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Physical and Nutritional Properties of Local Hawm Gra Dang Ngah Rice Varieties

PORNPEN PANOMWAN[1]* and WATTANA TEMDEE[2]

[1]Faculty of Medicine, Princess of Naradhiwas University, Narathiwat, Thailand.
[2]Faculty of Agriculture, Princess of Naradhiwas University, Narathiwat, Thailand.

Abstract

Information on the local rice varieties grown in each Tambon (subdistrict), community or part of Thailand is still outdated. The present pilot work aimed to determine physical characteristics (grain dimensions, 1000-grain weight and color parameters) of paddy and dehusked rice in order to enhance the nutritional quality of these varieties. Moreover, it further supports cultivation of local Hawm Gra Dang Ngah (HGDN) rice in Narathiwat to ultimately develop to commercial premium quality.The nutritional values of dehusked rice were also compared among Tambons, as well as between the dehusked rice of local HGDN versus pure line selection HGDN PTNC09002-59. The study analysed rice samples grown locally in 4 Tambons: Bangkhunthong, Phron, Praiwan and Salamai in Takbai Amphoe (district), Narathiwat, Thailand. The main findings in this study revealed that medium and long types of both paddy and dehusked rice were all found in each Tambon. Moreover, local dehusked HGDN grain was darker red-brown color. All Tambons were found to contain comparable nutrient levels. High levels of dietary fiber were detected in all Tambons. Overall, the dehusked HGDN rice grown in Bangkhunthong showed the highest levels of vitamin B2 and calcium. The dehusked HGDN (100 g/ dry weight) in Bangkhunthong, Phron, Praiwan and Salamai contains protein; 8.73±0.01, 7.65±0.00, 8.22±0.03 and 6.83±0.03, iron; 8.73±0.01, 7.65±0.00, 8.22±0.03 and 6.83±0.03, ash; 1.19±0.00, 0.75±0.00, 1.10±0.00 and 1.34±0.00. These findings provide new information about local HGDN, and may be utilized to support the agricultural community in Takbai, enabling the selection of optimal HGDN varieties for local commercial use, as well as in breeding programs, to facilitate the promotion of local HGDN in the national Thai rice market.

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CONTACT Pornpen Panomwan pornpen.p@pnu.ac.th Faculty of Medicine, Princess of Naradhiwas University, Narathiwat, Thailand.

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Introduction

Rice (*Oryza sativa*) is one of the most important dietary staple foods worldwide, and especially so for Asian people. At present, there is significant interest in its nutritional balance, as exemplified by research into fortified rice and glycemic index. Previous studies revealed some health effects of rice and its products.[1] Studies of rice pigmentation have identified that grains with red-brown or dark purple coloration may have useful nutritional benefits, including anti-oxidative and anti-inflammatory properties.[2] Moreover, colored rice is rich in nutrients, including vitamins and minerals, which vary depending on coloration as well as environmental conditions.[1,3,4] In Thailand, there are many varieties of rice. Therefore, consumers have many choices. Local rice varieties are becoming more popular due to increased consumer demand for organically-grown and healthier products. However, information on the local rice varieties grown in each Tambon (subdistrict), community or part of Thailand is still outdated; primarily only commercial rice consumption and composition data has been investigated. Even though the rice-growing area of southern Thailand is not the biggest of Thailand's rice-growing areas, there are 82 local southern rice varieties;[5] some,such as Sang Yod Phattalung are popular and are finally developing to commercial premium quality in the national Thai rice market. Three southern border provinces of Thailand - Narathiwat, Yala and Pattani - located close to the marginal body of water in the western Pacific Ocean and Malaysia, experience environmental variation in growing conditions such as climate and soil properties when compared to rice production areas elsewhere in Thailand. These factors may influence the grain quality and nutrient content of local rice varieties. Narathiwat is home to one of the local rice-growing areas in the three southern border provinces of Thailand. The local variety, named HawmGra Dang Ngah (HGDN), originated in Narathiwat. HGDN's rice features a red pericarp, and sub-varieties, established hundreds of years ago continue to be grown in the region. More recently, a pure line designated HGDN PTNC09002-59 has been produced.[6] This study is the first pilot report to describe the physical and nutritional characteristics of local HGDN in 4 large rice-growing areas. This research is key to developing nutritional qualities, breeding and further supporting growing local HGDN rice in Narathiwat, and ultimately developing this variety to commercial premium quality.

Materials and Methods

Rice Samples and Chemicals

HGDN rice samples used in this study were locally grown in 4 Tambons: Phron, Bangkhunthong, Praiwan and Salamai, in Takbaiamphoe (district), Narathiwat, Thailand. The samples were collected from 4 households per Tambon during February-March 2019. The pre-harvest and post-harvest activities were carried out manually. Paddy were dried in the sun for 3 days before packing in sacks.

Physical characteristics of Paddy and Dehusked Rice

Grain Dimensions

In order to classify the types of paddy and dehusked rice,[7] the grain dimensions of paddy and dehusked rice were determined. The length and width were measured by digital Vernier caliper and the ratio of length and width was calculated. These figures are shown in Table 1.

Table 1: Classification of the types in paddy and dehusked rice[7]

Types of grain	Paddy (length: width ratio)	Dehusked Rice (length:width ratio)
Long	≥ 3.4	≥ 3.1
Medium	2.3-3.3	2.1-3.0
Short	≤ 2.2	≤ 2.0

1000-Grain Weight

1000-grains weight of both paddy and dehusked rice, selected at random, were weighed using a digital scientific scale.

Color of Paddy and Dehusked Rice

The color of both paddy and dehusked rice was determined using a Hunter-Lab colorimeter (Ultrascan Color Flex, USA). The colorimeter was

calibrated with white board. It was set with standard condition of illumination D_{65} and observation 10°. The color parameters (L*, a* and b*) according to The International Commission on Illumination (CIE) were then read. four biological replicates were performed for each sample.

Nutritional Values

The proximate analyses for full standard nutritional values of dehusked HGDN rice, according to Thailand nutrition labeling, were performed using standard procedures.[8]

Statistical Analysis

All the analyses were carried out with at least five replicates and expressed as a mean and standard deviation. Data were statistically analyzed by one-way analysis of variance (ANOVA) and significant differences between two means were identified by Duncan's multiple range test using SPSS statistics program version 26.0. The probability value of less than 0.05 was considered significant. A comparison of nutritional values (mean and standard deviation) between local HGDN and pure line selection HGDN PTNC09002-59 was performed.

Table 2: Physical characteristics of paddy

Tambons	Paddy			1000-grain weight (g)	Color parameters		
	Length (mm)	Width (mm)	Types of grain		L*	a*	b*
Bangkhunthong	8.83±0.47^{a}	2.57±0.23^{ab}	Long	24.55±8.51^{ab}	52.26±1.38^{ab}	6.09±0.58^{a}	17.10±1.23^{a}
Phron	8.67±0.51^{ab}	2.60±0.21^{a}	Medium	20.30±1.14^{b}	51.68±1.66^{b}	5.63±0.77^{a}	16.78±2.17^{a}
Praiwan	8.42±0.64^{ab}	2.41±0.20^{b}	Long	25.20±7.86^{ab}	53.35±1.86^{a}	5.99±0.58^{a}	17.33±1.36^{a}
Salamai	8.28±0.70^{b}	2.44±0.22^{ab}	Long	28.06±8.09^{a}	52.46±1.89^{ab}	6.01±0.65^{a}	16.60±1.10^{a}

Mean value ± standard deviation of five replicates.
Mean values with different letters (a-c) in the same column are significantly different (p<0.05).

Results

Physical characteristics of Paddy and Dehusked Rice

Table 2 shows the physical characteristics of paddy including grain dimensions, 1000-grain weight and color parameters. Significant differences (p<0.05) within each column are indicated with different superscript letters. The values of length and width of each Tambons' paddy were in the range 8.28-8.83 mm. and 2.41-2.60 mm, respectively. The paddy grain of Phron was medium whereas others were long. The values of 1000-grain weight were in the range of 20.30-28.06 g. The color parameters of L*, a* and b* express the lightness, redness/greenness and yellowness/blueness, respectively. The L*, a* and b* values were in the range 51.68-53.35, 5.63-6.09 and 16.78-17.10, respectively. The a* and b* values did not show significant differences (p<0.05) between any Tambons.

The physical characteristics of dehusked rice are shown in Table 3. The values of length and width of each Tambons' dehusked grain were in the range 6.17-6.69 mm. and 1.92-2.27 mm, respectively. The dehusked grain types of Bangkhunthong and Salamai were long, while Phron and Praiwan corresponded to the medium type of dehusked grain. The values of 1000-grain weight were in the range of 16.19-19.53 g. The values of L* were in the range 42.09-44.89 which shows no significant difference (p<0.05) between Bangkhunthong, Phron and Salamai. The value of a* was in the range 9.78-10.57 and all Tambons showed no significant differences (p<0.05). The value of b* was in the range 12.38-13.41 and showed the same values in Bangkhunthong and Salamai. The physical characteristics of paddy and dehusked rice are presented in Figure 1.

Nutritional Value

The nutritional values of dehusked HGDN rice in 4 Tambons are presented in Table 4. Significant differences (p<0.05) within each row are indicated with different superscript letters.

Table 3: Physical characteristics of dehusked Rice

Tambons	Dehuskedrice			1000-grain weight (g)	Color parameters		
	Length (mm)	Width (mm)	Types of grain		L*	a*	b*
Bangkhunthong	6.66±0.25^{a}	1.92±0.26^{c}	Long	18.50±1.35^{ab}	43.79±1.87^{a}	9.84±1.07^{a}	12.72±0.75^{ab}
Phron	6.29±0.43^{b}	2.10±0.20^{b}	Medium	16.19±0.92^{c}	44.26±1.58^{a}	9.78±1.22^{a}	12.38±1.22^{b}
Praiwan	6.69±0.28^{a}	2.27±0.15^{a}	Medium	17.23±0.99^{bc}	42.09±1.41^{b}	10.57±0.48^{a}	13.41±0.66^{a}
Salamai	6.17±0.52^{b}	1.97±0.24^{bc}	Long	19.53±4.49^{a}	44.89±2.43^{a}	10.50±0.67^{a}	12.72±1.08^{ab}

Mean value ± standard deviation of five replicates.
Mean values with different letters (a-c) in the same column are significantly different (p<0.05).

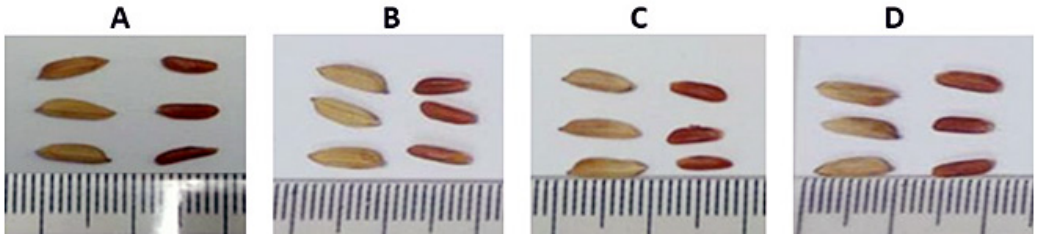

Fig.1: Physical characteristics of paddy (left) and dehusked (right) rice in (A) Bangkhunthong, (B) Phron (C) Praiwan and (D) Salamai

Table 4: Nutritional values of dehusked HGDN rice in each of 4 Tambons(units per 100 g/dry weight)

Compositions	Bangkhunthong	Phron	Praiwan	Salamai
Energy(kcal)	356.24±1.07^{c}	362.56±0.66^{a}	359.00±0.49^{b}	358.55±0.99^{bc}
Total fat(g)	2.73±0.12^{b}	2.44±0.08^{c}	2.95±0.07^{ab}	3.07±0.10^{a}
Protein(g)	8.73±0.01^{a}	7.65±0.00^{c}	8.22±0.03^{b}	6.83±0.03^{d}
Carbohydrate(g)	74.20±0.07^{d}	77.50±0.14^{a}	74.90±0.21^{c}	75.90±0.07^{b}
Dietary fiber(g)	4.99±0.14^{a}	4.10±0.07^{a}	5.00±0.04^{a}	4.70±0.11^{a}
Total sugar (g)	1.26±0.04^{b}	1.18±0.01^{c}	1.36±0.00^{a}	1.11±0.00^{d}
Vitamin B1 (mg)	0.501±0.00^{a}	0.490±0.06^{a}	0.430±0.03^{a}	0.410±0.00^{a}
Vitamin B2(mg)	0.077±0.00^{c}	0.086±0.00^{b}	0.093±0.00^{a}	0.080±0.00^{c}
Calcium(mg)	13.31±0.53^{a}	10.93±0.01^{b}	10.36±0.76^{b}	9.67±0.40^{b}
Iron(mg)	1.01±0.09^{ab}	0.87±0.04^{b}	0.93±0.01^{ab}	1.01±0.00^{a}
Ash(g)	1.19±0.00^{b}	0.75±0.01^{d}	1.10±0.00^{c}	1.34±0.00^{a}
Moisture(g)	13.22±0.03^{a}	11.68±0.02^{c}	12.89±0.07^{b}	12.88±0.01^{b}

Mean value ± standard deviation of five replicates.
Mean value with different letters (a-c) in the same row are significantly different (p<0.05).

The total energy determined per 100g sample in each of the 4 Tambons were in the range 356-362 kcal. The dehusked HGDN rice in Phron showed the highest total energy (362.56±0.66). The nutritional value of total fat was in the range 2.44-3.07 g. The dehusked HGDN rice grown in Phron showed higher energy, and that grown in Salamai showed higher total fat, than those grown in the remaining

areas. The amounts of protein, carbohydrate, dietary fiber and total sugar were in the ranges 6.83-8.73g, 74.2-77.5 g, 4.1-5.0 g and 1.11-1.36 g, respectively. There was no cholesterol found in any dehusked HGDN rice. Samples from each Tambon showed significant differences in the amount of protein, carbohydrate and total sugar; however, there were not significant differences in the amount of dietary fiber.

The amounts of vitamins found were: vitamin B1 (0.41-0.50 mg), and vitamin B2 (0.077-0.093 mg). The amount of minerals such as calcium and iron were 9.67-13.31 mg and 0.87-1.01 mg, respectively. Overall, the dehusked HGDN rice grown in Bangkhunthong showed the highest levels of vitamins and minerals. The moisture content was in the range 11.68-13.22 g.

Local HGDN was found to have higher total fat, carbohydrate, dietary fiber and ash than HGDN PTNC09002-59. Interestingly, calcium content detected in local HGDN was only a quarter that of HGDN PTNC09002-59, as shown in Table 5.

Table 5: Comparison of nutritional values between local HGDN and pure line selection HGDN PTNC09002-59

Compositions	Local HGDN (This study)	Pure line selection HGDN PTNC09002-59[6]
Total fat(g)	2.79±0.27	2.42
Protein(g)	7.85±0.81	8.96
Carbohydrate(g)	75.62±1.43	71.40
Dietary fiber(g)	4.69±0.42	1.52
Calcium(mg)	11.06±1.58	47.02
Iron(mg)	0.95±0.07	1.12
Ash(g)	1.09±0.25	0.87

Discussion

The grain type of paddy and dehusked rice was in the ranges of medium and high. In each Tambon, the most common type of paddy was long, except Tambon Phron. On the other hand, the most common type of dehusked rice was balanced between medium and long. The paddy and dehusked rice of pure line selection HGDN PTNC09002-59 were medium. The physical characteristics of local HGDN grown in Takbai differ from those of HGDN PTNC09002-59. However, the investigation of local rice varieties' physical characteristics by Phodjanawichaikul[9] showed similar ranges in the ratios of length and width to the values found for paddy and dehusked rice in this study. The color parameters of paddy and dehusked pigmented rice showed less difference within Tambons. The red-brown color of local dehusked HGDN had lower values of L* and higher values of a* compared to previous study of HGDN[10], which was provided by Pattani Rice Research Center, Thailand; therefore, local dehusked HGDN color was darker and redder in this study. Its pigment was in the color range of local rice SangYod Phattalung, a popular rice in Phatthalung, located to the north of Narathiwat.[10] Given the red-brown pericarp, the differences in grain color could depend on the quantities and proportions of polyphenols, which mainly consist of the anthocyanins cyanidin-3-O-β-D-glucoside and peonidin-3-O-β-D-glucoside in the grain.[2] These components of pigmented rice elevate the potent antioxidant activity, provide health benefits and have potential for nutraceutical development. However, further study should include consideration of environmental variations in growing conditions such as climate and soil properties. The Narathiwat Meteorological Department data reported the last 3-year rainfall in Amphoe Takbai during sowing in November and harvest in March was an optimal amount of water in the middle range of 10.1-35.0 mm.[11]

All Tambons were found to contain comparable nutrient levels. The comparison of nutritional content of local HGDN was within the range of protein, carbohydrate and ash observed by previous

studies[6,9,10,12] however, all of 4 Tambons showed higher amounts of dietary fiber and total fat.This data has shown local HGDN grown in Takbai still requires more research and breeding programs to develop nutrient content.

Rice is also a good source of vitamin B1 (thiamine) and vitamin B2 (riboflavin).[1] Local HGDN has high levels of thiamine compared to previous studies of thiamine content, which found ranges of 0.144-0.447 mg[13] and 0.16-0.32 mg.[14] Thiamine is useful in treating vitamin B1 deficiencies such as muscle weakness and neuritis.[1,15] Phosaeng and colleagues showed that the thiamine content in grains depended on the rate of biosynthesis and bioaccumulation during grain development.[13] Riboflavin content of local HGDN in each Tambon was in the range 0.08-0.09 mg/100g. However, the only previous report of vitamin B2 content was found in Pathum Thani 1 brown rice, which contained 0.12 mg/100g.[16] Other reports showed low levels of riboflavin in raw Brazilian long grain white rice (<0.02 mg/100g)[17,18] and Basmati Rice from India (0.033 mg/100g).[18,19] Riboflavin is a co-enzyme in many reactions, such as its role as electron carrier in cell respiration (related to releasing energy of carbohydrate, fat and protein in growth process), and the composition of flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) in metabolism of many nutrients.[20]

Conclusion

Local HGDN from 4 Tambons in the largest local HGDN rice-growing area of Takbai, Narathiwat, in this pilot study indicated that red-brown grain contains comparable nutrient levels among 4 Tambons. Moreover, the recorded values of carbohydrate, total fat, dietary fiber, thiamine and riboflavin are higher than previous reports. Local HGDN will be an excellent source of energy and vitamin B. The nutrient content data presented here will provide new information about local HGDN, thus supporting agricultural industry in Takbai to continue growing HGDN for commercial use, and providing further information to Takbai, Narathiwat Provincial Agricultural Extension Office in order to increase promotion of local HGDN for commercial sale in the Thai rice market. This study also contributes basic knowledge of the nutritional values of food products derived from HGDN, providing a basis for the development via breeding of new local HGDN to complement the pure line selection HGDN PTNC09002-59.

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Conflicts of interest

The authors declare no conflict of interest.

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