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Descriptive sensory characteristics of cooked mixed rice prepared by a different method using Rate-All-That-Apply and Quantitative Descriptive Analysis

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Abstract

Because of the cost and time-consuming nature of the classical sensory profiling method, a rapid method has been considered. This study aimed to investigate the sensory characteristics, consumer acceptability and purchase intent of healthier cooked mixed rice among different cooking methods by Rate-All-That-Apply (RATA) and Quantitative Descriptive Analysis (QDA®). Three types of cooking methods: electric rice cooker, pressure-cooker, and water-retort and two levels of rice bran protein hydrolysate content (RBH: 0% and 1%) were studied. Results showed that RATA resulted in higher sensory characterizations similar to QDA®. However, pandan leaves odor, Riceberry rice odor, bitterness, and astringent discriminative abilities were different between RATA and QDA®. For Principle Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) configuration, RATA intensity approached the samples grouping which divided samples into four groups with different sensory profiles, of which water-retort could improve consumer acceptability of cooked mixed rice. This current work indicated that RATA might successfully be used for gathering the sensory characteristics to QDA® with semi-trained panels. Therefore, RATA could be a useful tool for determining reliable results in quality control processes, investigating product characteristics, and designing a product in order to ascertain consumer acceptability.

Keywords: Cooked mixed rice, Consumer acceptability, Cooking method, Rate-All-That-Apply

1. Introduction

Pigmented rice has been considered as a healthy food due to its bioactive compounds and antioxidant activities which particularly present potential health benefits such as inhibiting cancer cells, preventing heart disease, oxidative stress reduction, anti-obesity, cardiovascular, and other chronic diseases [1-3]. In contrast, pigmented cooked rice tended to have a high intensity of stickiness, odor, hardness, sweetness and astringentcy which lowered the acceptance score for texture and aftertaste by consumers [4]; whereas aromatic rice of non-pigmented rice received a higher acceptance score due to its white color, soft texture and fragrant smell of 2-Acetyl-1-pyrroline [5]. Hence, cooked mixed rice may be a helpful way to improve the sensory quality of healthier cooked mixed rice and in particular, meet consumers needs. [6]. Since cooked rice from electric rice cookers generally has a short shelf-life [7], pressure-cookers and retort sterilization are regarded with special interest by food industries in order to prolong the shelf-life of high-quality foods [8]. Additionally, rice bran protein hydrolysate

(RBH) has been studied by several researchers. The consumption of RBH improves insulin resistance and prevents the development of metabolic syndrome [9]. Peptides derived from RBH could reduce blood pressure by controlling Angiotensin-converting enzyme, vasodilator and antioxidant properties in a rat model [10]. Previously, RBH has also been suggested for use as a co-product in the food industry, since it causes some effects on taste and aftertaste to the final product [11]. However, there was a limited application of RBH in cooked rice products and its sensory characteristics.

Sensory attributes including appearance, aroma, texture and taste directly influence consumer acceptability of the final products. Quantitative Descriptive Analysis (QDA®) is an effective method for product characterization [12-14], however, the cost and time-consuming nature of training a sensory panel can be issues. Currently, more rapid and flexible methods have been developed involving untrained or semi-trained panels such as Just-About-Right, Check-All-That-Apply and Rate-All-That-Apply. Among them, Rate-All-That-Apply (RATA) provided a sensory characterization and intensity which has been studied in milk desserts, bread, gummy lollies, fruit cake, wine, chocolate and emulsions [15-19]. Waehrens et al. [19] investigated the RATA potential using a three-point category scale with semi-trained panels. They found that RATA was efficient in performing and generating the sensory profile which could be part of QC programs in chocolate production and influencing consumer satisfaction. Recently, RATA was adapted to investigate the sensory profile of model double emulsions with untrained panels using a 9-box scale compared to QDA®. The results, showed that RATA had higher similarities ability and samples configuration compared to QDA® [18]. Moreover, the comparison of RATA and QDA® for sensory profiling of wine has been investigated with untrained panels using a 7-point intensity scale. RATA questions were able to be used in product characterizations to trained panels, therefore, it was recommended to continue with the same variety or similar wine types in the future study [16]. However, it is not clear whether RATA would be similar to QDA® when different cooked mixed rice samples and untrained panels are involved.

This study aimed to compare the determination of sensory characterizations of cooked mixed rice samples by RATA and QDA® methods and investigate sensory liking, consumer acceptability and the purchase intent of cooked mixed rice. prepared by different cooking methods.

2. Materials and methods

This research procedure was approved by Khon Kaen University Ethics Committee for Human Research (KKUEC) of the Faculty of Medicine, Khon Kaen University, Thailand with series number HE611231 in June 2018. Khao Dawk Mali 105 (KDML 105) was purchased from Ban Noonrang, Sawatee District, Mueang Khon Kaen, Khon Kaen province, Thailand, 2017. Maled Fai rice (MF: pigmented rice) was obtained from the Plant Breeding Research Center for Sustainable Agriculture, Department of Agronomy, Faculty of Agriculture, Khon Kaen University, Thailand, 2017. Rice bran protein hydrolysate (RBH) was provided by Thawornchinsombut et al. [2016].

2.1 Experimental set up

An experiment was conducted using three types of cooking methods (electric rice cooker, pressure-cooker and water-retort) and rice bran protein hydrolysate (RBH: 0 and 1%). Additional commercial cooked rice samples were obtained as the controls (Table 1). The experiment was done in duplicate.

Table 1 Cooked mixed rice and commercial cooked rice samples and its abbreviations.

Treatment	Cooking methods	RBH (%)	Cooking time (min)
0% EC	Electric rice cooker	0	20
1% EC	Electric rice cooker	1	20
0% PC	Pressure-cooker	0	48
1% PC	Pressure-cooker	1	48
0% WRT	Water-retort	0	48
1% WRT	Water-retort	1	48
Brand J	Ready-to-eat Jasmine rice (commercial brand)		
Brand R	Ready-to-eat Riceberry rice (commercial brand)		
Brand M	Ready-to-eat Jasmine rice mixed Riceberry rice (commercial brand)		

2.2 Sample preparations

Among cooking methods, cooked mixed rice was prepared by 1:1 ratio of rice mixing level (KDML 105 to MF rice) and 1.05:1 ratio of water-to-rice ratio (0% and 1% RBH was dissolved in water before being cooked) as follows:

Electric rice cooker: 75 g MF rice was soaked for 2 h after one-time washing at room temperature (30±2 ˚C) using distilled water. Then, 75 g KDML 105 rice (one-time washed) was mixed and cooked for 20 min using Sharp KSH-D06 0.6L Electric Rice Cooker.

Pressure-cooker: 25 g MF rice was washed one-time and soaked for 2 h at room temperature (30±2 ˚C) in stand pouch using distilled water. The sample was then mixed with 25 g KDML 105 (one-time washed) and sealed in a vacuum packaging (H 1500 model, Europac Co., LTD, Thailand) which was then placed in a pressure-cooker at 121 ˚C for 48 min.

Water-retort: 25 g MF rice was washed one-time and soaked for 2 h at room temperature (30±2 ˚C) in stand pouch using distilled water. The sample was then mixed with 25 g KDML 105 (one-time washed) and sealed in VAC-STAR S-225-M which was then cooked in a water-retort at 121 ˚C for 48 min.

2.3 Vocabulary developments

The sensory descriptive attributes were initially generated by two groups consisting of fifteen students (eight females and seven males) and ten vendors (five from University canteens; three owners from small restaurants which have less than 5 employees in each place; and two owners from medium restaurants which have 5-10 employees, all vendors were located in Khon Kaen province). They were asked to test the samples and create the sensory terms including appearance, odor, texture, taste and aftertaste. Then, all listed words were pulled and 70% frequencies of the words were selected to be in the final vocabulary list with their definitions. In total, 14 terms were included in the Rate-All-That-Apply and Quantitative Descriptive Analysis lists (Table 2).

Table 2 Descriptive attributes, definitions, standard references, and evaluation methods of cooked rice samples.

Terms	Definitions	Standard references	Evaluation methods
Appearance			
Red-purple color	The degree of red color to the purple color of cooked rice grain	Lipton tea (main color) was mixed with violet and red color (Winner Brand): SC1* = 0, SC2*=7, SC3*=11.5, SC4*=15	Measure the intensity of red to the purple color of cooked rice surface to the standard color
Stickiness	The degree of stickiness of cooked rice grain holds together	Polished rice = 0, cooked Jasmine rice[1] (w/r1.2:1)=8.5, cooked Sticky rice[2]=15	Measure the intensity of the degree of stickiness of cooked rice surface
Fluffy rice	The degree of becoming fluffy of cooked rice	Polished rice= 0, cooked Jasmine rice [1] (w/r1.2:1) = 7.8, cooked Jasmine rice (w/r 1.85:1) = 15	Measure the intensity of the degree of fluffiness after cooked
Odor			
Jasmine rice	Odor related to Jasmine rice	Ground Jasmine rice[3]: 5 g=12.5, 10 g =15	Evaluate the intensity of Jasmine rice aroma when smelling samples
Riceberry rice	Odor perceived related to Riceberry rice	Ground Riceberry rice[4]: 5 g = 8, 10 g = 15	Measure the intensity of riceberry rice odor when smelling samples
Pandan leaves	Odor perceived related to Pandan leave	Fresh Pandan leave[4]: 5g = 10, 10 g = 15	Measure the intensity of Pandan leave odor when smelling samples
Texture			
Cohesiveness of mass	The formation of mass when chewing the sample after 2-3 time	Cracker (HWA TAI Brand)=0, Mini white Marshmallows =8.5, Sticky rice =15	Chew 2 - 3 times of cooked rice using molars teeth and evaluate
Chewiness	The amount of chewing before samples become soft	Tofu=0,cooked Jasmine rice (W/R1.75:1) = 3.5, cooked Sticky rice = 15	Compress sample 10 time before swallowing
Hardness	The force to cut cooked rice kernels using the front teeth	Tofu = 0, Brown rice (Ezygo Brand) = 6.5, Roasted peanut = 15	Measure the force when cutting the rice kernel using front teeth
Taste			
Sweetness	The sweet taste after 20 sec of chewing associated with sucrose solution	Sucrose solution: 2.5% = 8, 5% = 15	Evaluate the intensity of sweetness after 5-8 times of chewing
Bitterness	The bitter taste after 20 sec of chewing associated with a caffeine solution	Caffeine solution: 0.035 = 9, 0.07% = 15	Evaluate the intensity of bitterness after 5-8 times of chewing

Terms	Definitions	Standard references	Evaluation methods
Aftertaste			
Astringent	The harsh sensation perceived in mouth and tongue after swallowing 1 min	Tannic acid solution: 0.035=7.5, 0.1% = 15	Evaluate the intensity of astringent after swallowing samples
Sweetness	The sweetness perceived after swallowing	Sucrose solution: 2.5% = 8, 5% = 15	Evaluate the intensity of sweetness after swallowing samples
Bitterness	The bitterness perceived after swallowing	Caffeine solution: 0.035 = 9, 0.07% = 15	Evaluate intensity of bitterness after swallowing samples

*SC1: 100 ml of the main color was added with 0.2 ml violet color and 0.04 ml red color.
SC2: 20ml of SC1 was diluted with 20 ml tap water and 40 ml SC4 added.
SC3: 50 ml of SC4 was diluted with 50 ml tap water.
SC4: 50 ml of SC1 was diluted with 50 ml tap water and 0.27 violet color added.
[1]Cooked Jasmine rice (from the experiment) was prepared using different water-to-rice ratio.
[2]Cooked Sticky rice was bought from Five Stars, food store.
[3&4]Ground Jasmine (from the experiment) and Riceberry rice (from local market) was kept overnight in brown bottle before test.
[5]Fresh Pandan leaves (from local market) were soaked in hot water for 1 min (fresh prepare).

2.4 Rate-All-That-Apply (RATA) technique

30 untrained panelists (15 females and 15 males, 20-40 years) who were regular rice consumers were recruited to test the samples. The Panelists were provided with a checklist of the terms and asked to rate the intensity of the given 14 descriptors using a 5-point scale. However, the scale was converted to 6-point (0, no intensity; 1, little; and 5, high). Panelists left the scale blank when they did not perceive the sensory descriptors. Nine samples were labelled with three-digit identifiers which were divided into two sets with a 10 min break between each set. To prevent sensory fatigue, drinking water was given as palate cleansing and a 5 min break before testing a new sample. Each section lasted between 40-50 min.

2.5 Quantitative Descriptive Analysis (QDA®) technique

Six out of eleven panelists (five females and one male) were screened following the criteria method of ASTM (1981) and ASTM (1992) [20]. Briefly, panelists were asked to define the terms and discussed which references and definitions would be appropriate to narrow down the number of sensory terms during the first session. Then, they were instructed on the used of 15 cm line scales (0, weak; 7.5, medium; 15 strong). Each reference was presented at different levels of intensity to standardize the use of 15 cm line scales as presented in Table 2. Throughout 40 h training, nine samples were evaluated under white lights in a sensory testing laboratory (25±2 ˚C) featuring individual booths as a modified method from Kwak et al. [14] which divided into two sets with a 10 min break between each set. Three-digit identifiers were used to identify the nine samples and presented to the panelists (served at 55±5 ˚C) with the drinking water to eliminate any bias. Panelists were instructed to rate the sample based on its intensity compared to the references and a 5 min break before starting the new sample.

2.6 Consumer acceptance test

To conduct sensory testing, samples were heated for 1 min in a microwave at 1000W (R-36P-SHARP; Thai City Electric, Bangkok, Thailand). Samples (approximately 15 g) were put into a white bowl and labeled with a three-digit number before being kept warm in a steamer (Philips HD9150 9L, Thailand). Samples were served at 55±5 ˚C and consumers were asked to rinse their mouth and palate with drinking water and a 5 min break before each testing. Sensory liking of the nine samples was conducted (N=40) in the sensory laboratory, Building TE06, Khon Kaen University using individual booths illuminated with controlled temperature (25±2 ˚C). Cooked rice samples were divided into two sets with a 10 min break before starting a new set. Consumers were instructed on the use of a 9-point hedonic scale (1= dislike extremely to 9=like extremely) and properly taste the samples that followed Kwak et al. [14]. They were asked to rate their liking of nine attributes of cooked rice samples (the overall liking of; appearance, color, stickiness, odor, softness, cohesiveness, taste, and aftertaste) and 5 min break before starting the new sample.

However, cooked mixed rice with 1% RBH was used in sensory evaluation during Science weeks, August 2018 in the Faculty of Technology, TE06 building, Khon Kaen University. Consumers (N=100; 51 females and 49 males) were students, staff, and lecturers from the other districts/provinces near to Khon Kaen University. They were instructed in how to properly taste the samples and the use of a 9-point hedonic scale as mentioned above. Besides, they were asked to make a decision about consumer acceptance and the purchase intent of the cooked mixed rice sample as well as selecting the packaging preference (pouch, cup, and tray type) using a Yes/No scale.

2.7 Statistical analysis

RATA and QDA® intensity and sensory liking were analyzed by ANOVA using IBM® SPSS Statistics 19.0 following Duncan's multiple range test (DMRT) to identify the differences among means by a posthoc test at 95% probability. Data were reported as mean±standard deviations. Principle Component Analysis (PCA) was generated to investigate the correlation between samples and descriptive attributes. Agglomerative Hierarchical Clustering (AHC) analysis was conducted to categorize samples based on their descriptive attributes. XLSTAT version 2018.6 was used for PCA and AHC analysis based on RATA and QDA® terms of cooked rice samples. The data of the consumer test were reported as mean (liking) and frequency (acceptance and purchase intent) using Microsoft Excel 2010 (Microsoft Corporation).

3. Results and discussion

3.1 Sensory descriptive attributes based on RATA vs. QDA® intensity

The results of ANOVA by RATA assessments of cooked rice samples with 30 untrained panelists using a 5-point scale are presented in Table 3. In nine attributes out of 14 sensory attributes there were significant differences. For cooking methods, electric rice cooker (EC added with 0 and 1% RBH) had the highest intensity of red-purple color, hardness, and chewiness; followed by pressure-cooker (PC) and commercial cooked rice in Brand M (Jasmine rice mixed Riceberry rice); and water-retort (WRT). These results agreed with Hiemori et al. [2] who reported that cooked black rice in an electric rice cooker, electric pressure cooker and stainless steel pot resulted in thermal degradation of anthocyanin. The pressure-cooker resulted in the highest loss of total anthocyanins, followed by the electric rice cooker and gas range methods. Moreover, Patras et al. [21] also revealed that thermal processing involving heating from 50-150 ˚C caused anthocyanin degradation which may impact on the color quality and nutritional value of the products.

However, rice cooked by PC and WRT (added with 0 and 1% RBH) had the highest intensity of stickiness and cohesiveness of mass. These results agreed with Hu et al. [22] who indicated that water molecules could effectively penetrate into starch granules under pressure to increase water adsorption to a greater extent. At higher temperatures, the lower molecular weight of amylopectin leached out which may reduce hardness, and increased the stickiness and cohesiveness of cooked rice by interacting with the fine structure of amylose surrounding its surface [23]. Hence, the PC and WRT processes had the greatest effect on hardness, cohesiveness of mass and chewiness compared to EC.

To consider RBH addition, 1% RBH increased the intensity of the purple color in a red-purple color system (i.e. 0% EC = 3.60 and 1% EC = 4.27) and hardness (i.e. 0% EC = 3.13 and 1% EC = 3.40) of cooked mixed rice samples. The active polyhydroxy group (ROH) could penetrate into starch granules and may block or be inserted into the hydrogen bonds among the starch molecules [24]. However, protein hydrolysate/polypeptides might interact with amylose/amylopectin by adhering starch granules on the surface which could be easily rearranged with a shorter cooling time [25]. Additionally, RBH seemed to increase the intensity of bitterness (i.e. 0% EC = 0.87 and 1% EC = 1.47) and astringentcy (i.e. 0% EC = 1.60 and 1% EC = 2.00) of cooked mixed rice samples. Schaafsma [11] mentioned that protein hydrolysate was related to the bitterness and astringentcy of the final product due to its hydrophobic amino acid content. Comparatively, cooked mixed rice samples had similar fluffy, hardness, and chewiness intensity to commercial cooked rice samples in this study. However, commercial cooked rice in Brand R (Riceberry rice) had the highest intensity of sweetness, bitterness and astringentcy, followed by 1% RBH added samples.

The results of ANOVA by the QDA® method of cooked rice samples are presented in Table 4 in which 13 attributes except pandan leave odor were significantly different. Among cooking methods, red-purple color, hardness, cohesiveness of mass, chewiness, and astringent intensities were similar to the RATA method. 1% RBH increased the intensity of bitterness and astringentcy of cooked mixed rice samples. By comparison, the commercial cooked rice in Brand R (Riceberry rice) had the lowest intensity of red-purple color, but obtained the highest bitterness intensity; while 1% RBH added in water-retort had the highest astringency intensity.

The summarized sensory profiles of the six cooked mixed rice samples by RATA (5-point scale) and QDA® (15 cm line scale) results are presented in Figure 1 (A) and (B). Further details, the significant differences of the 14 sensory attributes were found in 9 terms from the RATA results and 13 terms from the QDA® results. However, the intensity of red-purple color, hardness, cohesiveness of mass, chewiness, the taste of sweetness and bitterness, and astringentcy had similar trends with both techniques after converting 15 to 5 cm line scale of the QDA® results (Figure 1 (C)).

The use of RATA was deemed to be useful for untrained participants for describing the different attributes (i.e. color, sweetness, and bitterness); meanwhile the capturing of odor and aftertaste (i.e. pandan leaves odor, Riceberry rice odor, bitterness and astringentcy) seemed to be complicated. Moreover, the odor perception has been studied concerning which experts were consciously able to identify the mixture of odorants, compared to normal participants, through training on a single odor and the ability to focus with their familiarity which was found to be more efficient with 87% vs. 58% correct identification by experts and normal panels respectively [26-27]. Hence, trained panels were more professional than untrained panels at discriminating and identifying odors [28].

Additionally, Schwarz and Hofmann [29] who revealed that the mechanisms of bitterness and astringentcy involving the interaction between stimuli and lipid liposomes, and the taste receptor on the tongue, which Ma et al. [30] who reviewed the perception of bitterness and astringentcy in wine also recommended that most of the bitterness studied depends on the sensorial method. These results indicated that RATA could be performed when the different products are involved, therefore, semi-trained panels should be used when complex attributes are listed.

Table 3 The intensity of descriptive terms of cooked mixed rice and commercial cooked rice samples by RATA technique.

Treat. [1]	Appearance			Odor			Texture			Taste		Aftertaste		
	Red-purple color	Stickiness	Fluffy ^{NS}	Riceberry rice	Jasmine rice	Pandan leaves ^{NS}	Hardness ^{NS}	Cohesiveness of mass	Chewiness ^{NS}	Sweetness ^{NS}	Bitterness	Sweetness	Bitterness	Astringent
0% EC	3.60^{AB}	1.93^{D}	2.67	3.40^{A}	2.60^{AB}	1.13	3.13	2.40^{C}	2.67	2.87	0.87^{BC}	2.13^{AB}	1.47^{B}	1.60^{A}
	(0.73)	(1.03)	(1.17)	(1.12)	(1.45)	(0.63)	(1.06)	(1.24)	(1.29)	(1.50)	(0.74)	(1.24)	(1.18)	(1.59)
1% EC	4.27^{A}	2.73^{BCD}	2.53	3.87^{A}	2.20^{B}	1.33	3.40	2.73^{ABC}	3.20	2.93	1.47^{B}	2.67^{A}	1.73^{B}	2.00^{A}
	(0.96)	(0.79)	(1.12)	(0.74)	(1.01)	(0.81)	(1.05)	(0.88)	(1.52)	(1.48)	(1.30)	(1.71)	(1.75)	(1.92)
0% PC	3.00^{B}	3.60^{AB}	2.47	3.13^{AB}	2.00^{B}	1.40	3.00	3.73^{A}	2.67	2.47	1.47^{B}	2.53^{A}	1.40^{B}	1.67^{A}
	(1.25)	(1.24)	(1.12)	(1.18)	(1.36)	(1.29)	(1.00)	(1.22)	(1.23)	(0.91)	(1.35)	(1.18)	(1.12)	(1.34)
1% PC	4.07^{A}	3.60^{AB}	2.67	3.47^{A}	2.27^{B}	1.80	3.13	3.33^{ABC}	2.67	3.00	1.73^{B}	3.00^{A}	1.73^{B}	1.67^{A}
	(1.48)	(0.98)	(1.11)	(1.24)	(1.38)	(0.94)	(1.06)	(1.23)	(1.17)	(1.19)	(1.33)	(1.51)	(1.09)	(1.23)
0% WRT	1.93^{C}	3.73^{A}	2.40	2.27^{B}	2.73^{AB}	1.20	2.47	3.07^{ABC}	2.40	2.93	1.47^{B}	2.73^{A}	1.40^{B}	1.73^{A}
	(1.09)	(0.88)	(1.05)	(1.16)	(1.22)	(0.67)	(1.50)	(1.38)	(0.91)	(1.33)	(1.50)	(1.33)	(1.12)	(1.70)
1% WRT	1.33^{C}	3.00^{ABC}	2.53	2.40^{B}	1.60^{C}	1.00	2.60	3.67^{AB}	2.67	3.20	1.53^{B}	2.87^{A}	2.13^{AB}	1.60^{A}
	(0.89)	(1.25)	(1.12)	(1.40)	(1.12)	(0.75)	(1.05)	(0.81)	(1.04)	(1.42)	(0.91)	(1.50)	(1.80)	(1.40)
Brand J	0.00*	2.60^{CD}	3.07	0.80^{C}	3.47^{A}	1.00	2.73	2.60^{C}	2.87	2.47	0.37^{C}	1.27^{B}	0.00^{C}	0.00^{B}
		(1.45)	(1.43)	(1.08)	(1.68)	(1.13)	(0.79)	(1.59)	(1.35)	(1.64)	(0.48)	(0.71)		
Brand R	1.20^{C}	3.27^{ABC}	3.00	2.93^{AB}	2.27^{B}	1.33	3.13	2.67^{BC}	2.20	2.80	3.27^{A}	2.87^{A}	3.00^{A}	2.27^{A}
	(0.56)	(1.09)	(1.19)	(1.48)	(1.38)	(1.04)	(1.40)	(1.58)	(1.32)	(1.47)	(1.27)	(1.72)	(1.36)	(1.75)
Brand M	2.93^{B}	2.60^{CD}	3.07	3.20^{AB}	2.00^{B}	1.27	3.20	2.47^{C}	2.73	2.73	1.27^{B}	2.20^{AB}	1.60^{B}	1.73^{A}
	(1.22)	(1.35)	(1.22)	(1.37)	(1.51)	(1.33)	(1.82)	(1.12)	(1.09)	(1.22)	(1.28)	(1.01)	(1.45)	(1.48)

[1]See Table 1 for sample abbreviations.
Values showed in mean and (standard deviation).
Value with a different capital letter within column is significantly different among samples by One-Way ANOVA ($p<0.05$).
*The intensity of red-purple color was compared among eight cooked rice samples due to the native color of Jasmine rice (commercial cooked rice in Brand J).
NS = non significantly difference.

Table 4 The intensity of descriptive terms of cooked mixed rice and commercial cooked rice samples by QDA® technique.

Treat. [1]	Appearance			Odor			Texture			Taste		Aftertaste		
	Red-purple color	Stickiness	Fluffy	Riceberry rice	Jasmine rice	Pandan leave ^{NS}	Hardness	Cohesiveness of mass	Chewiness	Sweetness	Bitterness	Sweetness	Bitterness	Astringent
0% EC	11.25^{B}	6.07^{E}	6.50^{F}	5.35^{E}	3.87^{F}	0.08	6.17^{B}	5.18^{E}	7.02^{A}	0.93^{AB}	0.25^{CD}	0.00^{D}	0.00^{B}	0.73^{C}
	(0.61)	(0.48)	(0.49)	(0.45)	(0.45)	(0.20)	(0.42)	(0.29)	(0.33)	(0.31)	(0.23)			(0.29)
1% EC	12.25^{A}	6.08^{E}	6.05^{F}	6.52^{D}	3.07^{G}	0.00	6.55^{A}	4.72^{F}	7.12^{A}	1.10^{A}	0.33^{C}	0.27^{C}	0.00^{B}	1.47^{B}
	(0.42)	(0.48)	(0.52)	(0.50)	(0.51)		(0.39)	(0.40)	(0.20)	(0.20)	(0.41)	(0.45)		(0.45)
0% PC	7.48^{D}	9.42^{A}	13.22^{CD}	5.60^{E}	5.52^{C}	0.42	5.15^{D}	6.62^{BC}	5.70^{BC}	0.37^{D}	0.00^{D}	0.60^{B}	0.00^{B}	0.70^{C}
	(0.47)	(0.44)	(0.48)	(0.47)	(0.53)	(0.49)	(0.21)	(0.38)	(0.40)	(0.15)		(0.17)		(0.19)
1% PC	8.57^{C}	9.18^{A}	13.13^{D}	6.32^{D}	5.02^{CD}	0.20	5.65^{C}	6.08^{D}	5.33^{C}	1.10^{A}	0.17^{CD}	1.02^{A}	0.00^{B}	0.48^{C}
	(0.36)	(0.48)	(0.45)	(0.44)	(0.44)	(0.23)	(0.35)	(0.40)	(0.29)	(0.20)	(0.26)	(0.04)		(0.15)

Treat.[1]	Appearance			Odor			Texture			Taste		Aftertaste		
	Red-purple color	Stickiness	Fluffy	Riceberry rice	Jasmine rice	Pandan leave ^{NS}	Hardness	Cohesiveness of mass	Chewiness	Sweetness	Bitterness	Sweetness	Bitterness	Astringent
0% WRT	1.90^{E} (0.51)	8.25^{B} (0.46)	13.80^{B} (0.39)	9.38^{C} (0.50)	4.48^{DE} (0.47)	0.37 (0.37)	3.10^{F} (0.38)	7.37^{A} (0.42)	4.38^{D} (0.45)	0.75^{BC} (0.27)	0.65^{B} (0.21)	0.00^{D}	0.00^{B}	1.60^{B} (0.38)
1% WRT	1.15^{F} (0.43)	8.07^{BC} (0.56)	13.70^{BC} (0.51)	10.15^{B} (0.41)	4.05^{EF} (0.50)	0.25 (0.42)	3.97^{E} (0.19)	6.77^{B} (0.25)	4.42^{D} (0.48)	1.15^{A} (0.23)	0.43^{BC} (0.15)	0.00^{D}	0.00^{B}	2.57^{A} (0.18)
Brand J	0.00*	7.52^{CD} (0.43)	7.33^{E} (0.57)	0.00^{F}	8.05^{A} (0.50)	0.00	3.03^{F} (0.21)	6.38^{BCD} (0.32)	4.27^{D} (0.29)	0.58^{CD} (0.13)	0.00^{D}	0.58^{B} (0.13)	0.00^{B}	0.00^{D}
Brand R	0.00^{G}	5.58^{E} (0.49)	15.00^{A}	14.27^{A} (0.42)	0.20^{H} (0.32)	0.35 (0.42)	3.08^{F} (0.11)	5.28^{E} (0.37)	3.52^{E} (0.32)	0.63^{CD} (0.22)	3.12^{A} (0.18)	0.62^{B} (0.20)	1.20^{A} (0.24)	0.70^{C} (0.21)
Brand M	7.44^{D} (0.34)	7.23^{D} (0.48)	7.18^{E} (0.44)	5.67^{E} (0.61)	6.52^{B} (0.43)	0.17 (0.41)	6.03^{B} (0.31)	6.22^{CD} (0.34)	5.83^{B} (0.43)	0.60^{CD} (0.15)	0.25^{CD} (0.27)	0.23^{CD} (0.26)	0.00^{B}	0.60^{C} (0.09)

[1] See Table 1 for sample abbreviations.
Values showed in mean and (standard deviation).
Value with a different capital letter within column is significantly different among samples by One-Way ANOVA (p<0.05).
* The intensity of red-purple color was compared among eight cooked rice samples due to the native color of Jasmine rice (commercial cooked rice in Brand J).
NS= non significantly difference.

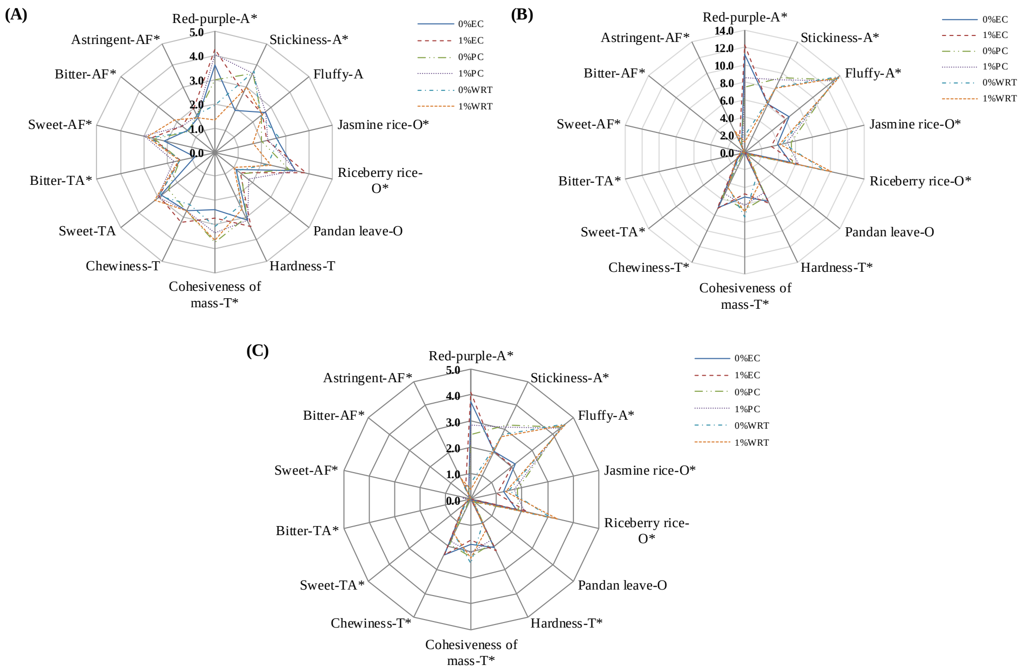

Figure 1 The intensity of descriptive terms of the six cooked mixed rice samples by (A) RATA terms using 5-point scale, (B) QDA® terms using 15 cm line scale, and (C) QDA® terms as converted into 5-point scale. Letters A, O, T, TA, and AF after attributes meant appearance, odor, texture, taste, and aftertaste respectively. The asterisks * indicate the significant variable based on one-way ANOVA (p<0.05).

3.2 Principal component analysis of RATA vs. QDA®

For RATA results, the PCA-biplot explained 64.46% of the total variance (F1: 43.47% and F2: 20.99% in Figure 2 (A)) which was divided samples into four groups as confirmed by Agglomerative Hierarchical Clustering (AHC: Figure 2 (B)). The commercial cooked rice in Brand M (Jasmine rice mixed Riceberry rice), 0% EC, 1% EC, 0% PC, and 1% PC samples were clustered as the first group which predominated with a red-purple color, Riceberry rice odor, pandan leaves odor, hardness, and chewiness. 0% WRT and 1% WRT samples were clustered as the second group which related to stickiness and cohesiveness of mass. The commercial cooked rice in Brand R (Riceberry rice) was clustered as the third group which related to bitterness and aftertaste of sweetness, bitterness, and astringentcy; while commercial cooked rice in Brand J (Jasmine rice) was clustered as the last group which focused onthe Jasmine rice odor. However, PCA could successfully be analyzed and interpreted by RATA data as recommended by Meyner et al. [17].

For QDA® results, the PCA-biplot explained 64.58% of the total variance (F1: 39.06% and F2: 25.52% in Figure 3 (A)) which divided samples into three groups as confirmed by cluster analysis (AHC: Figure 3 (B)) with a different configuration to the RATA method. However, the commercial cooked rice in Brand M (Jasmine mixed Riceberry rice), 0% EC, 1% EC, 0% PC, and 1% PC samples were clustered as the first group which was associated with a red-purple color, hardness, and chewiness. The commercial cooked rice in Brand R (Riceberry rice), 0%WRT and 1%WRT samples were clustered as the second group due to its sensory profiles which related to fluffiness, pandan leaves odor, Riceberry rice odor, bitterness, and an aftertaste of sweetness, bitterness and astringentcy. Meanwhile the commercial cooked rice in Brand J (Jasmine rice) was clustered as the last group which focused on stickiness, Jasmine rice odor, and cohesiveness of mass.

Therefore, PCA-biplot of the combination of RATA and QDA® yielded 59.21% of the total variance (F1: 32.71% and F2: 26.50%) are presented in Figure 4. Results showed most of the samples locations were predominatly the same sensory terms from RATA and QDA® methods except for fluffiness, Riceberry rice odor, pandan leaves odor, sweetness, bitterness, and astringent attributes. Meanwhile, the sensory characteristics of a red-purple color, stickiness, Jasmine rice odor, hardness, and chewiness are close to each other.

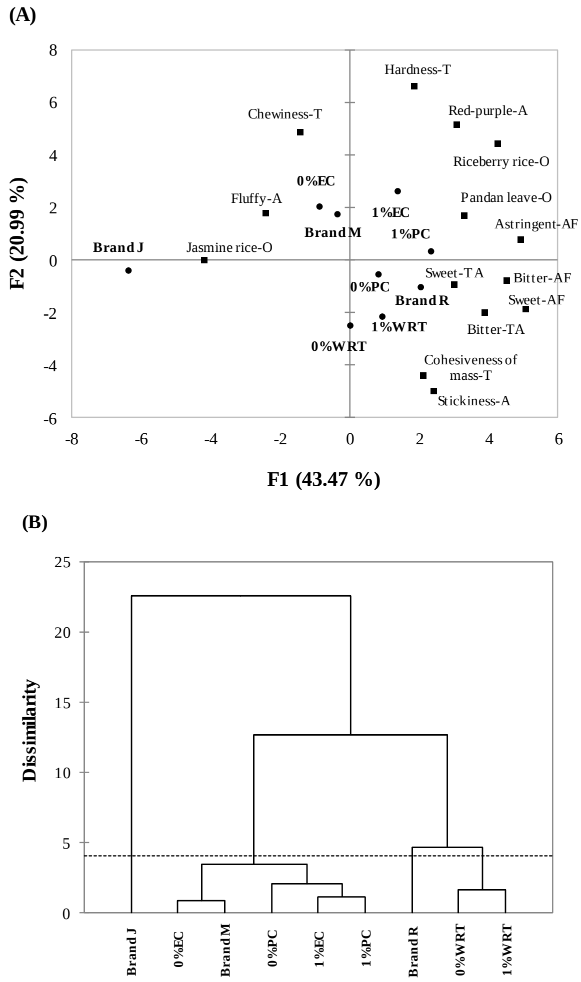

Figure 2 (A) PCA-biplot showed the relationship between the descriptive attributes of cooked mixed rice samples by RATA (see abbreviation samples in Table 1). Letters A, O, T, TA, and AF after attributes meant appearance, odor, texture, taste, and aftertaste for descriptive attributes respectively. Symbols of ● and ■ were represented for samples and RATA terms respectively. (B) Dendrogram by Hierarchical Cluster analysis on the scores of cooked rice samples by RATA.

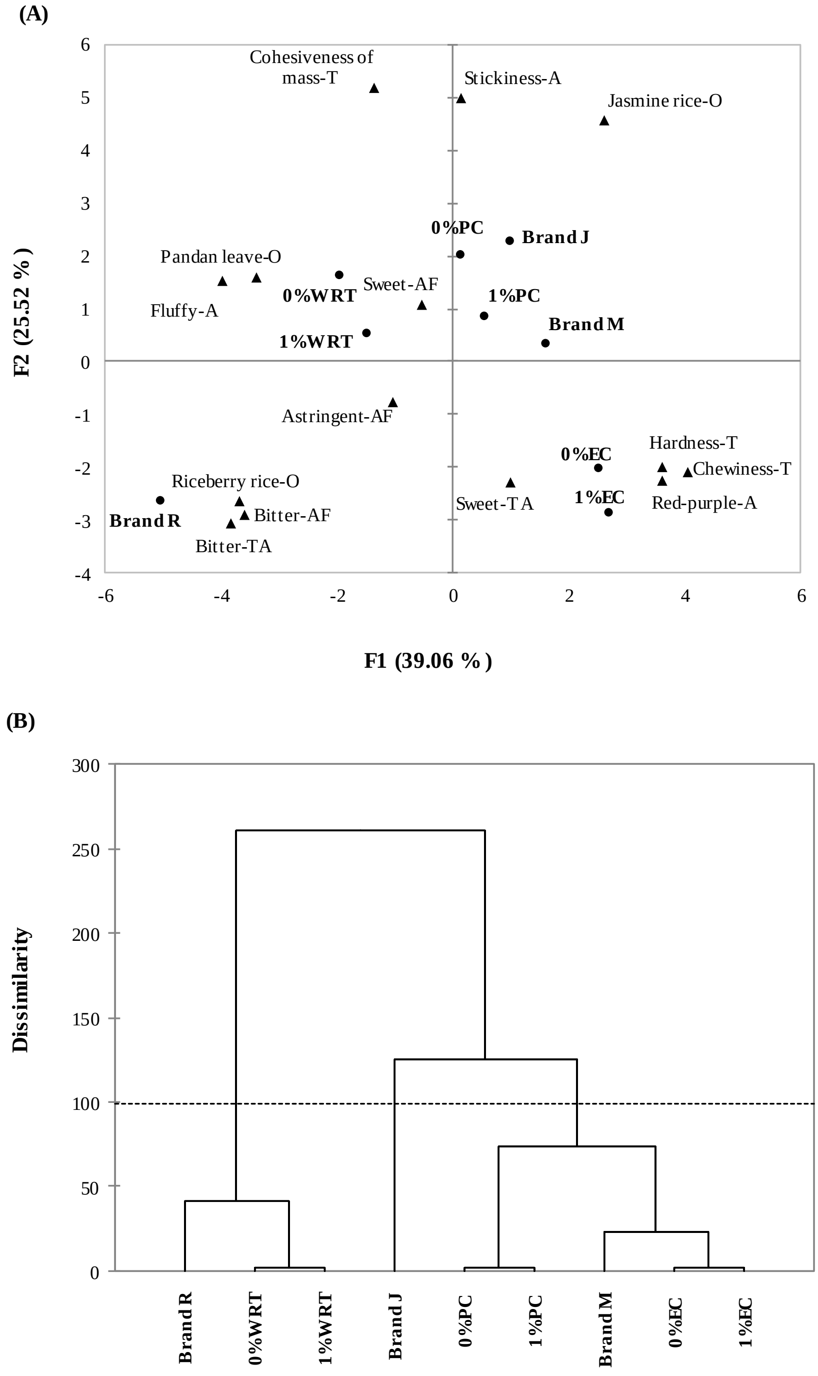

Figure 3 (A) PCA-biplot showed the relationship between the descriptive attributes of cooked mixed rice samples by QDA® (see abbreviation samples in Table 1). Letters A, O, T, TA, and AF after attributes meant appearance, odor, texture, taste, and aftertaste for descriptive attributes respectively. Symbols of ● and ▲ were represented for samples and QDA® terms respectively. (B) Dendrogram by Hierarchical Cluster analysis on the scores of cooked rice samples by QDA®.

The results agreed with the previous studies. The RATA method showed similar discriminative ability to QDA® for sensory profiling of model double emulsions [18], red table wine [16], and a chocolate quality control program [19]. Significantly, results showed that RATA may not be able to measure some complicated sensory attributes using untrained panels (i.e. bitterness and astringentcy) which involves interaction with stimuli, smell/taste receptors as mention by Schwarz and Hofmann [26] and Ma et al. [27]. However, RATA might be able to compare to QDA® when semi-trained panelists are involved.

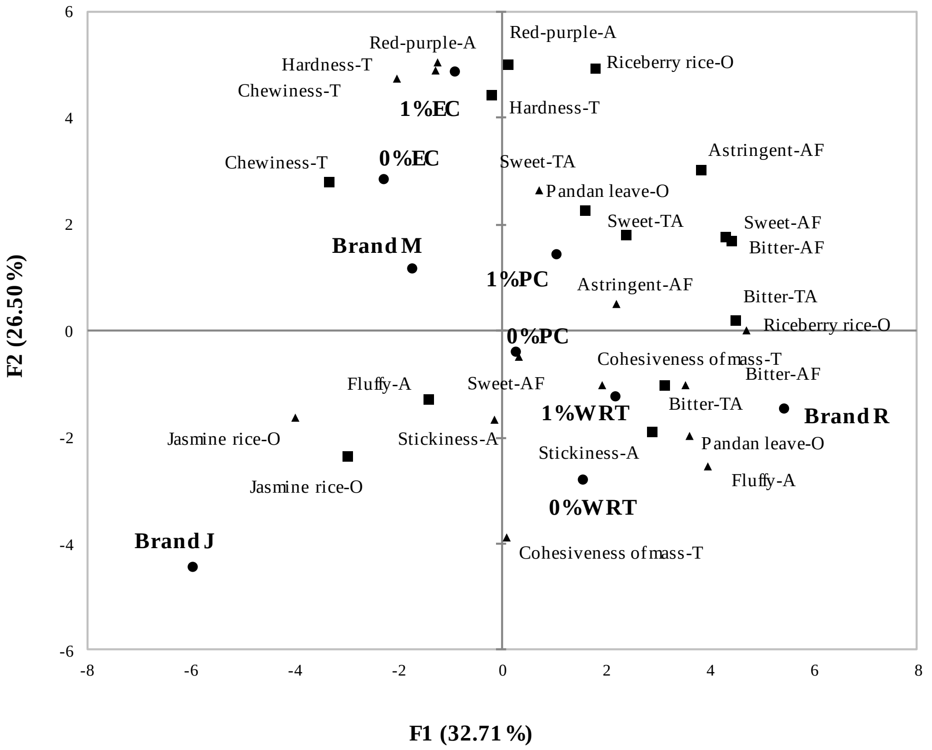

Figure 4 PCA-biplot showed the relationship between the descriptive attributes of cooked mixed rice samples by RATA and QDA® (see abbreviation samples in Table 1). Letter A, O, T, TA, and AF after attributes meant appearance, odor, texture, taste, and aftertaste for descriptive attributes respectively. Symbols of ●, ▲, and ■ were represented for samples, QDA® terms, and RATA terms respectively

3.3 Consumer acceptance test

The results of nine sensory attributes of cooked mixed rice and commercial cooked rice samples are presented in Table 5. The overall liking of cooked mixed rice samples range between 6.33-6.83 while the commercial cooked rice samples ranged between 5.88-6.78. Of the cooking methods, rice cooked in PC and WRT resulted in the higher sensory liking for almost all attributes. However, WRT had the highest liking of softness and cohesiveness, followed by PC and EC. These results agreed with its intensity of hardness and cohesiveness in each cooking method as mentioned above. Concurrently, rice cooked in EC received higher liking of overall liking and appearance, but lower in the liking of softness, cohesiveness, taste and aftertaste.

Table 5 The sensory liking of cooked mixed rice and commercial cooked rice samples.

Treatments [1]	Sensory liking								
	Overall liking	Appearance	Stickiness	Color	Odor	Softness	Cohesiveness	Taste	Aftertaste
0% EC	6.33^{AB} (1.51)	6.78^{A} (1.42)	6.55^{AB} (1.36)	6.38^{AB} (1.72)	6.15^{ABC} (1.81)	5.03^{B} (1.70)	5.33^{BC} (1.90)	5.63^{AB} (1.81)	5.48^{BC} (1.58)
1% EC	6.67^{A} (1.77)	6.50^{A} (1.63)	6.83^{A} (1.34)	6.53^{AB} (1.50)	5.50^{BC} (1.87)	4.97^{B} (2.01)	4.87^{C} (1.87)	5.83^{AB} (1.70)	5.90^{ABC} (1.97)
0% PC	6.63^{A} (1.43)	5.50^{BC} (1.50)	5.48^{C} (1.52)	5.83^{BC} (1.55)	6.35^{AB} (1.76)	5.88^{AB} (1.87)	6.13^{A} (1.45)	6.25^{A} (1.51)	6.25^{AB} (1.64)
1% PC	6.43^{AB} (1.41)	6.25^{A} (1.82)	6.38^{AB} (1.51)	5.88^{BC} (2.03)	6.63^{A} (1.72)	5.60^{AB} (1.78)	6.43^{A} (1.52)	6.15^{A} (1.67)	6.18^{AB} (1.55)
0% WRT	6.75^{A} (1.17)	6.18^{AB} (1.13)	5.83^{BC} (1.69)	5.25^{C} (1.61)	6.30^{AB} (1.52)	6.43^{A} (1.60)	6.00^{AB} (1.54)	6.25^{A} (1.43)	6.33^{A} (1.07)
1% WRT	6.83^{A} (1.58)	6.25^{A} (1.64)	6.58^{A} (1.60)	6.05^{ABC} (1.93)	5.83^{ABC} (1.84)	6.35^{A} (1.76)	6.58^{A} (1.50)	6.05^{A} (1.71)	6.18^{AB} (1.72)

Treatments [1]	Sensory liking								
	Overall liking	Appearance	Stickiness	Color	Odor	Softness	Cohesiveness	Taste	Aftertaste
Brand J	6.33^{AB} (1.69)	6.68^{A} (1.58)	6.73^{A} (1.32)	6.78^{A} (1.76)	5.30^{C} (1.83)	5.55^{AB} (2.22)	6.23^{A} (1.53)	5.65^{AB} (1.93)	5.95^{ABC} (1.58)
Brand R	5.88^{B} (1.56)	5.38^{C} (1.64)	5.30^{C} (1.44)	5.40^{C} (1.72)	5.73^{BC} (1.88)	6.23^{A} (1.91)	5.30^{BC} (1.52)	5.15^{B} (1.85)	5.35^{C} (1.64)
Brand M	6.78^{A} (1.33)	6.40^{A} (1.34)	5.83^{BC} (1.53)	6.03^{ABC} (1.62)	6.35^{AB} (1.41)	6.28^{A} (1.92)	6.30^{A} (1.42)	6.28^{A} (1.48)	6.33^{A} (1.70)

[1] See Table 1 for sample abbreviations.
Values showed in mean ± standard deviation.
Value with a different capital letter within a column is significantly different among samples by One-Way ANOVA (p<0.05).

These results are close to Somthawil and Sriwattana [4] who revealed that pigmented rice cooked in a rice cooker-steamer tended to have a higher intensity of hardness and the average acceptance scores ranged between 5.6-7.0.

However, the appropriate intensity of descriptive attributes of WRT and PC could help to achieve consumer acceptability of cooked mixed rice especially the liking of softness, cohesiveness, taste, and aftertaste compared to EC. For 1% RBH added, the liking of softness seemed to decrease without significant differences noted by consumers. RBH did not effect the liking of taste and aftertaste, however, the higher intensity of bitterness and astringentcy of descriptive attributes (RATA and QDA® results) may not be detected by consumers and was acceptable to consumers in the range of neither like nor dislike to like moderately in all sensory attributes.

Results revealed that cooking methods strongly influenced the overall acceptability of the cooked mixed rice samples. However, 1% WRT sample was selected to use in a consumer test [N=100; 51 females whose ages were in the range of <15 years (21consumers); 16-30 years (22 consumers); 31-45 years (19 consumers); 46-60 years (20 consumers); and >60 years (18 consumers)]. The sensory liking of nine sensory attributes of cooked mixed rice samples is presented in Figure 6 (A) which ranged between 7.34-8.17 in all sensory attributes including texture, taste, and aftertaste. Results indicated that cooked mixed rice could enhance consumer liking of pigmented rice from 5 (neither like nor dislike) to 8 (like very much) including the liking of appearance, taste, and aftertaste for consumers who participated in this study.

After tasting, consumer acceptance and purchase intent of cooked mixed rice samples were 97% and 95% respectively (Figure 6 (B)). This purchase intent was positively affected by cooking methods and RBH added which provided appropriate sensory characteristics and higher consumer acceptance in all sensory attributes. Moreover, 61% of consumers preferred cup packaging, followed by tray packaging 31% and stand pouch 8% (Figure 6 (C)).

Figure 5 Graphical representation of packaging types for preference test. (A) Pouch, (B) Cup and (C) Tray.

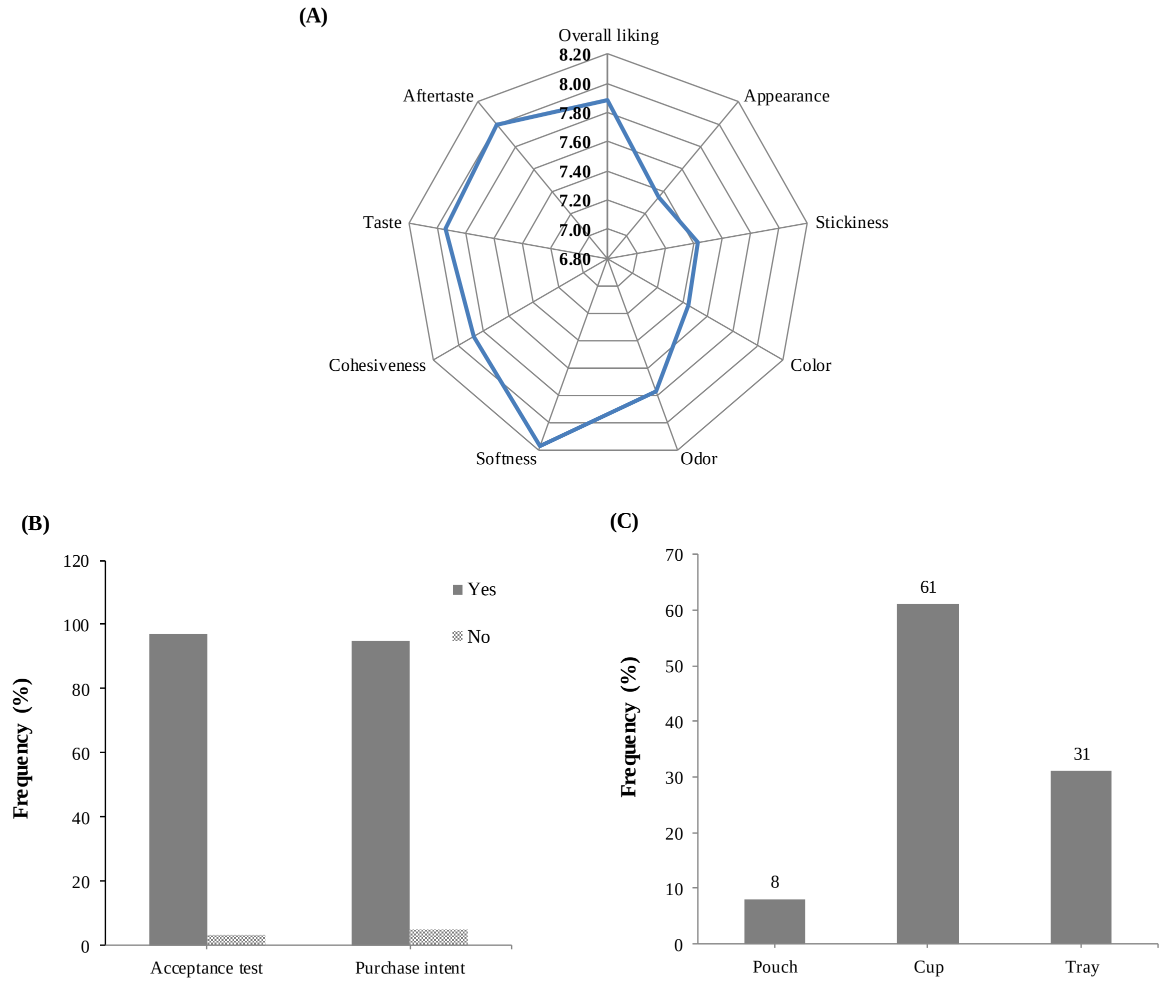

Figure 6 (A) Sensory liking of aseptic-packaged cooked mixed rice with 1% RBH (1% WRT sample) based on 9-point hedonic scale (1 = dislike extremely; 9 = like extremely; performed and taken from 100 consumers) and frequency of (B) consumer acceptance test and purchase intent and (C) packaging type preference of cooked mixed rice samples.

4. Conclusions

Results revealed that the RATA technique was able to analyze and capture the sensory characteristics of cooked mixed rice samples which proved time saving when the complex attribute is not seriously needed as compared to QDA® (i.e. bitterness and astringent), but better to identify the product characterizations. However, PCA and AHC configuration suggested that RATA intensity approached samples grouping as similar to QDA® in this study.

This current work indicated that RATA might be successfully achieved in capturing the sensory characteristics intensity of QDA® if semi-trained panelists are used. Moreover, RATA could be a useful tool for determining reliable results in quality control processes, investigating product characteristics, and designing products in order to ascertain consumer acceptability.

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