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RESEARCH ARTICLE

Glutinous Rice's (*Oryza sativa* var. glutinosa) Sensory Identification Used Principal Component Analysis and Consumer's Group Identification via Hierarchical Cluster Analysis

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Abstract

The aims of this study were to identify glutinous rice (*Oryza sativa*var. glutinosa) and to identify consumer group base on their liking on glutinous rice. Five glutinous rice samples were harvested in difference district in Kalasin province, Thailand. All rice samples have been the code T1-T5.(T1 was rice from north districts group. T2 was rice from west districts group. T3 has been general identification guarantee from Department of Intellectual Property, Thailand (GI rice). T4 was rice from south districts group. T5 was rice from east districts group).Principal component analysis was used to investigate the sensory characteristics. Hierarchical cluster analysis was used to investigate consumer group base on their liking. Glutinous rice was soaked in water (water: rice ratio is 2:1) for 6 hours and then steam at 100ºC for 45 min and sensory attributes were identified follow repertory grids method by sensory panel. Whiteness, rice odor, sweetness, hardness, softness and stickiness were identified. Sensory mapping can be approaches to identify sensory characteristics of five glutinous rice samples such as T3 has more softness, whiteness, high rice odor and stickiness than the others. T1 has the highest hardness and T5 has highest sweetness. Cluster analysis can be identified into three group base on their liking. The first and the second consumers' group have more liking GI glutinous rice sample than the other. However, the third has more liking for T4 sample than the others. Both sensory mapping and Cluster analysis results also showed sensory characteristics that the large consumers group preference.

Keywords General Identification, glutinous rice, repertory grids, sensory mapping and cluster analysis

Introduction

Glutinous rice (*Oryza sativa* var. glutinosa) cultivar widely found is South East Asia. It is a stable food in the local cuisines of northern and northeastern Thailand. Kaowong Kalasin is a cultivar of glutinous rice in Thailand, and it name is a geographical indicator (GI) of Kalasin province in northeastern Thailand (Department of Intellectual Property, 2014).It originally derived from RD6, which is cultivated in many parts of the upper and middle provinces of northeastern Thailand (Department of Intellectual Property, 2014). It quality can be described as outstandingly soft and sticky.

Koawong Kalasin has very low amylose content resulting in a sticky and dense quality when cooked (Department of Intellectual Property, 2014). Kaowong farmers have found that after cooking their rice was softer and more fragrant than the original RD6 cultivar. Even stored in a sticky rice container made from bamboo woven for several hours until it cooed down, its texture remained stable. As a reason they sell glutinous rice at a price of up to 17,000 baht per ton.

Thailand has been rice production area of 61 million rai (Thai rice exporters association, 2021). So rice is the main Thailand's export product and in 2021, Thailand had exported glutinous rice equal to92,042 tons. However, Thailand's farmers have been lowest income in ASEAN (11,300 Bath/rai), the cost of rice production equal 9,700 Bath/rai (Thai rice exporters association, 2021). As recently several researches were studied physical property such as textural properties, chemical properties and applied rice on the other products, such as Gao et al., (2014) was studied effect of rice glutinous on physical property and sensory quality of ground pork patties that indicated rice glutinous has influence on moisture and fat retention of product. Huasan (2006) was found glutinous rice KD 6 from Khao Wong district was lowest hardness and chewiness value. Highest protein and ash content were found in the sample cultivated at Khao Wong district aria. Siriphollakul et al., (2017) was founded near infrared spectroscopy wavelengths of 940-2222 nm can used determine textural property of Khao Dawk Mali 105 rice before cooking. Hapsari, Kin and Eun, (2016) had modified parboiled Korean glutinous rice by used tumbling to replace soaking the rice grains. Then, tempering and heat in retort were applied to prepare the partially milled parboiled rice that indicated the new parboiled methods can produce high hardness rice by taking save energy for soaking and higher milled rice yield and heat rice yield. Some research had applied rice flour to make food product substitute wheat flour such as Jeong, Kim, and Lee (2017) was applied rice flour-zein to substitute wheat gluten in gluten free dough was found 5% zein produce thin and long noodle strands.

Principal component analysis is a method to study relationships between product and variables, the result display into mapping, X axis is the first Principal component (PC) and the Y axis is second is PC, PC is component of variables were studied, PC score is value of relationships between

each variable with PC. The first PC has most explained of data variance, so at recently have several researches were study preference mapping of food product such as Varela et al., (2014) were study preference mapping of consumers of coffee product as a result indicate most coffee preference that has high body, coffee aroma, coffee flavor intensity and low sweetness and milky intensity. Paulsen et al., (2013) used principal component analysis and for creating preference mapping of salmon sauce product that indicated less detailed information regarded drivers liking and disliking on salmon sauce product, however salmon sauce characteristics has comprised saltiness, umami, bitterness, sea flavor and sweetness attribute. Rapina et al., (2012) was studied consumer preference on the cake with prebiotic added (oligofructose and inulin) by creating preference mapping that was indicated cake has crust brownness and high stickiness when added prebiotics.

Cluster analysis is a method to grouped sample base on degree of sameness or difference of products. The distance between products has calculated and products group will consider by a researcher. The means distance of each product group is the main factor to the decision setting product group. As a reason, this research is using cluster analysis for identifying glutinous rice consumers. To increase Famers' income, Department of Intellectual Property, Thailand has generated geographical Indications or GI project. GI is type of intellectual property for some place to grow rice that product high sensory quality. In Kalasin province, Thailand have been one GI rice is glutinous rice KD 6 that produce from Khao Wong district (Department of Intellectual Property, 2014). Any research to finding difference sensory attribute of GI rice that obtained Khao Wong district, Kalasin province, Thailand. Then identify consumers into groups based on their preference was used hierarchical cluster analysis. The expected outcome of this research is generating the new high sensory rice for generating the new GI rice from Kalasin province, Thailand. Base on their sensory quality and consumers liking behavior.

Objective of this study were

1. Identify sensory properties of GI and commercial glutinous rice.
2. Identify consumers into groups based on their liking.

Materials and Methods

Samples and Prepared

Glutinous rice samples

Five glutinous rice grains samples (KD6 Variety) (*Oryza sativa* var. glutinosa) were chosen from the local market with known rice production area (in Kalasin province, Thailand), they have coded T1-T5 (Fig.1).

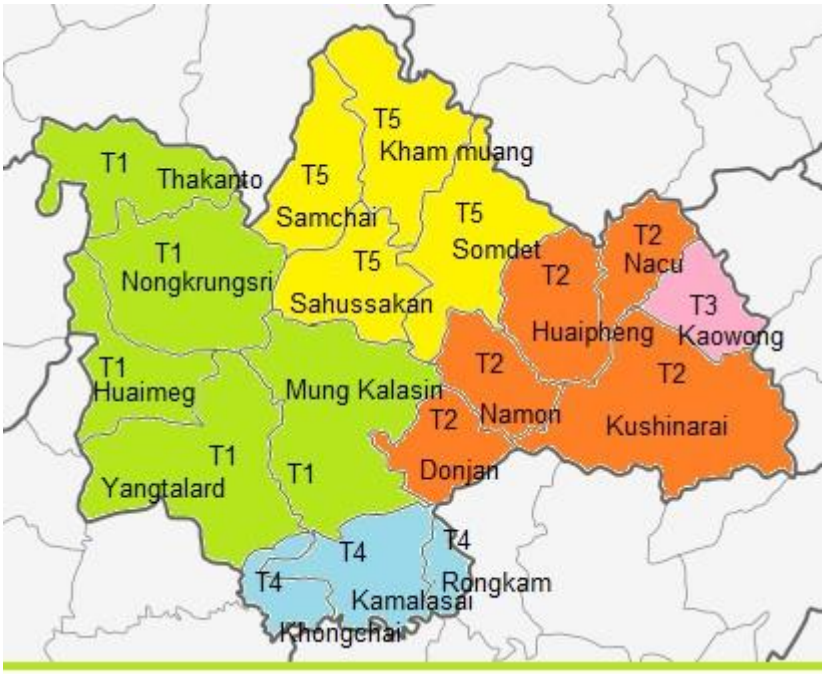


Figure 1 Districts map of Kalasin (Singpanite, 2008)

Glutinous rice, which was milled rice, were collected from the local market with rice production area.

Rice cooking methods

Glutinous rice 1000 g was soaked in water, then water was added to give rise: water ratio, 2:1 and holding in water for 6 hours. After that rice was steamed for 45 min. Then hold at room temperature for 10 min. 25 g rice was packed in PE plastic bag and conducted into the foam box to keep warm (50-60ºC) before serving.

Sensory Evaluation

Sensory panel screening

Sensory panels were recruited from students in Kalasin University, Thailand. Quantitative descriptive analysis was applied from Stone and Sidel, (1993). Sensory panels were recruited through a triangle test (minimum 13 of correct responses from a total of 24 times). Test samples were two differences grown area glutinous rice that cooking as same as rice cooking trophic (applied from Stone and Sidel, 1993). 12 Sensory panels were passed to train session.

Sensory attribute generation

Sensory attributes generation using the repertory grid method. Six glutinous rice (KD6 variety) samples (A-E) that purchase from 6 commercial rice brands in local market and then cook grouping into 4 sets as the first set was ABC, the second set was CDE, the third set was EFA and the fourth set was FBD (applied from Meigaard, Civille, & Carr, 1999). The sensory evaluation teat was performed

in individual boots. The rice samples were served under a plastics cup with three digit random codes. After that was the consensus discussion and sensory attribute description has generated by sensory panels. Then reference samples were selected by sensory panels as Table 1. After word generations was training state trained panels must be high performance of the repeat sensory test ($F_{samples} \leq 0.05$) and $F_{samples*block} > 0.05$).

Table 1 Definitions and references for sensory attribute of glutinous rice

Sensory attribute	Definitions	References
Whiteness	Degree of whiteness of steamed rice.	**Low:** Steamed rice KD 6 variety which Harvested over 1 year. **High:** Steamed rice KD 6 variety which harvested within 3 mounts.
Glutinous rice odors	Characteristics glutinous rice odor.	**Low:** Filtered water. **High:** Steamed rice KD 6 variety which harvested within 3 months and serving at temperature rank 50-60ºC.
Sweetness	Degree of sweetness when chews rice after 30 s.	**High:** Sweet glutinous rice (traditional Thai dessert compose of steam glutinous rice 5% of coconut milk and 5% of sugar).
Stickiness	Degree of adhesiveness of glutinous rice.	**Low:** Steamed Just mine rice, which harvested within 3 mounts. **High:** Glutinous rice steamed in banana leaf (traditional Thai dessert).
Softness	Degree of deformation when compress and degree of return original state of glutinous rice.	**Low:** Steamed rice KD 6 variety which Harvested over 1 year. **High:** Steam rice KD 6 variety which harvested within 3 mounts.
Hardness	Degree of force to compress rice between teeth.	**Low:** Steamed Just mine rice, which harvested within 3 mounts. **High:** Steamed rice KD 6 variety which Harvested over 1 year.

The sensory evaluation test was performed in individual booth. The rice samples were served under a plastics cup with three digit random codes. Twelve trained panels had scoring sensory attributes as showed in Table 1 by used unstructured 6 in line scale.

Consumers Liking Test by Central Location Tests

Thirty farmers were recruited Mung Kalasin district, Kalasin province, Thailand which consumed glutinous rice over 5 times a week were sensory panels. Thirty sensory panels are liking score by hedonic scale (1=dislike extremely; 5=neither liked nor disked; 9=like extremely)

Statistical Analysis

Principal component analysis was analyzed sensory characteristics of glutinous rice and hierarchical cluster analysis was used to identify consumer group.

Results and Discussions

Sensory Evaluation

Glutinous rice was described using one attribute for appearance, one for odor and four for texture (Table 1). Descriptive sensory evaluation by 10 trained panels was showed as table 2. Glutinous rice samples T2, T3, T4 and T5 presented highest in softness. Glutinous rice samples T2, T3, T4 and T5 presented highest glutinous rice odor ($P \leq 0.05$).T3 and T4 have greater in whiteness than the others ($P \leq 0.05$). Glutinous rice samples T1, T2, T3 and T4 presented highest in stickiness. T1 and T5 have highest hardness ($P<0.05$).

T3 is most consumers liking than the others sample, second is T4 and T5 and third is T1, T2 and T5 ($P \leq 0.05$) (Table 3).

As result Table 2 showing the most outstanding glutinous rice is T3 because it is the glutinous rice odor, whiteness, stickiness and softness the most. The second most interesting glutinous rice is T4 because it is highest glutinous rice odor, whiteness, and softness the most. Both T3 and T4 have first and second consumers liking respectively. The glutinous rice sample T3 was grown in Kaowong district. The glutinous rice sample T4 was grown in Rongkam, Kamalasai and Khongchai districts respectively. Glutinous rice odor, whiteness, stickiness, softness and sweetness are collectively reference to as the cooking quality, which consumers use as a factor in deciding to buy that kind of rice (Zheng et. al., 2021)

Chemical Composition

Glutinous rice samples T1 and T2 presented high in ash content than others samples ($P \leq 0.05$). Glutinous sample T3 and T4 has greater protein content in relation to T1, T2, T3 and T5 samples

(Table 4). Moisture content, fat content and carbohydrate content are non-significant different (P>0.05). From Table 4, it was found that carbohydrate content was the hishest in rice, which carbohydrate in rice consist of amylose and amylopectin. Amylose and amylopectin are important factors in cross-breeding considerations for genetic development (Zheng et. al., 2021). In addition, amylose and amylopectin content was found to be related to rice hardness as Hongyan et al., (2016) was indicated hardness of rice has effect by Long amylopectin chain and amylose chain (DP 10020,000), while amylose chain DP<70 has negative correlate with hardness

Table 2 Intensity sensory attribute for glutinous rice KD6 variety was grown in difference district in Kalasin province, Thailand (mean data ±SD)

Treatment	Glutinous rice odor	Whiteness	Stickiness	Softness	Hardness^{NS}	Sweetness^{NS}
T1	5.5^{c}±2.9	3.64^{c}±1.5	6.12^{c}±2.9	5.45^{d}±2.8	6.49±3.2	4.88±2.50
T2	5.43^{c}±2.8	5.95^{b}±2.5	6.15^{c}±3.0	5.92^{c}±2.6	4.75±3.1	5.16±2.4
T3	7.41^{a}±2.8	8.21^{a}±2.6	7.54^{a}±3.0	7.18^{a}±2.9	4.2±3.1	5.68±2.6
T4	7.24^{ab}±2.4	7.67^{ab}±2.2	6.72^{b}±2.6	6.99^{a}±2.7	4.5±3.0	5.27±2.0
T5	6.99^{b}±2.5	5.67^{b}±2.7	5.92^{c}±2.8	6.27^{b}±3.0	5.18±2.9	5.83±2.9

Different letters in the same line indicate different means (p _ 0.05)

NS; non significantly difference (P>0.05)

Table 3 Consumers liking for glutinous rice KD6 variety was grown in difference district in Kalasin province, Thailand (mean data ±SD)

Treatment	Consumer liking (points)
T1	6.26^{c}±1.44
T2	6.33^{c}±1.71
T3	8.134^{a}±1.17
T4	7.06^{b}±1.53
T5	6.86^{bc}±1.48

Different letters in the same line indicate different means (p _ 0.05)

Table 4 Chemical composition for glutinous rice KD6 variety was grown in difference district in Kalasin province, Thailand (mean data ±SD)

Treatment	Moisture content^{NS} (%)	Ash content(%)	Protein content (%)	Fat content^{NS} (%)	Carbohydrate content^{NS} (%)
T1	9.74±0.73	0.72^{a}±0.02	6.00^{b}±0.78	1.38±0.10	8.2.16±1.63
T2	8.93±1.75	0.59^{ab}±0.02	5.75^{b}±0.40	1.01±0.31	83.72±2.48
T3	8.94±0.9	0.28^{c}±0.05	7.31^{a}±0.27	0.59±0.22	82.88±1.44
T4	9.16±0.62	0.33^{c}+0.02	8.17^{a}±0.19	1.02±1.01	81.32±1.84
T5	9.16±0.34	0.49^{b}+0.16	5.55^{b}+0.56	1.09±0.09	81.32±0.83

Different letters in the same line indicate different means (p _ 0.05)

NS; non significantly difference (P>0.05)

Glutinous Rice Configuration

Principal component analysis showed first and second principal components explained, respectively 72.55% and 16.44% of observed variant 88.99%. As Fig.2a and Table 6 indicated that T1 has strong negative relationships with first factor, while T2 has less negative relationship with the first factor.T3 has strong positive relationships with first factor, while T4 has less positive relationships with first factor.T5 has strong positive correlated with second factors. Whiteness, rice odor and stickiness have positive correlations with the first factor, while hardness has negative correlations with the first factor. However, sweetness has negative correlation with second factor (Fig.2b and Table 5) indicate GI rice (T3) has higher on softness, whiteness stickiness and rice odor than the others. T1 and T2 have the highest hardness. T5 has the highest sweetness (Fig.2ab and Table 6). This research was found T5 sample is sweeter than the others. It's the best sensory characteristic of rice. The sweetness of rice is caused by digestion from starch into dextrin by the amylase enzyme in the mouth. Amylose content is the key determine eating and cooking quality (ECQ) (Monsur et. al., 2021), 20-25% of amylose content and 60-80 mm gel consistency make to soft texture is preferred by most consumers (Zeng et al., 2020). Matsue, Takasaki, and Abe, (2021) has report appearance quality and percent of perfect rice grain is higher for saturated irrigation than flooded irrigation and intermittent. Eating quality of cooked rice for saturated irrigation is great with a tendency for appearance, aroma and taste to be superior compared to those for flooded irrigations and intermittent. Rice with high sensory quality has low H/-H ratio and protein content. Rice grain thickness is closely related to sensory quality, protein content and H/-H ratio, thicker rice grain associate with highest sensory quality, lower protein content and lower H/-H ratio. In addition,

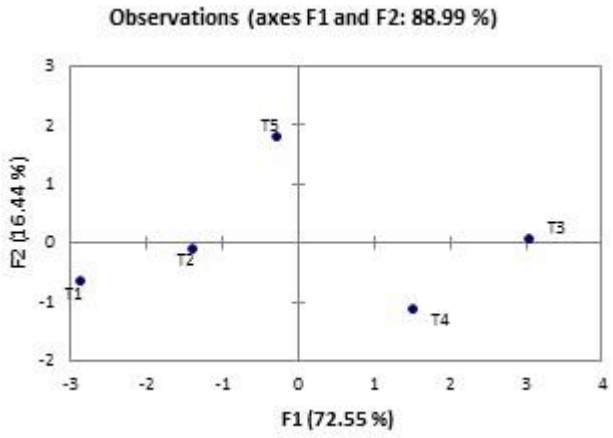
temperature at day/night time has effect on sensory quality of japonica rice., Rice that was grown at temperature above 28ºC at day and 28ºC at night time showed a deterioration sensory quality (Chun et. al., 2015).

Table 5 Factor loading of sensory attribute of glutinous rice and factors 1-4

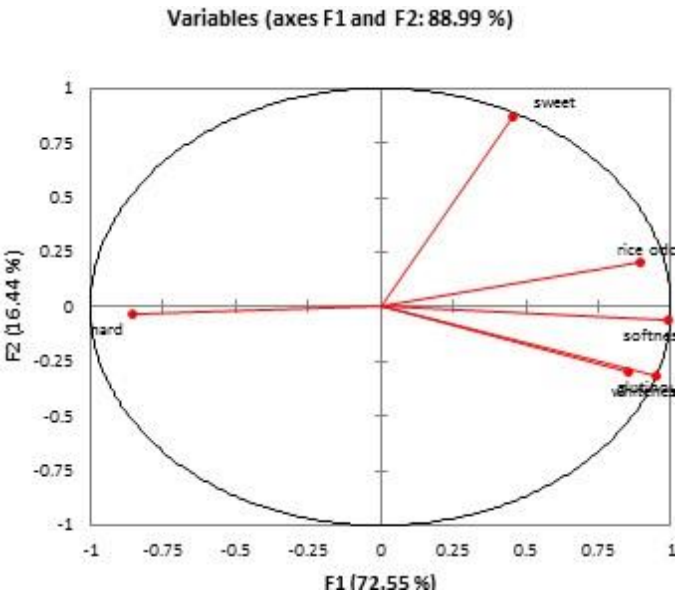
Attribute	F1	F2	F3	F4
whiteness	**0.899**	0.097	0.001	0.003
rice odor	**0.802**	0.040	0.046	0.112
glutinous	**0.732**	0.086	0.107	0.075
softness	**0.980**	0.003	0.002	0.015
hard	**-0.735**	0.001	0.259	0.004
sweet	0.205	**0.759**	0.005	0.032

Table 6 Relationships between glutinous rice samples and factors 1-4

Samples	F1	F2	F3	F4
T1	-2.866	-0.658	0.823	-0.117
T2	-1.392	-0.092	-1.104	-0.393
T3	3.040	0.065	0.383	-0.606
T4	1.511	-1.116	-0.205	0.714
T5	-0.293	1.800	0.103	0.402



a



b

Figure 2 Principal Component Analysis of all glutinous rice samples a; Loading scatter plot: Rice variety on the first two factors, b; Relationships between Sensory attribute on the first two factors

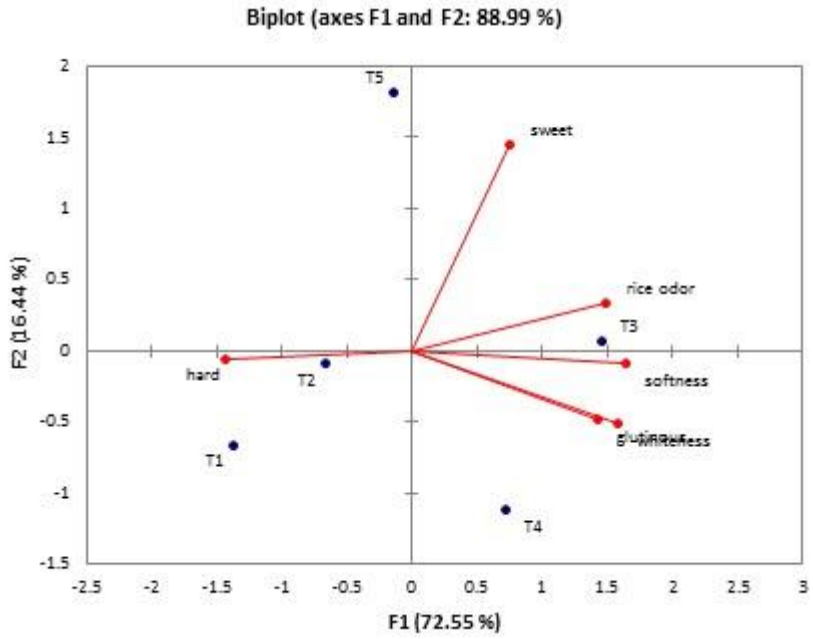


Figure 3 Principal component analysis of glutinous rice: Each vertex of vector was sensory attributes and relationships between rice varieties on the first two factors

Consumer's Groups Identification

Three consumer groups were identified by hierarchical cluster analysis (Fig.4), the first group represents greenling under cutting line (dashed line) that comprised 18 consumers (18 green line at bottom of dendogram was represented as 18 consumers into a group. The second group was comprised two consumers. And the third group was comprised 8 consumers. The first group was

highest liking on GI rice samples (T3), followed by T4, T2, T5 and T1 respectively. The second group was highest liking on GI rice (T3) samples. The samples from second to fifth of their liking are T4, T2, T5 and T1 respectively (Table 7). The third groups was highest liking on T4, and from second to fifth of their liking are on T5 as same as T2, T1 and GI sample (T3), respectively (Table7), that indicated cultivars had affected on sensory characteristics of glutinous rice KD 6 variety. Corresponding with Tsukagushi et al., (2016) was founded environment affected on rice grain protein content. The new knowledge in this research is the discovery the glutinous rice varieties RD6 from Kamalasai, Rongkam and Khongchai district (T4) was more prominent than those from other districts except the T3 rice sample from Khaowong district, which is the most famous glutinous rice in Kalasin province. It was the most accepted by the third group of consumers (as shown in Table 4) and the discovery that glutinous rice from Khammuang, Samchai district, somdet and Sahatsakhan district the most sweetest which is suitable to be process into traditional Thai snack and dessert products such as crispy rice and kho tom mud (glutinous rice steamed in banana leaf) etc.

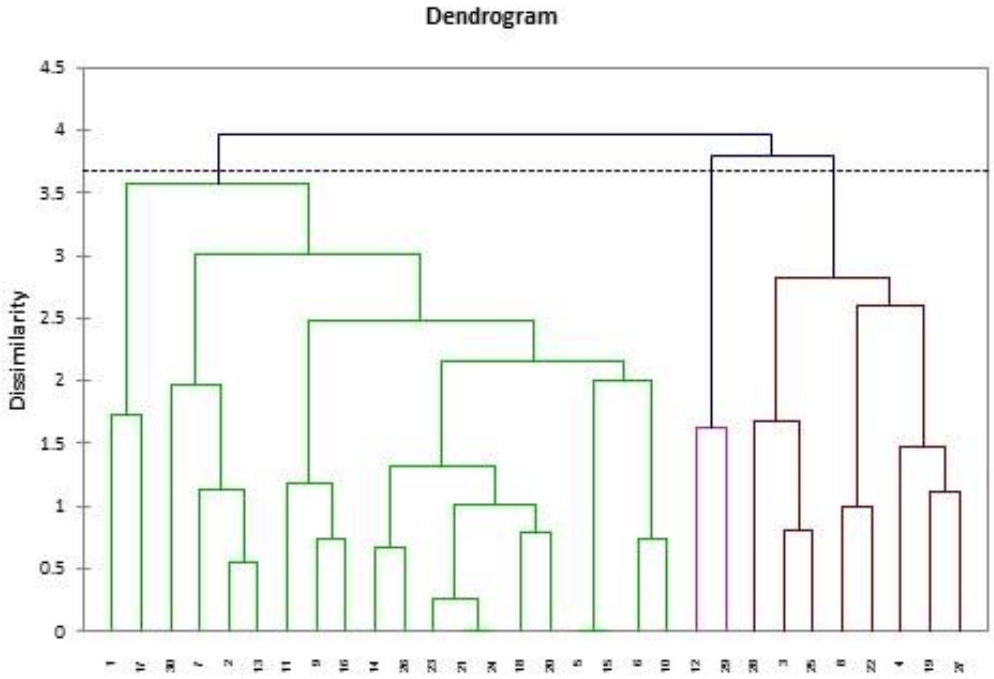


Figure 4 Euriden distances diagram

Table 7 Mean of liking of each consumer group

Class	T1	T2	T3	T4	T5
1	6.20	6.75	8.50	7.15	6.60
2	6.550	5.25	8.00	6.87	7.26
3	6.00	6.50	5.00	7.00	6.50

Conclusion

T3 (GI) rice has highest on whiteness, softness, stickiness and glutinous rice odor. The first and second consumers group has highest liking on T3 (GI) sample, however; eight consumers from the third group has liking on the T4 sample. T5 is highest sweetness.

T4 is characterized by soft texture, whiteness and glutinous rice odor. T5 is characterized by sweetness, suitable for processing into Thai desserts. Both T4 and T5 are suitable for certification as a Geographical Indication of Kalasin province, Thailand.

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