

Formulation and evaluation of physical, chemical and sensory properties of instant functional beverage powder containing Pathum Thani fragrance rice, soy protein and milk powder

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Abstract

The purpose of this study was to determine the influence of proportion and ratio of the following main ingredients comprising Pathum Thani fragrance rice powder, soy protein and milk powder on physicochemical properties and sensory characteristics of instant functional beverage powder. The experimental procedures consisted of prerequisite processing steps of cooking, drying, crushing and mixing all ingredients. The design was used to produce a total of ten samples of powdered beverage products. Whereas, dry samples and complete dissolution samples were analyzed for their physicochemical properties and sensory characteristics. Results indicated that the prepared beverage powder with various ratios of ingredient combinations delivered significant impact on their physical chemical and sensory characteristics. Principal component analysis (PCA) was implemented to group the attributes into three key dimensions that explained 76.51% of the total variance. Furthermore, Partial least squares regression (PLSR) was employed as a multivariate statistical tool to accurately determine carbohydrate, fiber, L* (dissolve), a* (dissolve) and b* (dissolve) as key drivers of liking. Having the highest consumer satisfaction levels and highest average liking scores of all sensory characteristics, the optimum formulation for instant functional beverage powder was formula 10 containing 23.34% of Pathum Thani fragrance rice powder, 13.33% of soy protein and 13.33% of milk powder, 20% of sugar, 10% of cocoa powder, 10% of malt powder, 5% of non-dairy cream powder and 5% inulin powder. More importantly, these research findings may influence decisions at many levels in increasing consumer acceptance of the product, manufacturing healthier products for people, and adding value to products of agriculture.

1. Introduction

Pathum Thani province is considered to be one of Thailand's major agricultural areas occupying a total farmland area of approximately 53.03% of the provincial area. Hom Pathum Rice (Pathum Thani fragrance Rice 1) as Pathum Thani's major crop can be grown year-round possessing aromatic flavor and soft texture when well-cooked. As an ingredient in many products such as instant beverages, ready-to-eat drinks, snacks, noodles, bread, ice cream and desserts, rice is used in the food industry.

The health drinks market is one of the fast-growing markets in Thailand. Moreover, consumer behaviors have been shifting dramatically as more and more of such products such as vegetable juice, fruit juice, herbal juice, and green tea, shelving up from markets. As consumers in Thailand opt for healthy, functional

beverages, manufacturers developed various market strategies, one of which is to reach more health-conscious customers. One of the good examples is adding nutrients to increase nutritional value to vegetable-based beverages, particularly in instant cereal-based powdered beverages. There are mainly two types of cereal-based beverages available in Thailand including ready-to-drink and instant powder. Both of these contain ingredients that must be imported from abroad, including wheat as their main ingredient. Due to concerns about the presence of contamination and diseases of imported wheat that may adversely affect the health of consumers, healthy alternatives to wheat are uncovered. According to previous research, different varieties of rice were commonly used as ingredients to replace wheat in healthy drinks including Hom-Nin rice (Tirasarot and Tanomwong, 2015), germinated purple rice tea (Noosing *et al.*, 2014), young rice (Rawdsiri and Thongrak, 2012)

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and germinated black glutinous rice (Ruangdee, 2012). Although there are many studies related to different types of rice varieties as ingredients of instant powdered beverage products, the research on Pathum Thani fragrance rice remains limited. The processing of Pathum Thani fragrance rice into instant beverage powder will give the product a unique aroma, nutritious, convenient, easy to drink and prolong shelf life. Moreover, the addition of high-protein raw materials such as soy protein and milk powder into the product can make higher nutritional value of the product.

Regarding the analytical method, preference mapping has been applied as the multivariate analysis method to inter-relate data on instrument analytical data and acceptability data. preference mapping has been categorized into types: internal preference mapping and external preference mapping. On one hand, internal preference mapping tends to be applied only for consumer preference data to assist analyzing consumer preference patterns. On the other hand, external preference mapping has been relating the acceptability data of consumers to instrument analysis (Lawlor *et al.*, 2000).

Preference Mapping has been used in market research to gain deep insight into product analysis including food products as found in the works of cheese (Lawlor *et al.*, 2000), coffee (Pinsuwan *et al.*, 2022), strawberry vinegar (Ubedaa *et al.*, 2017) and cassava-chia seeds composite porridges (Kilewela *et al.*, 2022). Preference Mapping, in addition, has also been applied to analyze product preferences on orange cakes with the addition of prebiotics inulin and oligofructose as found in the study of (Rapina *et al.*, 2012). In this research work, the partial least square regression approach (PLSR) is applied for the analysis of instant powdered beverage products containing Pathum Thani fragrance rice in order to establish its preference mapping. Moreover, key features of the product for the consumer choice will be also be analyzed through preference mapping analysis.

In order to achieve the added value to local Thai rice varieties, reduce the oversupply of rice, and help Thai farmers earn a higher and sustainable income, processing rice into a commercial product is necessary. Improvement of local rice varieties for high yield with good qualities and purchase of local rice would help decrease the chances of introducing exotic and unwanted weeds, pests and diseases into Thailand. Therefore, finding solutions to replace wheat flour with local Thai varieties to produce instant powdered beverage products came to light.

The objectives of this research were to study the

physical chemical and sensory characteristics of instant beverage powder containing Pathum Thani fragrance rice (IBPR) and to assess the correlation between instrument analytical data and consumer liking of these products using preference mapping.

2. Materials and methods

2.1 Materials

Pathum Thani fragrance rice was purchased from a local market in Pathum Thani Province, Thailand. Other ingredients such as soy protein, sugar, malt powder, cocoa powder, inulin powder and non-dairy cream powder used in the production of milk powder were purchased in Pathum Thani Province, Thailand.

2.2 Rice powder preparation

Pathum Thani fragrance rice was thoroughly washed with water. The rice was cooked in an electric cooker (the ratio of rice to water was 1:1.5 by weight) until cooked. The cooked rice had been dried in a hot air oven at 65°C for 10 hrs. The dried rice was ground using the grinder and sifted through a 100-mesh sieve. The rice powder was packed in polyethylene terephthalate (PET) bags, and stored at 25°C.

2.3 Experimental design and sample preparation

The simplex centroid mixture design was applied to investigate the effects of 3 ingredients (Pathum Thani fragrance rice powder, soy protein and milk powder) on the physicochemical and sensory characteristics of IBPR samples. The constraints used for each ingredient were 40-50% of Pathum Thani fragrance rice powder (X_1), 20-30% of soy protein (X_2) and 20-30% of milk powder (X_3). The IBPR samples as ten combinations were presented in Table 1. The other ingredients were weighed and mixed into a glass container based on the formulations which were presented in Table 2. The 20 g of IBPR samples were mixed with 150 mL of hot water (approximately 80-90°C).

Table 1. Experimental design of three ingredients in instant beverage powder containing Pathum Thani fragrance rice.

Mixture	X_1	X_2	X_3
1	50.00	25.00	25.00
2	50.00	30.00	20.00
3	48.34	28.33	23.33
4	45.00	30.00	25.00
5	45.00	25.00	30.00
6	40.00	30.00	30.00
7	43.34	28.33	28.33
8	48.34	23.33	28.33
9	40.00	30.00	30.00
10	46.66	26.67	26.67

Table 2. The formulations and ingredients of instant beverage powder containing Pathum Thani fragrance rice.

Ingredient	Amount (%)
Rice powder + soy protein powder + Milk powder	50
Sugar	20
Cocoa powder	10
Malt powder	10
Non-dairy cream powder	5
Inulin powder	5

2.4 Physicochemical analysis

2.4.1 Colour measurement

Colour measurement was carried out using a Spectrophotometer (HunterLab, ColorFlex EZ, USA) and results were reported as L^* (0 = darkness, 100 = lightness), a^* ($-a^*$ = greenness, $+a^*$ = redness) and b^* ($-b^*$ = blueness, $+b^*$ = yellowness). The measurement was conducted on both powder and dissolved samples while these samples were measured in five replications.

2.4.2 Solubility test

Solubility was measured using a modified method by Al-Kahtani and Bakri (1990). A total of 1 g of each sample was added into 50 mL of warm water (approximately 70°C) in a 250 mL beaker. The mixture was stirred continuously using a magnetic stirrer (IKA, C-MAG HS7, Germany) at speed level 2. To determine the solubility of the powder, real-time monitoring (seconds) was conducted on the complete dissolution of the powder. The samples were measured in five replications.

2.4.3 Water activity

Water activity was determined using a water activity meter (Aqualab, CX3 TE, USA). The samples were measured in five replications.

2.4.4 Chemical analysis

The proximate analysis tests consisting of moisture, ash, fat, crude fiber, crude protein content, and carbohydrate of the samples were determined according to AOAC (2012). All analyses were carried out in triplicates.

2.5 Sensory evaluation

Initially, fifty consumers between the ages of 18 and 60 years old are randomly selected to participate in this study. All consumers were asked to evaluate all 10 samples in two sessions (5 samples per session) with 10 mins break between each session. Samples were prepared in the ratio of 20 g IBPR samples to 150 mL of hot water (approximately 80-90°C). Samples were

served 25 mL at approximately 50-60°C on a clear plastic cup coded with three-digit random numbers. A Latin square design was used for the serving samples for each session. Each consumer was asked to rate their liking of appearance, colour, rice flavour, cocoa flavour, overall flavour, sweetness, viscosity, and overall liking using a 9-point hedonic scale (1 = dislike extremely, 5 = neither dislike nor like and 9 = like extremely). A bottle of water was provided to the consumers for cleansing their palates between the samples.

2.6 Statistical analysis

The results were expressed as mean \pm standard deviation (SD). The multivariate analysis of variance (MANOVA) and Duncan's multiple range test (DMRT) was performed to determine differences among IBPR samples at the 95% confidence level ($p \leq 0.05$) using IBM SPSS statistical software. The principal component analysis (PCA) with varimax rotation was performed to investigate relationships between physicochemical characteristics and IBPR samples. Partial least square regression (PLSR) analysis was performed to evaluate sensory drivers of liking using sensory physicochemical characteristics and liking scores among ten IBPR samples. The software used for PCA and PLSR was XLSTAT statistical software.

3. Results and discussion

3.1 Colour values

The colour values of IBPR samples (dry and dissolved) are shown in Table 3. The color of the IBPR samples was dark brown due to cocoa powder was mixed with all samples. IBPR powder and samples with complete dissolution were significantly different in colour values ($p \leq 0.05$). The L^* a^* b^* values of all IBPR samples were slightly different due to the influence of the three main ingredients consisting of rice powder, soy protein, and milk powder in different quantities. The powder mixtures (7) comprising 43.34% of Pathum Thani fragrance rice powder, 28.33% of soy protein and 28.33% of milk powder had the highest L^* value (55.13), while mixtures (2) containing 50% of Pathum Thani fragrance rice powder, 30% of soy protein and 20% milk powder had the highest a^* (9.12) and b^* value (14.09). The mixtures with complete dissolution (10) possessing 46.67% of Pathum Thani fragrance rice powder, 26.67% of soy protein and 26.67% of milk powder had highest L^* value (32.78), whereas mixtures (8) containing 48.33% of Pathum Thani fragrance rice powder, 23.33% of soy protein and 28.33% of milk powder had highest a^* (10.81) and b^* value (13.24). The L^* value of all IBPR samples was lower than the one reported by Thonabut *et al.* (2020) for an instant drink of germinated

Table 3. Color of instant beverage powder containing Pathum Thani fragrance rice.

Mixture	Powder sample			Dissolved Sample		
	L*	a*	b*	L*	a*	b*
1	52.68±0.02 ^h	8.61±0.05 ^d	13.15±0.01 ^h	26.94±0.06 ⁱ	9.48±0.05 ^g	10.73±0.03 ^g
2	51.93±0.01 ^j	9.12±0.02 ^a	14.09±0.03 ^a	29.79±0.06 ^f	10.12±0.05 ^{dc}	12.07±0.10 ^d
3	52.79±0.02 ^g	8.84±0.01 ^b	13.72±0.01 ^d	30.25±0.07 ^c	10.08±0.02 ^f	12.24±0.04 ^c
4	52.95±0.02 ^f	8.73±0.01 ^c	13.79±0.02 ^b	31.21±0.01 ^c	10.10±0.04 ^{ef}	12.21±0.02 ^c
5	53.75±0.02 ^c	8.13±0.01 ^f	13.36±0.02 ^c	27.65±0.03 ^g	10.57±0.03 ^b	12.01±0.07 ^d
6	54.54±0.01 ^b	7.88±0.00 ⁱ	13.03±0.01 ⁱ	27.45±0.08 ^h	10.34±0.04 ^c	11.26±0.10 ^f
7	55.13±0.01 ^a	7.63±0.01 ^j	12.61±0.01 ^j	31.17±0.06 ^c	10.14±0.06 ^d	11.59±0.10 ^c
8	52.52±0.02 ⁱ	8.45±0.02 ^e	13.76±0.01 ^c	32.06±0.08 ^b	10.81±0.02 ^a	13.24±0.04 ^a
9	53.64±0.01 ^c	8.06±0.01 ^g	13.33±0.01 ^f	30.86±0.07 ^d	10.35±0.01 ^c	12.19±0.05 ^c
10	53.93±0.02 ^c	7.89±0.00 ^h	13.22±0.02 ^g	32.78±0.09 ^a	10.37±0.05 ^c	12.36±0.07 ^b

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($P \leq 0.05$).

brown rice with beetroot and Bunrat (2015) for an instant drink of Sungyod broken rice, while a* and b* of all IBPR samples were higher than the reported by Thonabut *et al.* (2020) and Bunrat (2015).

3.2 Water activity and solubility

The water activity and solubility of IBPR samples (dry and dissolved) are shown in Table 4. Water activity of IBPR samples ranged between 0.27 and 0.36 and had significant differences among samples ($p \leq 0.05$). Microbiologically safe dried foods have water activity less than 0.60 (Prabhakar and Mallika, 2014). The powder mixtures (1) containing 50% of Pathum Thani fragrance rice powder, 25% of soy protein and 25% of milk powder had the highest aw value (0.36). The water activity of all IBPR samples was similar to that reported by Thonabut *et al.* (2020) for an instant drink of germinated brown rice with beetroot. The solubility of IBPR samples ranged between 27.00-29.67s. There was no significant difference among samples ($p > 0.05$). The results were relevant to the study of Birchal *et al.* (2005) who revealed that the soluble quality of food powder

Table 4. Water activity Viscosity and solubility of instant beverage powder containing Pathum Thani fragrance rice.

Mixture	aw	Solubility ^{ns} (s)
1	0.36±0.02 ^a	28.33±1.15
2	0.30±0.02 ^b	29.33±2.08
3	0.28±0.01 ^{cd}	27.67±1.53
4	0.27±0.05 ^d	28.00±1.00
5	0.27±0.01 ^d	29.67±1.53
6	0.28±0.01 ^{cd}	27.67±0.58
7	0.29±0.00 ^{bc}	27.00±1.00
8	0.28±0.01 ^{cd}	27.67±0.58
9	0.28±0.01 ^{cd}	28.33±1.53
10	0.28±0.00 ^{cd}	28.00±1.00

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($P \leq 0.05$). ^{ns} not significantly different.

would depend on moisture content, fat content, particle shape, particle size distribution, bulk density, and drying conditions. Food powder had low moisture content resulting in high solubility as mentioned by (Goula and Adamopoulos, 2005). Whilst, the optimum moisture content is approximately 11–12% for the dissolution powder as revealed by Neff and Morris (1968).

3.3 Chemical compositions

The chemical compositions of IBPR samples are shown in Table 5. Moisture content and ash content were not significantly different among the ten IBPR samples ($P > 0.05$). The moisture contents ranged from 2.18 to 3.33 and the ash content ranged from 2.00 to 3.50. In general, foods that are dried tended to contain less than 25% of moisture content (Jay *et al.*, 2005). Moisture content in food of less than 8% helps avoid the microorganism's growth (Akther *et al.*, 2020). The moisture content of all IBPR samples was lower than reported by Thonabut *et al.* (2020) for an instant drink of germinated brown rice with beetroot, Bunrat (2015) for an instant drink of Sungyod broken rice, and Singh *et al.* (2021) for Burma black rice instant beverage mixed. The energy of all IBPR samples ranged from 69.37 to 72.75 Kilocalories. All samples had slightly different energy content ($P \leq 0.05$). All IBPR samples had high carbohydrate contents (ranging from 69.37- to 72.75 g/100 g of sample), and low fat (ranging from 0.87 to 1.19 g/100 g of sample) due to the product containing rice as a main ingredient. Increasing rice flour content on IBPR samples resulted in increased carbohydrate content. The carbohydrate content of all IBPR samples was higher than reported by Singh *et al.* (2021) for Burma black rice instant beverage mixed, while fat content of all IBPR samples was lower than reported by Thonabut *et al.* (2020) for instant drink of germinated brown rice with beetroot, Bunrat (2015) for instant drink of Sungyod broken rice, and Singh *et al.* (2021) for

Table 5. Chemical compositions of instant beverage powder containing Pathum Thani fragrance rice.

Mixture	Energy (kcal)	Moisture ^{ns}	Ash ^{ns}	Fat	Crude Fiber	Protein	Carbohydrate
1	371.50±2.19 ^{bc}	2.86±0.26	3.37±0.28	1.11±0.08 ^{ab}	2.28±0.12 ^{cd}	17.67±0.50 ^g	73.44±0.84 ^a
2	369.50±3.02 ^c	3.33±0.61	3.27±0.05	1.20±0.13 ^a	2.52±0.35 ^c	17.60±0.53 ^g	73.10±0.21 ^a
3	375.62±2.59 ^{ab}	2.85±0.10	2.88±0.46	0.97±0.03 ^{ab}	1.57±0.05 ^c	17.94±0.18 ^{ef}	72.75±0.79 ^b
4	371.71±1.56 ^{bc}	3.10±0.21	3.29±0.05	0.96±0.13 ^{ab}	1.89±0.48 ^{de}	19.88±0.39 ^{bcd}	72.08±1.32 ^c
5	372.09±2.22 ^{bc}	2.47±0.17	3.50±0.26	1.00±0.18 ^{ab}	2.25±0.11 ^{cd}	19.65±1.09 ^{bcd}	72.12±1.38 ^c
6	378.43±5.36 ^a	2.48±0.12	2.00±1.25	1.19±0.10 ^a	2.40±0.20 ^c	20.81±0.24 ^a	70.89±0.62 ^d
7	370.48±4.05 ^{bc}	2.39±0.06	3.08±1.00	0.96±0.10 ^{ab}	3.11±0.09 ^b	19.96±0.46 ^{bc}	70.81±0.52 ^d
8	369.27±3.24 ^c	2.72±0.18	2.64±0.58	1.01±0.11 ^{ab}	3.59±0.15 ^a	18.59±1.20 ^{ef}	72.55±0.32 ^b
9	371.86±2.13 ^{bc}	2.26±0.11	2.53±0.75	1.03±0.08 ^{ab}	3.53±0.29 ^{ab}	20.32±0.24 ^a	70.28±0.15 ^c
10	370.50±0.90 ^{bc}	2.18±0.017	3.17±0.12	0.87±0.24 ^b	3.17±0.04 ^b	18.98±0.38 ^{cd}	72.37±0.38 ^b

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($P \leq 0.05$). ^{ns} not significantly different.

Burma black rice instant beverage mixed. For protein of IBPR samples, all samples had slightly different protein content ($P \leq 0.05$) (ranging from 17.60 to 20.81 g/100 g of sample). Increasing milk powder and soy protein powder content on the IBPR sample resulted in increased protein content. The protein content of all samples was higher than reported by Thonabut *et al.* (2020) for an instant drink of germinated brown rice with beetroot, Bunrat (2015) for an instant drink of Sungyod broken rice, and Singh *et al.* (2021) for Burma black rice instant beverage mixed. For dietary fiber of IBPR samples, they were ranged from 1.57 to 3.59. All samples had slightly different dietary fiber content ($P \leq 0.05$). The addition of inulin into samples resulted in samples containing dietary fiber due to the function of inulin as dietary fiber. Dietary fiber content of all IBPR samples was lower than reported by Singh *et al.* (2021), and higher than reported by Thonabut *et al.* (2020).

3.4 Sensory characteristics

According to the results in Table 6, color liking scores were not significantly different among ten IBPR samples ($P > 0.05$). The color liking scores ranged from 6.4-6.9 and were slightly preferred. The mean scores of appearance, rice flavour, cocoa flavour, overall flavour,

sweetness, viscosity, homogenous, overall liking among ten IBPR samples were significantly different ($P \leq 0.05$). The IBPR mixtures (10) containing 46.67% Pathum Thani fragrance rice powder, 26.67% soy protein and 26.67% milk powder were considered to have the highest liking score on all sensory characteristics ($P \leq 0.05$). The liking scores ranged from 6.8-7.6 and were slightly to moderately preferred.

3.5 Principal component analysis and partial least square regression analysis

Results from PCA indicated that these physicochemical characteristics formed into 3 dimensions that explained 76.51% of the total variability of all the IBPR samples. The details of each component are shown in Table 7. For principal component (PC) 1, loaded attributes in the positive dimension were L* (dissolve), a* (dissolve) and b* (dissolve) while attributes in the negative dimension were aw and fat. The IBPR mixtures F5, F8, F9 and F10 had higher L* (dissolve), a* (dissolve) and b* (dissolve) but had lower aw and fat, while F1 was the opposite (as shown in Tables 7, 8 and Figure 1A). For PC2, loaded attributes in the positive dimension were a* (powder) and b* (powder), while the attribute in the negative dimension

Table 6. Sensory characteristics of instant beverage powder containing Pathum Thani fragrance rice.

Mixture	Sensory Characteristics								
	Appearance	Color ^{ns}	Rice flavour	Cocoa flavour	Overall flavour	Sweetness	Viscosity	Homogenous	Overall liking
1	6.8±1.3 ^b	6.9±1.2	6.7±1.2 ^b	6.4±1.5 ^b	6.5±1.3 ^{bc}	6.3±1.6 ^{bc}	6.4±1.4 ^{bcd}	6.2±1.9 ^{bcd}	6.6±1.2 ^{bc}
2	6.6±1.0 ^b	6.4±1.0	6.6±0.8 ^b	6.4±0.9 ^b	6.5±0.9 ^{bc}	6.2±1.0 ^{bc}	6.8±1.0 ^{bc}	6.2±1.2 ^{ab}	6.6±1.0 ^{bc}
3	6.8±1.3 ^b	6.7±1.4	6.5±1.4 ^b	6.3±1.6 ^b	6.3±1.4 ^c	5.9±1.5 ^c	5.8±1.6 ^c	6.4±1.5 ^{bcd}	6.4±1.5 ^c
4	6.9±1.0 ^b	6.9±1.0	6.9±1.1 ^{ab}	6.8±1.1 ^{ab}	6.8±1.0 ^{ab}	6.5±1.3 ^{ab}	6.8±0.9 ^{bc}	6.8±1.1 ^{abc}	6.8±1.1 ^{bc}
5	6.6±1.5 ^b	6.6±1.4	6.9±0.9 ^{ab}	6.3±1.3 ^b	6.7±1.0 ^{bc}	6.3±1.4 ^{abc}	6.5±1.5 ^{bcd}	6.7±1.4 ^{abcd}	6.6±1.3 ^{bc}
6	6.9±0.8 ^b	6.8±1.0	6.8±1.0 ^{ab}	6.7±1.0 ^{ab}	6.8±0.9 ^{ab}	6.7±1.1 ^{ab}	6.7±1.0 ^{bc}	6.8±1.1 ^{abc}	6.7±1.2 ^{bc}
7	6.7±1.3 ^b	6.6±1.4	6.5±1.5 ^b	6.6±1.3 ^b	6.4±1.4 ^{bc}	5.9±1.6 ^c	6.0±1.4 ^e	6.2±1.8 ^{de}	6.3±1.5 ^c
8	6.7±1.0 ^b	6.7±1.0	6.7±1.0 ^b	6.6±1.2 ^{ab}	6.7±1.0 ^{bc}	6.6±1.1 ^{ab}	6.9±0.9 ^b	6.9±1.0 ^{ab}	7.0±1.0 ^b
9	6.5±1.3 ^b	6.6±1.3	6.5±1.2 ^b	6.3±1.3 ^b	6.4±1.1 ^{bc}	5.9±1.5 ^c	6.3±1.3 ^{de}	6.3±1.5 ^{cde}	6.5±1.3 ^c
10	7.6±1.3 ^a	6.9±1.0	7.3±1.7 ^a	7.1±1.7 ^a	7.2±1.4 ^a	6.8±1.5 ^a	7.4±1.3 ^a	7.2±1.1 ^a	7.5±1.1 ^a

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($P \leq 0.05$). ^{ns} not significantly different.

Table 7. PC explaining differences in physical chemical characteristics of instant beverage powder containing Pathum Thani fragrance rice.

PC	Physical properties	Chemical properties	Explained variability
1	L*(dissolved) (0.786)	Fat (-0.505)	28.55
	a* (dissolved) (0.819)		
	b* (dissolved) (0.883)		
	Water activity (a _w) (-0.885)		
2	L* (powder) (-0.972)	-	26.91
	a* (powder) (0.974)		
	b* (powder) (0.939)		
3		Energy (0.574)	21.05
		Fiber (-0.501)	
		Protein (0.956)	
		Carbohydrate (-0.746)	

Numbers in brackets are factor loadings (range from -1 to +1) which are similar to correlation coefficients.

Table 8. Principal component score of instant beverage powder containing Pathum Thani fragrance rice.

Sample	PC1	PC2	PC3
F1	-2.681	0.300	-1.099
F2	-0.068	1.808	1.091
F3	0.077	0.767	0.377
F4	0.585	0.802	0.873
F5	0.057	-0.357	-0.466
F6	-0.436	-1.154	1.773
F7	0.036	-1.682	0.166
F8	1.161	0.658	-1.656
F9	0.396	-0.443	-0.482
F10	0.873	-0.700	-0.576

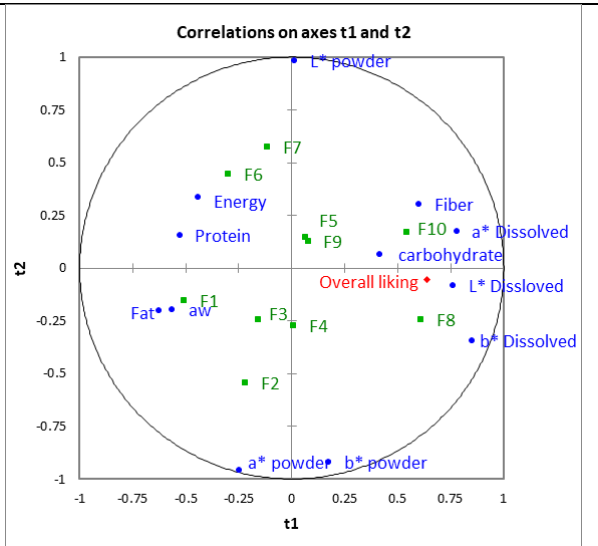


Figure 2. Preference mapping of instant beverage powder containing Pathum Thani fragrance rice. ● = Physicochemical attributes, ◆ = Overall liking, ■ = Ten IBPR Samples (F1-F10).

was L* (powder). The IBPR mixtures F2 and F3 had higher a* (powder) and b* (powder) but had lower L* (powder), while F6 and F7 were opposite (as shown in Table 7, 8 and Figure 1A). For PC3, loaded attributes in the positive dimension were energy and protein, while attributes in the negative dimension were fiber and carbohydrate. The IBPR mixtures F4 had higher energy

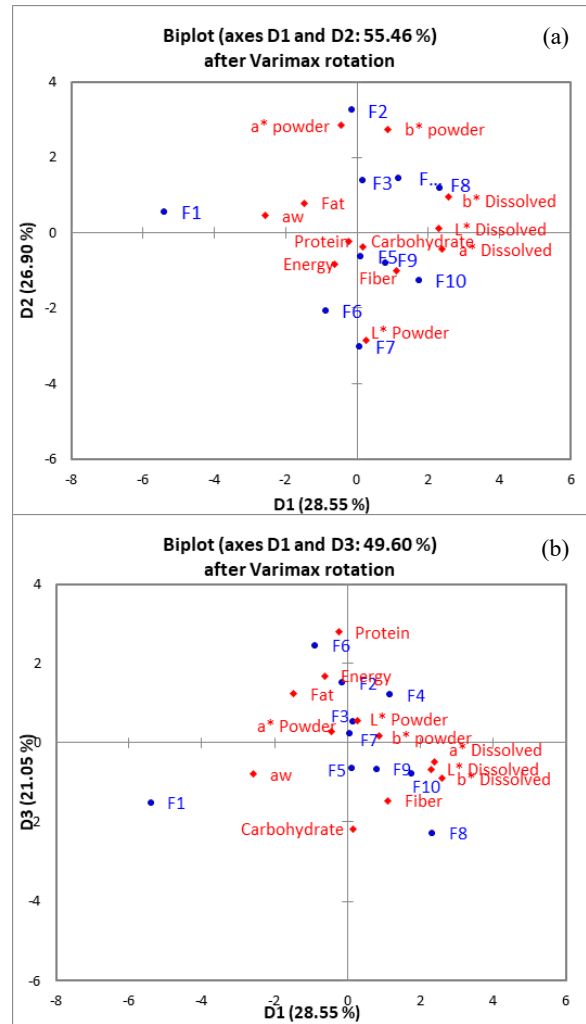


Figure 1. Principal component mapping of instant beverage powder containing Pathum Thani fragrance rice. ● = Ten IBPR Samples (F1-F10), ◆ = Physicochemical attributes.

and protein but had low fiber and carbohydrate (as shown in Tables 7, 8 and Figure 1B). Results from PLSR analysis (Figure 2) indicated that physical and chemical characteristics that affect high overall liking consist of carbohydrates, fiber, L* (dissolve), a* (dissolve) and b* (dissolve). On the other hand, energy, fat, a_w and protein resulted in low overall liking. The IBPR mixtures F8 and

F10 had the highest overall liking scores high those characteristics, while F1, F2, F3, F6 and F7 were opposite. Therefore, the product should have an L* value between 32.06-32.78, a* value between 10.81-13.24, b* value between 10.37-12.36, fiber content between 3.17-3.59, and carbohydrate content between 72.37-72.55 in order for the product to be accepted by consumers.

4. Conclusion

This research was conducted to develop a nutritious instant beverage powder product, promoting the utilization of Thai rice variety that can be grown domestically, reducing the cost of raw materials to import it from abroad and increasing income for farmers, therefore, was carried out to determine suitable formulation for instant beverage powder containing Pathum Thani fragrance rice using the data from physical, chemical, sensory qualities principal component analysis and partial least square regression analysis. As its most desired characteristics required to meet consumers' needs and the highest average liking score of all sensory characteristics, the test results indicated that the formula (10) is considered as most appropriate formulation for Instant beverage powder containing 23.34% Pathum Thani fragrance rice powder, 13.33% of soy protein and 13.33% of milk powder, 20% of sugar, 10% of cocoa powder, 10% of malt powder, 5% of non-dairy cream powder and 5% of inulin powder. Thus, the findings from this research may provide valuable data for use by both scholars and practitioners of the food and beverage (F and B) industry to help develop healthy instant beverage powder and somehow help increase consumer product acceptance.

Conflict of interest

The authors declare no conflict of interest.

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