5 h sessions of orientation was conducted before evaluate the old crop samples in March 2007. The old crop session included new crop of KDML 105 and old crops of RD 15, KDML105, Pathum Thani 1, Chai Nat 1, Suphan Buri 1, and Phitsanulok 2. During orientation and testing session, the samples were presented with three-digit random numbers. One sample was served at a time with the randomized order with 3 repeated measurements. During testing, panelists individually evaluate the sensory attributes of the samples that obtained from the orientation sessions by using a 15-point numerical scale with 0.5 increments ballots, where 0 represents none and 15 represents extremely strong. They rated according to the universal scale rating. The standard references from Sensory Analysis Center reference standard database were provided to the panelist. Reverse osmosis, deionized, carbon-filtered water and unsalted cracker (Nabisco Premium Saltine Unsalted Top Crackers, 8 oz, East Hanover, NJ) were provided to cleanse palate between samples during testing. The experiment was applied as split plot design with repeated measurement. There were 2 factors in the study included rice varieties (RD 15, KDML 105, Pathum Thani 1, Chai Nat 1, Suphan Buri 1, and Phitsanulok 2) and storage time (0, 1 year).

2.4 Statistic Analysis

Analysis of variance procedure (Glimmix Procedure) using SAS® (Statistical Analysis System for Windows, Version 9.1, 2006, SAS Institute Inc., Cary, NC) was performed to determine the differences between samples and least significant differences for mean separation of samples to indicate different mean of the attribute intensities among the products at p-value < 0.05. The mean obtained of each variable were subjected to principle components analysis (PCA) using Unscrambler 9.6 software (Camo AS, Trondeim, Norway).

3. Results and Discussion

Six rice varieties including three aromatic rice (Jasmine rice) samples were KDML 105, Pathum Thani 1 and RD 15; and three non-aromatic rice were Chai Nat1, Suphan Buri1 and Phitsanulok 2 were tested in the study. Nineteen attributes were investigated including aromas (sewer/animal, popcorn and floral); textures (adhesiveness to lips, firmness, adhesiveness grain to grain, cohesiveness of mass, toothpacking, and starchy mouthcoating), flavors (grain, straw-like, starch, popcorn, musty, overall sweet, metallic, sweet and bitter).The rice attribute descriptors with their definition are shown in Table1.

3.1 Aroma

Comparing between three aromas, it was found that jasmine rice samples had high intense of floral and popcorn aroma than non-aromatic rice; while non-aromatic rice samples had higher intense of sewer/animal aroma. The unscented rice samples (Chainart1 and Suphanburi1) had higher sewer aroma than both new and old crop of scented rice since they tended to have more concentration of indole (Soontrunnarudrungsri et al., 2008). After one year storage, floral aroma of jasmine rice samples decreased from 3.0 to 1.0 as same intensity as non-aromatic rice which stable over one year. There was no change in sewer/animal and popcorn aroma of all samples except for Phitsanulok 2 that appeared to increase for sewer/animal but popcorn decreased as shown in Table 2. The sewer/animal aroma might be caused by lipid degradation which corresponding to off-flavor development from carbonyl compounds (Villareal et al., 1976; Piggott et al., 1991). The study also included new crop of KDML105, which is known as the best jasmine rice among other aromatic rice varieties, that harvested in 2007 and compare with the KDML105 that harvested in 2006. It was found that the important attributes; popcorn and floral aroma that used to indicate jasmine rice from non-aromatic rice in these two new crop samples were not different.

Table 1. Definition and references of rice sensory profiles.

Sensory Attributes	Definition	References
Aroma		
Sewer/Animal	An immediate and distinct pungent aroma characterized as sulfur-like and generic animal. The animal aroma can sometimes be identified as "piggy".	Dimethyl Disulfide
Popcorn	A dry, dusty, slightly toasted and slightly sweet aroma that can be specifically identified as popcorn.	Orville Redenbacher's Original Gourmet Popping Corn (8.5)
Floral	Sweet, light, slightly perfumy impression associated with flowers	Welch's White Grape Juice = 5.0
Texture		
Adhesiveness to lips	Degree to which product sticks to the upper lip.	American Beauty elbow macaroni = 7.0
Firmness	The force required to compress (or bite through) cooked rice using the molar teeth.	Egg White = 2.5 Kraft Mild Cheddar Cheese = 4.5
Adhesiveness grain to grain	Degree to which the sample holds together when first placed in the mouth and then separates into individual pieces when manipulated with the tongue.	Cornbread Muffin Mix = 4.0 American Beauty elbow macaroni = 7.0
Cohesiveness of mass	The maximum degree to which the mass holds together during mastication. Measured after 7 chews.	Fresh Mushroom = 4.0 Oscar Mayer Beef Frank = 7.5 Kraft Mild Cheddar Cheese = 10.0
Residuals	Amount of particles remaining in the mouth after swallowing.	General Mills Cheerios = 3.0
Toothpacking	Degree to which product sticks on/in surfaces of teeth.	General Mills Cheerios = 3.5
Starchy Mouthcoating	Degree to which sample mixes with saliva to form a starchy, pasty slurry that coats mouth surfaces.	American Beauty elbow macaroni = 8.0
Flavor		
Grain	A general term used to describe the aromatics associated with grains such as corn, oats, and wheat. It is an overall grainy impression characterized as sweet, brown, sometimes dusty, and sometimes generic nutty.	Cereal Mix (Dry) = 8.0 American Beauty elbow macaroni = 6.0
Straw-like	A dry, dusty, slightly brown aroma.	Capsule Lecithin = 7.5
Starch	Aromatics associated with starch and starch based ingredients. A clean, flat aromatic reminiscent of distilled water.	American Beauty elbow macaroni = 9.0
Popcorn	A dry, dusty, slightly toasted and slightly sweet aroma that can be specifically identified as popcorn.	Orville Redenbacher's Original Gourmet Popping Corn = 8.0
Musty	Aromatics associated with wet grain and damp earth.	American Beauty elbow macaroni = 5.0 Fresh mushroom = 10.5
Overall sweet	A sweet impression that may appear in the aroma and/or aromatics and/or taste.	Spoon-size Post Shredded wheat = 1.5 General Mills Wheaties = 3.0
Sweet	A fundamental taste factor of which sucrose is typical.	1% Sucrose Solution = 1.0
Bitter	The fundamental taste factor of which caffeine or quinine is typical	0.010% Caffeine Solution = 2.0 0.020% Caffeine Solution = 3.5 0.035% Caffeine Solution = 5.0
Metallic	An aromatic associated with iron, copper and silver.	0.10% Potassium Chloride solution = 1.5 0.20% Potassium Chloride solution = 4.0 0.50% Light Salt solution = 2.0

Food and Applied Bioscience Journal, 2014, 2 (1): 69-84

3.2 Texture

Adhesiveness to lips and adhesiveness grain to grain in jasmine rice samples tended to be higher than in non-aromatic rice since jasmine rice was considered as low amylose rice (12-19% amylose) (Rice Knowledge Bank, n.d.). Adhesiveness to lips and adhesiveness grain to grain of jasmine rice and non-aromatic rice did not change over time except the intense of adhesiveness to lips of Pathum Thani 1 that decreased from 12 to 10. Cohesiveness of mass in jasmine rice samples was higher than non-aromatic rice samples but Suphan Buri1 had the same degree of cohesiveness of mass as found in jasmine rice. After storage for one year, cohesiveness of mass in all non-aromatic rice samples and RD 15 dropped from the beginning. Firmness of non-aromatic rice was higher than jasmine rice since the amylose content of non-aromatic rice samples (26-29%) were higher than amylose content in jasmine rice samples (12-19%) (Rice Knowledge Bank, n.d.). There was somewhat unexpected, because Pathum Thani1 was consider as low amylose rice as same as KDML 105 and RD 15 but it was found that firmness of Pathum Thani1 was higher than the other two jasmine rice samples in accordance to rage of amylose content in Pathum Thani was highest (15-19%) comparing to KDML105 (12-17%) and RD15 (14-17%) (Rice Knowledge Bank, n.d.). After one year storage, firmness of all samples did not change except Pathum Thani1 and Suphan Buri1. Degree of starch mouthcoating in new jasmine rice was higher than non-aromatic rice samples but it dropped off from 1.5-2.3 to 0.7-0.9 during storage while non-aromatic rice samples were stable over time. Residual and toothpacking of all samples were not different from each other and did not change during storage. The textural properties of different harvested year KDML105 rice samples were not different in adhesiveness to lips, adhesiveness grain to grain, cohesiveness of mass, residuals, and toothpacking. While KDML105 samples from 2007 was softer and had less starch mouthcoating than KDML105 that harvested in 2006.

3.3 Flavor

Comparing to the other flavors found in the rice samples, starch flavor was perceived as the highest intensity flavor. The flavor did not change overtime after the rice samples were kept for one year except for Pathum Thani1 and Suphan Buri1. Starch flavor in jasmine rice samples were more intense than in non-aromatic rice samples. Popcorn flavor of jasmine rice and non-aromatic rice were not different among the new crop samples but after storage for one year the intense of popcorn flavor in non-aromatic rice decreased while the intense of popcorn flavor in jasmine rice was stable at 0.6-0.9. New jasmine and new non-aromatic rice samples had the same intense of grain, straw-like flavor and overall sweet and these flavors dropped off after storage. The different intensity in musty flavor and bitter taste between varieties were not observed but they all increased after one year. The increasing of musty flavor might be contributed by the presence of 1-octen-3-ol in the samples (Jezussek et al., 2001). The metallic in both new crop of jasmine rice and unscented rice were not different but after one year metallic in jasmine rice samples decreased except RD 15 that did not change overtime as same as unscented rice samples. There was no effect of the storage time and varieties on sweetness. Comparing between KDML105 that harvested in 2006 and 2007, it was found that there was no different in Straw-like, starch, popcorn, overall sweet and sweetness between samples but the sample that harvested in 2007 had higher intense of musty flavor and bitter taste while the sample form 2006 had higher intense in grain flavor and metallic. According to the principle component analysis, PC1 explained 84% and PC2 explained 8%. Even the differences that showed in the PCA map was not huge but it help to get the big picture of the differences between jasmine and non-aromatic rice; and the changes of rice quality after storage. The PCA presented that non-aromatic rice samples had more intense of sewer/animal aroma and firmness than aromatic rice samples. It also demonstrated that after one year storage; jasmine rice tended to have less in floral aroma and grain flavor but more in bitter taste and musty flavor.

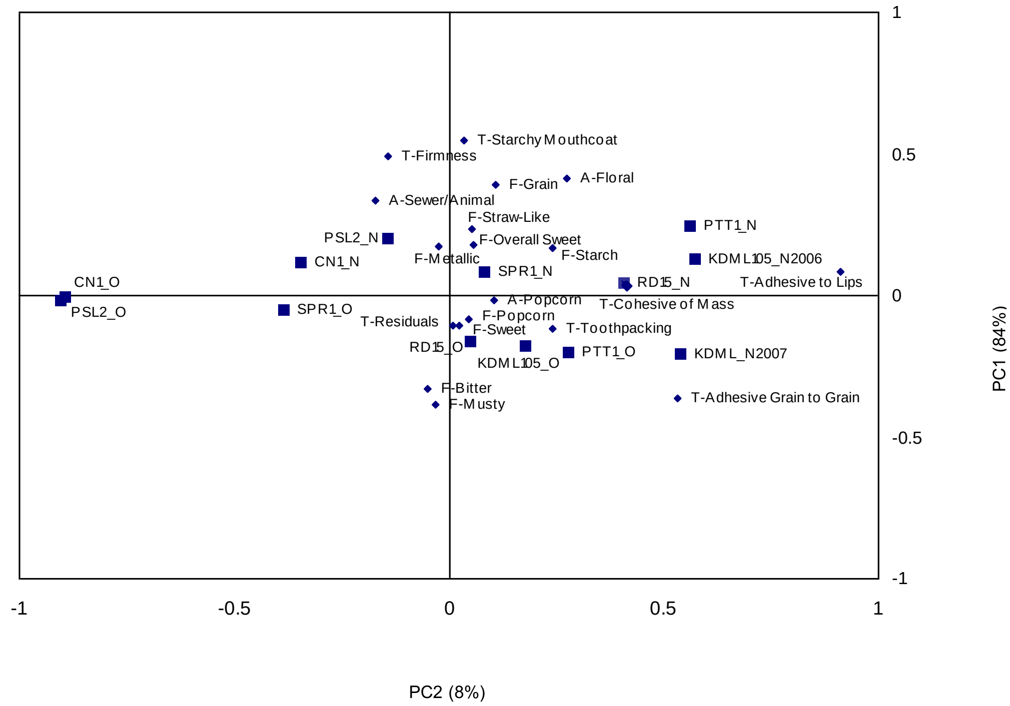

Figure 1. Result of principle components analysis of sensory attributes of rice.

Note: Rice sample are: KDML105 = Khao Dawk Mali105; PTT = Pathum Thani1; CN1 = Chai Nat1; PSL2 = Phisanulok2; SPR1 = Suphan Buri1; RD15 = RD15.

A- = aroma, F- = flavor, T- = Texture, _O = old crop, _N = new crop.

Food and Applied Bioscience Journal, 2014, 2 (1): 69-84

Table 2. Sensory profile of jasmine rice samples and non-aromatic rice comparing between new crop and old crop.

Rice Variety-Age	Age	Sewer/ Animal (A)		Popcorn (A)		Floral (A)		Adhesiveness to lips		Firmness	
KDML105	New	0.47	c	1.24	ab	3.42	a	11.56	ab	3.42	c
Pathum Thani1	New	0.92	bc	1.32	ab	3.09	ab	12.40	a	4.10	b
RD 15	New	0.44	c	0.96	abc	3.09	ab	10.21	bc	3.30	c
Chai Nat1	New	2.52	a	0.65	bcd	0.59	d	6.86	e	4.24	ab
Suphan Buri 1	New	1.74	ab	0.36	cd	0.59	d	8.92	cd	4.81	a
Phitsanulok 2	New	0.60	c	1.03	abc	2.06	bc	7.61	de	4.49	ab
KDML105 (2007)	New	0.12	c	1.57	a	2.67	ab	10.75	ab	2.60	d
KDML105	Old	0.27	c	1.00	abc	1.03	cd	10.00	bc	3.11	cd
Pathum Thani1	Old	0.26	c	0.82	bcd	0.97	cd	10.36	bc	3.07	cd
RD 15	Old	0.41	c	0.80	bcd	0.97	cd	8.93	cd	3.01	cd
Chai Nat1	Old	1.60	ab	0.36	cd	0.72	d	2.97	f	4.38	ab
Suphan Buri 1	Old	2.01	a	0.44	cd	0.36	d	6.54	e	4.13	b
Phitsanulok 2	Old	1.79	ab	0.16	d	0.17	d	2.93	f	4.52	ab

Note: Old crop were the rice samples that harvested in 2006 and tested in 2007. The standard deviations have range between 0.24-1.18

The same subscribe letter in the same column shows no significant different at α = 0.05

Table 2. Sensory profile of jasmine rice samples and non-aromatic rice comparing between new crop and old crop.(Cont.)

Rice Variety-Age	Age	Adhesiveness grain to grain		Cohesiveness of mass		Residuals	Tooth-packing	Starchy Mouthcoating	
KDML105	New	7.41	ab	7.72	a	2.14	7.41	7.72	a
Pathum Thani1	New	6.21	abc	7.20	abc	2.25	6.21	7.20	abc
RD 15	New	7.11	ab	7.20	abc	2.09	7.11	7.20	abc
Chai Nat1	New	4.33	cd	4.59	g	1.67	4.33	4.59	g
Suphan Buri 1	New	5.97	abc	6.68	bcd	2.05	5.97	6.68	bcd
Phitsanulok 2	New	4.25	cd	5.67	ef	2.08	4.25	5.67	ef
KDML105 (2007)	New	8.34	a	7.27	ab	2.49	8.34	7.27	ab
KDML105	Old	5.90	abc	6.30	cde	2.26	5.90	6.30	cde
Pathum Thani1	Old	6.96	ab	6.50	bcde	2.48	6.96	6.50	bcde
RD 15	Old	5.57	bc	5.82	def	2.28	5.57	5.82	def
Chai Nat1	Old	2.68	d	3.56	h	2.14	2.68	3.56	h
Suphan Buri 1	Old	3.79	cd	5.23	fg	2.34	3.79	5.23	fg
Phitsanulok 2	Old	2.57	d	3.54	h	2.15	2.57	3.54	h

Note: Old crop were the rice samples that harvested in 2006 and tested in 2007. The standard deviations have range between 0.24-1.18

The same subscribe letter in the same column shows no significant different at α = 0.05

Table 2. Sensory profile of jasmine rice samples and non-aromatic rice comparing between new crop and old crop.(Cont.)

Rice Variety-Age	Age	Grain		Straw-like		Starch		Popcorn		Musty	
KDML105	New	3.45	a	1.19	abc	6.79	ab	0.90	ab	0.45	ef
Pathum Thani1	New	3.48	a	1.40	a	7.18	a	0.59	bc	0.62	def
RD 15	New	3.42	a	1.48	a	6.14	abc	0.68	bc	0.51	ef
Chai Nat1	New	3.25	ab	1.10	abcde	4.99	de	0.62	bc	0.28	f
Suphan Buri 1	New	3.58	a	1.13	abcd	5.88	abcd	0.65	bc	0.78	cd
Phitsanulok 2	New	3.46	a	1.33	ab	5.68	bcd	0.9	ab	0.23	f
KDML105 (2007)	New	2.87	bc	0.83	bcdef	6.61	ab	1.25	a	1.30	ab
KDML105	Old	2.53	cd	0.66	cdef	5.46	bcd	0.94	ab	1.22	abc
Pathum Thani1	Old	2.53	cd	0.52	f	5.72	bcd	0.61	bc	1.30	abc
RD 15	Old	2.56	cd	0.72	cdef	6.02	abcd	0.81	ab	1.27	abc
Chai Nat1	Old	2.06	e	0.58	def	4.00	e	0.61	bc	1.05	bcd
Suphan Buri 1	Old	2.17	de	0.54	ef	5.77	abcd	0.25	c	1.47	a
Phitsanulok 2	Old	2.16	de	0.44	f	4.66	de	0.22	c	1.33	ab

Note: Old crop were the rice samples that harvested in 2006 and tested in 2007. The standard deviations have range between 0.24-1.18

The same subscribe letter in the same column shows no significant different at α = 0.05

Table 2. Sensory profile of jasmine rice samples and non-aromatic rice comparing between new crop and old crop.(Cont.)

Rice Variety-Age	Age	Overall Sweet		Sweet (ns)	Bitter		Metallic	
KDML105	New	1.87	a	0.67	2.07	d	1.31	ab
Pathum Thani1	New	1.90	a	0.59	1.95	d	1.61	a
RD 15	New	1.98	a	0.67	2.20	d	1.28	abcd
Chai Nat1	New	1.76	ab	0.50	2.12	d	1.33	ab
Suphan Buri 1	New	1.87	a	0.42	2.10	d	1.61	a
Phitsanulok 2	New	1.73	abc	0.50	2.02	d	1.25	abcd
KDML105 (2007)	New	1.66	abc	0.88	2.67	bc	0.65	e
KDML105	Old	1.45	bcd	0.77	2.99	ab	0.88	de
Pathum Thani1	Old	1.51	bcd	0.80	2.63	c	1.05	bcde
RD 15	Old	1.40	cd	0.80	2.70	bc	0.94	cde
Chai Nat1	Old	1.21	d	0.66	2.72	bc	1.30	abc
Suphan Buri 1	Old	1.32	d	0.66	2.96	ab	1.10	bcde
Phitsanulok 2	Old	1.32	d	0.71	2.79	abc	1.41	ab

Note: Old crop were the rice samples that harvested in 2006 and tested in 2007. The standard deviations have range between 0.24-1.18

The same subscribe letter in the same column shows no significant different at α = 0.05

4. Conclusion

There are several attributes that differentiate non-aromatic rice and jasmine rice. Jasmine rice tended to have more intense of popcorn aroma, floral aroma, adhesive to lips, adhesiveness grain to grain, cohesiveness of mass and overall sweet; while non-aromatic rice had more intense of sewer/animal aroma and firmness. The quality of rice sample were change over time, musty flavor and bitter taste tended to increase after storage. On the other hand, it tended to have less intense of floral aroma, grain flavor, straw-like flavor, and overall sweet. The changes in non-aromatic rice were on adhesiveness to lips, cohesiveness of mass, grain flavor, straw-like flavor and overall sweet that were decreased; while, musty flavor and bitter taste increased. The attributes that did not change overtime and not different between varieties were residuals, tooth-packing and sweet.

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