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Diversity and utilization of indigenous up land rice varieties in Nakhon Si Thammarat Province, Thailand

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Abstract Results revealed that the 17 farmers are still used 20 varieties of indigenous rice. Biodiversity was estimated by seed morphology and found four seed-nature-quality. Seven seed-nature-quantity factors were identified in rice using the diversity index (H'). Diversity indices (H') included the seed color of 2.90832, the length of brown rice of 2.8553, the color of brown rice of 2.79396, and the appearance of brown rice of 2.91743. The cluster analysis was significantly different ($P<0.05$), revealed that 25% dendrogram was classified as indigenous rice in two groups, including the first group of Niaw Dam Dard, Med Fai, Niaw Kluay, Niaw Dam, Chaw Mud, Dawk Pa-yawm, Nhiw Dam Ton keaw, Hawm Mali Rai, Sangyod Rai, Gai Reang, Ya Sai, Niaw Dam Puak Keaw, Niaw Dam Ka Ton Dam, Nang Khean, Leb Nok Rai, Pukaow Tong and Chaw Mai Pai and the second group of Dawk Kham, Niaw Dam Plee and Niaw Nam Pueng The results indicated that indigenous rice varieties in southern Thailand were highly diverse due to community enterprises producing rice for daily consumption, making desserts in festivals, feeding animals, and selling it as local products.

Keywords: Indigenous rice varieties, Biodiversity, Seed morphology

Introduction

Rice is a prime global food crop, with over three billion consumers, and 600 million of them, especially members of Asian households, consume rice as their main dish (Chantha, 2015). This notion also applies to Thailand, as most Thais have rice as their main dish. More than half of Thai citizens are farmers. Rice is a component of Thai social, traditional, and cultural constructs. It is a source of income in Thailand. Evidence shows that 5,000-year-old rice varieties were discovered in Non Nok Tha, Phu Viang District, Khon Kaen Province,

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suggesting that the rice culture is tied to Thailand and every Thai ethnic group (Thongdee, 1998). Diversity-wise, there are over 20,000 rice varieties in Thailand (Khaosa-ard *et al*., 1998) from 120,000 global rice varieties (Siamwala and Na Ranong, 1993). Of 23,903 rice samples collected by the National Rice Laboratory and Collective Center, 17,093 were classified as indigenous rice 17,093 and 5,928 had unique names (Chantha, 2015). There is reportedly over 11 million rai of rice farms in the country (Office of Agricultural Economics, 2007). Chuthammarach (1998) found that more than 50% of southern Thai farmers cultivated indigenous rice varieties. Nevertheless, many indigenous rice varieties have disappeared. As an ideal choice for sustainable development, indigenous rice varieties are conserved using good heredities from those rice directly and indirectly (Panomjan and Amornwiriyachai, 2011). In addition, indigenous rice varieties offer high nutritional values, such as phenolic acid, flavonoid, and anthocyanins antioxidants (Tian *et al*., 2004; Zhou *et al*., 2004). Indigenous rice could be conserved using morphological and physiological knowledge, which also can be easily transferred to farmers (Panomjan and Amornwiriyachai, 2011). The study was collected indigenous rice samples in Nakhon Si Thammarat and examined their local state of biodiversity using seed morphology.

Materials and methods

Sampling

Seeds of indigenous rice varieties were sampled through community collaborations within Nakhon Si Thammarat Province.

The study was analyzed 20 samples by morphology and estimate biodiversity at the Faculty of Science and Technology, Nakhon Si Thammarat Rajabhat University. The nature of Morphology was measured in four areas: seed size, seed shape, 100-seed weight, and husk and rice grain (brown rice). Biodiversity was estimated in two dimensions: qualitative and quantitative (IRRI, 1996).

The nature of morphology was done by measured seed sizes the digital vernier caliper using random seeds. Paddy and brown rice were measured four times repeatedly by randomizing of 10 from 20 rice varieties. The obtained data were calculated for the average width, length, and thickness (IRRI, 1996) to determine seed shapes. Furthermore, 100-seed weight was measured four times repeatedly using 100 randomized paddy seeds and baked to 110 ℃ for one hour and weighed, then calculated the weight per seed. Husk and rice grain (brown rice) were sorted by seed color and seed membrane color.

Biodiversity was qualitatively estimated seed biodiversity based on four physical appearances of the samples (i.e., seed membrane color, brown rice color, brown rice seed length, and brown rice shape). Biodiversity was estimated using the Shannon-Weaver Index(H) (Fowler *et al*., 1998), where H at zero refers to all the seeds being the same, and H exceeding zero refers to higher diversity.

$$H' = \sum_{i=0}^{s} pi \ln pi$$

where = number of diversity,
s = number of saved diversity,
pi = ni/N = founded proportion in that nature (ni) per all samples,
ln = natural log and
Σ = summary.

Statistical analysis

Quantitative seed biodiversity was measured using seven factors (i.e., 100-seed weight, paddy seed width, paddy seed length, paddy seed thickness, brown rice width, brown rice length, and brown rice thickness). Data were statistically analyzed using the Duncan multiple range test (DMRT).

Cluster analysis was utilized to process indigenous rice by morphology, determine its variants using similarity coefficients, and group them with the UPGMA formula. The morphology analysis was recorded from 100-seed weight, paddy seed width, paddy seed length, paddy seed thickness, brown rice width, brown rice length, and brown rice thickness of 20 indigenous-rice varieties . SPSS was employed via dendrograms to analyze the set of morphology standards. Simultaneously, UPGMA and the mantel formulawere applieexamine the cluster group, whereas COPH and MxComp were used for the averages between the group.

Data collection and utilization

Data were collected from observations, interviews, and group discussions and utilized to promote a better understanding of relevant socioeconomic factors and the conservation of indigenous rice amid changing global landscapes.

Results

The coordinates of 20 indigenous upland rice varieties in Nakhon Si Thammarat Province are shown in Table 1. This study collected samples from the 20 varieties in the area, including glutinous and non-glutinous. Specifically, their distinctive names included Dawk Kham, Hawm Mali Rai, Leb Nok Rai, Niaw Dam Dard, Dawk Pa-yawm, Sangyod Rai, Niaw Dam Ton Keaw, Med Fai, Niaw Dam Plee, Niaw Dam Ka Ton Dam, Niaw Kluay, Chaw Mud, Niaw Nam Pueng, Ya Sai, Nang Khean, Pukaow Tong, Niaw Dam, Niaw Dam Puak keaw, Chaw Mai Pai, and Gai Reang.

Table 1. The coordinates of 20 indigenous rice varieties in Nakhon Si Thammarat Province

Code Thai Name	Place	
	Province	Latitude/Longitude
Dawk Kham (R1) Hawm Mali Rai (R2) Leb Nok Rai (R3) Niaw Dam Dard (R4) Dawk Pa-yawm (R5) Sangyod Rai (R6) Niaw Dam Ton Keaw (R7) Med Fai (R8) Niaw Dam Plee (R9) Niaw Dam Ka Ton Dam (R10) Niaw Kluay (R11) Chaw Mud (R12) Niaw Nam Pueng (R13) Ya Sai (R14) Nang Khean (R15) Pukaow Tong (R16) Niaw Dam (R17) Niaw Dam Puak keaw (R18) Chaw Mai Pai (R19) and Gai Reang (R20)	Nakon Si Thammarat	8°13'29.2"N 99°38'28.1"E 8°11'46.6"N 99°41'44.7"E 8°10'59.3"N 99°43'15.2"E 8°03'33.1"N 99°35'19.8"E 8°03'29.4"N 99°35'24.2"E

Seed morphology results

NTSYS 2.1's UPGMA formula was analyzed the seed morphology and group Diversities of 25% were divided into two groups. The first group contained Niaw Dam Dard (R4), Med Fai (R8), Niaw Kluay (R11), Niaw Dam (R17), Chaw Mud (R12), Dawk Pa-yawm (R5), Niaw Dam Ton Keaw (R7), Hawm Mali Rai (R2), Sangyod Rai (R6), Gai Reang (R20), Ya Sai (R14), Niaw Dam Puak Keaw (R18), Niaw Dam Ka Ton Dam (R10), Nang Khean (R15), Leb Nok Rai (R3), Pukaow Tong (R16), and Chaw Mai Pai (R19). The second group contained Dawk Kham (R1), Niaw Dam Plee (R9), and Niaw Nam Pueng (R13) (Figure 1).

Seed physical appearances

Chaw Mai Pai Paddy had the widest seeds ($P<0.05$), followed by Niaw Kluay and Niaw Dam Dard. Contrarily, Nang Khean had the narrowest seed

(P<0.05). Furthermore, Ya Sai had the longest seeds, and Niaw Dam Plee had the shortest (P<0.05). Finally, Chaw Mai Pai had the thickest, and White Seed Niaw Dam had the thinnest (P<0.05).

Chaw Mai Pai had the widest seeds, whereas White Seed Niaw Dam, Niaw Kluay, Dawk Pa-yawm, Hawm Mali Rai, Niaw Dam Ton Keaw, Leb Nok Rai, Sangyod Rai, and Dawk Kham had the narrowest seeds (P<0.05). Nang Khean and Gai Reang had the longest seeds, and Med Fai had the shortest seeds (P<0.05). Chaw Mai Pai had the thickest seeds, and Leb Nok Rai, Chaw Mud, Hawm Mali Rai, and Niaw Nam Pueng had the thinnest seeds (P<0.05).

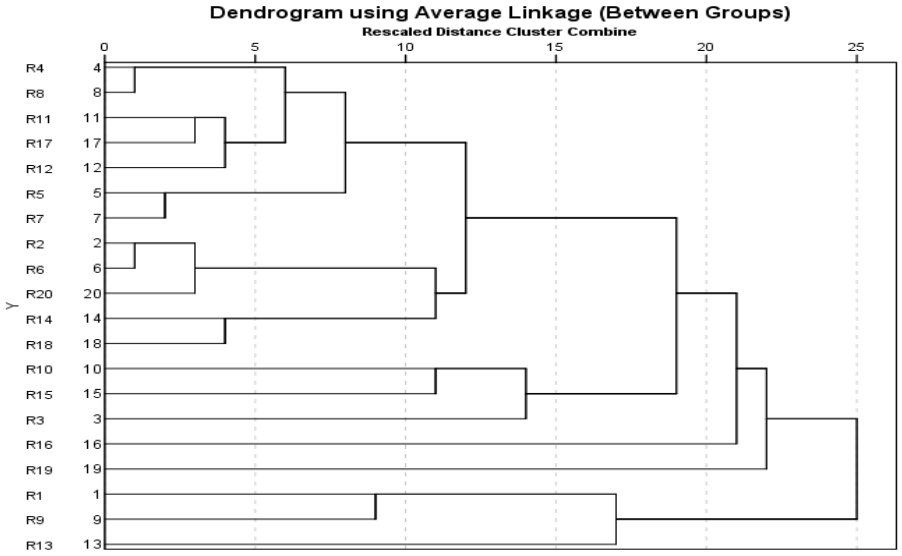

Figure 1. The dendrogram of 20 indigenous rice varieties obtained through UPGMA based on seven morphological characteristics

Seed sizes

Seed lengths were classified by IRRI (1996) into four types as follows: very long (over 7.5 mm) found in Hawm Mali Rai, Sangyod Rai, Nang Khean, and Gai Reang, long (6.6-7.5 mm) found in Dawk Pa-yawm, Med Fai, Niaw Dam Dard, Niaw Dam Ka Ton Dam, Niaw Kluay, Chaw Mud, Ya Sai, Nang Khean, and Chaw Mai Pai, medium (5.5-6.6 mm) found in Leb Nok Rai, Niaw Dam Plee, Niaw Dam Ton keaw, Niaw Kluay, Niaw Dam, and Chaw Mai Pai and short (less than 5.5 mm) was bot found.

100-paddy-seed weight (gram) was found in Chaw Mai Pai which showed the heaviest (P<0.05), followed by Sangyod Rai, Dawk Kham, Niaw Dam Dard, Hawm Mali Rai, Med Fai, Niaw Kluay, Niaw Dam Ka Ton Dam, Dawk

Pa-yawm, Niaw Dam Ton Keaw, Ya Sai, Niaw Nam Pueng, Chaw Mud, and Leb Nok Rai. Niaw Dam Plee was the lightest ($P<0.05$).

100-brown-rice-seed weight (gram) was found in Chaw Mai Pai with the heaviest ($P<0.05$), followed by Sangyod Rai, Leb Nok Rai, Med Fai, Hawm Mali Rai, Niaw Dam Dard, Niaw Kluay, Niaw Dam Ka Ton Dam, Dawk Pa-yawm, Niaw Dam Ton Keaw, Niaw Nam Pueng, Chaw Mud, Ya Sai, Dawk Kham, and Leb Nok Rai. Niaw Dam Plee had the lightest seeds ($P<0.05$).

Membrane colors were sorted into three groups as follows: straw found in Dawk Kham, Nang Khean, Dawk Pa-yawm, Leb Nok Rai, Chaw Mud, Niaw Dam, Niaw Dam Plee and Gai Reang.

Straw and red found in Niaw Dam Dard, Sangyod Rai, Hawm Mali Rai, Med Fai, Ya Sai and Chaw Mai Pai. Straw with Brown and Black found in Niaw Dam Ton Keaw. Straw and Brown found in Niaw Dam Ka Ton Dam. Brown and Red found in Niaw Kluay, Niaw Nam Pueng and Pukaow Tong. Brown rice had four colors categories: white found in Dawk Kham, Hawm Mali Rai, Leb Nok Rai, Dawk Pa-yawm, Ya Sai, Niaw Kluay, Chaw Mud, Nang Khean, Pukaow tong, and Gai Reang. Brown and red found in Niaw Dam Dard, Niaw Dam Ka Ton Dam, and Sangyod Rai. Purple and red found in Chaw Mai Pai and Niaw Nam Pueng. Purple and black found in Niaw Dam Ton keaw, Med Fai, Niaw Dam, and Niaw Dam Plee.

Biodiversity estimates from seed morphology

The qualitative seed biodiversity data were contributed by four factors: seed membrane colors, brown rice colors, brown rice seed lengths, and brown rice shapes. There were five seed membrane colors: straw, straw and red, straw with brown and black, straw and brown, and brown-red. Additionally, there were four brown rice colors: white, brown-red, purple-black, and purple-red. Most indigenous rice colors were white. The seed quality was determined by seed membrane color and length, as well as the diversity index (H) of rice varieties (Table 2).

The quantitative seed biodiversity data of the 20 indigenous rice varieties included the factors of 100-seed weight, paddy width, paddy length, paddy thickness, brown rice width, brown rice length, and brown rice thickness. Their values were significantly differed ($P<0.05$) (Table 3). Chaw Mai Pai had the largest seeds with 3.57±0.45 g in weight, 3.13±0.15 mm in width, 2.07±0.06 mm in paddy thickness, and 1.90±0.00 mm in brown rice thickness. However, all indigenous varieties had averaged of 100-seed weight of 2.23±0.10 g. The most paddy seeds in this study (12 varieties) had a long shape within the range

of 6.6-7.5 mm, followed by the moderately long (5 varieties) and the very long seeds exceeding 7.5 mm (3 varieties).

Table 2. Quality and diversity index (H') of rice Varieties (Paddy) in Nakhon Si Thammarat Province

	Seed Nature Quality			
Varieties	**Seed Membrane color**	**Brown Rice Color**	**(Length) mm.**	**Brown Rice Shape**
1. Dawk Kham	Straw	White	Medium (5.9)	Medium
2. Hawm Mali Rai	Straw and red	White	Very long (8.07)	Slender
3. Leb Nok Rai	Straw	White	Medium (5.97)	Medium
4. Niaw Dam Dard	Straw and red	Brown-red	Long (7.20)	Slender
5. Dawk Pa-yawm	Straw	White	Long (6.83)	Slender
6. Sangyod Rai	Straw and red	Brown-red	Very long (7.93)	Slender
7. Niaw Dam Ton Keaw	Straw and brown	Purple-black	Medium (6.53)	Medium
8. Med Fai	Straw and red	Purple-black	Long (7.37)	Slender
9. Niaw Dam Plee	Straw and red	Purple	Medium (5.73)	Medium
10. Niaw Dam Ka Ton Dam	Straw and brown	Brown-red	Long (6.80)	Slender
11.Niaw Kluay	Brown and red	White	Long (6.67)	slender
12. Chaw Mud	Straw	White	Long (7.47)	Slender
13. Niaw Nam Pueng	Brown and red	Purple-red	Very long (8.73)	Slender
14.Ya Sai	Straw	White	Long (7)	Slender
15. Nang Khean	Straw	White	Long (6.73)	Slender
16. Pukaow Tong	Brown and red	White	Vary long (7.74)	Slender
17. Niaw Dam	Straw	Purple-black	Vary long (7.96)	slender
18. Niaw Dam Puak Keaw	Straw and red	Brown-red	Vary long (7.74)	Slender
19. Chaw Mai Pai	Straw and red	Purple-red	Long (7.47)	Medium
20. Gai Reang	Straw	White	Very long (8.10)	Slender
Diversity index (H')	2.90832	2.79396	2.8553	2.91743

Table 3. Quantitative seed biodiversity of indigenous rice in Nakhon Si Thammarat Province

Varieties	100-seed weight (g)	Paddy Seed (mm)			Brown rice seed (mm)		
		Width	Length	Thickness	Width	Length	Thickness
1. Dawk Kham	2.53±0.03^{j}	2.10±0.01^{b}	8.17±0.01^{b}	1.97±0.01^{g}	1.93±0.01^{a}	5.93±0.01^{b}	1.57±0.01^{e}
2. Hawm Mali Rai	2.38±0.03^{i}	2.23±0.01^{c}	9.90±0.01^{g}	1.73±0.01^{cd}	1.80±0.01^{a}	8.07±0.01^{i}	1.13±0.01^{a}
3. Leb Nok Rai	2.37±0.03^{hi}	2.10±0.01^{b}	10.93±0.01^{h}	1.90±0.01^{fg}	1.90±0.00^{a}	5.97±0.01^{b}	1.10±0.01^{a}
4. Niaw Dam Dard	2.50±0.01^{j}	2.77±0.01^{e}	9.87±0.01^{fg}	1.87±0.01^{efg}	2.07±0.01^{ab}	7.20±0.01^{g}	1.57±0.01^{e}
5. Dawk Pa-yawm	2.15±0.06^{e}	1.97±0.01^{a}	9.03±0.01^{d}	1.50±0.00^{b}	1.77±0.01^{a}	6.83±0.01^{e}	1.30±0.01^{ab}
6. Sangyod Rai	2.54±0.04^{j}	2.37±0.01^{d}	9.63±0.01^{ef}	1.63±0.01^{c}	1.90±0.01^{a}	7.93±0.01^{i}	1.47±0.01^{de}
7.Niaw Dam Ton Keaw	2.01±0.03^{d}	2.07±0.01^{ab}	9.50±0.00^{e}	1.33±0.01^{a}	1.87±0.01^{a}	6.53±0.01^{c}	1.20±0.01^{ab}
8. Med Fai	2.32±0.02^{gh}	2.47±0.01^{d}	9.90±0.01^{g}	1.73±0.01^{cd}	2.17±0.01^{ab}	7.37±0.01^{h}	1.43±0.01^{cde}
9. Niaw Dam Plee	1.59±0.05^{a}	1.97±0.01^{a}	7.83±0.01^{a}	1.63±0.01^{c}	1.73±0.01^{a}	5.73±0.02^{a}	1.37±0.01^{cd}
10. Niaw Dam Ka Ton Dam	2.25±0.04^{f}	2.40±0.01^{d}	9.07±0.01^{d}	1.83±0.01^{def}	2.03±0.01^{ab}	6.80±0.01^{de}	1.53±0.01^{fg}
11.Niaw Kluay	2.29±0.02^{fg}	2.87±0.01^{e}	9.67±0.01^{efg}	1.90±0.00^{fg}	2.20±0.01^{ab}	6.67±0.01^{cd}	1.43±0.01^{cde}
12. Chaw Mud	1.80±0.02^{b}	2.07±0.01^{ab}	8.17±0.01^{b}	1.77±0.01^{de}	1.67±0.01^{a}	7.47±0.01^{h}	1.10±0.01^{a}
13. Niaw Nam Pueng	1.91±0.01^{c}	1.97±0.01^{a}	9.90±0.01^{g}	1.33±0.01^{a}	1.70±0.01^{a}	7.10±0.01^{fg}	1.13±0.01^{a}
14.Ya Sai	1.92±0.02^{c}	2.07±0.01^{ab}	11.80±0.04^{j}	1.83±0.01^{def}	1.77±0.01^{a}	7.00±0.01^{f}	1.33±0.01^{e}
15. Nang Khean	1.46±0.05^{a}	1.40± 0.03^{a}	9.87±0.01^{fg}	2.33±0.01^{bc}	1.83± 0.01^{a}	8.30±0.20^{bc}	2.10± 0.01^{c}
16. Pukaow Tong	2.72±0.03^{j}	2.30 ±0.00^{ab}	10.93±0.01^{h}	1.60 ±0.02^{a}	2.10 ±0.01^{ab}	7.40 ±0.03^{bc}	1.60 ±0.02^{ab}
17. Niaw Dam	2.07±0.26^{d}	2.30±0.00^{ab}	9.60±0.00^{ef}	1.70±0.00^{cd}	2.10±0.00^{ab}	6.60±0.00^{cd}	1.60±0.01^{a}
18.Niaw Dam Puak Keaw	2.01±0.26^{d}	1.96±0.57^{a}	10.00±0.00^{g}	1.00±0.00^{a}	1.10±0.00^{a}	7.40±0.04^{h}	1.20±0.01^{ab}
19. Chaw Mai Pai	3.57±0.45^{k}	3.13±0.15^{f}	10.30±0.52^{h}	2.07±0.06^{bc}	2.67±0.15^{d}	7.47±0.40^{h}	1.90±0.00^{i}
20. Gai Reang	2.25±0.50^{f}	2.00±0.00^{ab}	9.93±0.23^{g}	1.83±0.06^{ef}	1.93±0.06^{a}	8.10±0.10^{i}	1.70±0.10^{h}
Average	**2.23±0.10**	**2.60±0.04**	**9.70±0.02**	**1.72±0.03**	**1.91±0.01**	**7.09±0.01**	**1.44±0.01**

Note: Column average followed by alphabets at the 0.05 statistical difference using the DMRT formula

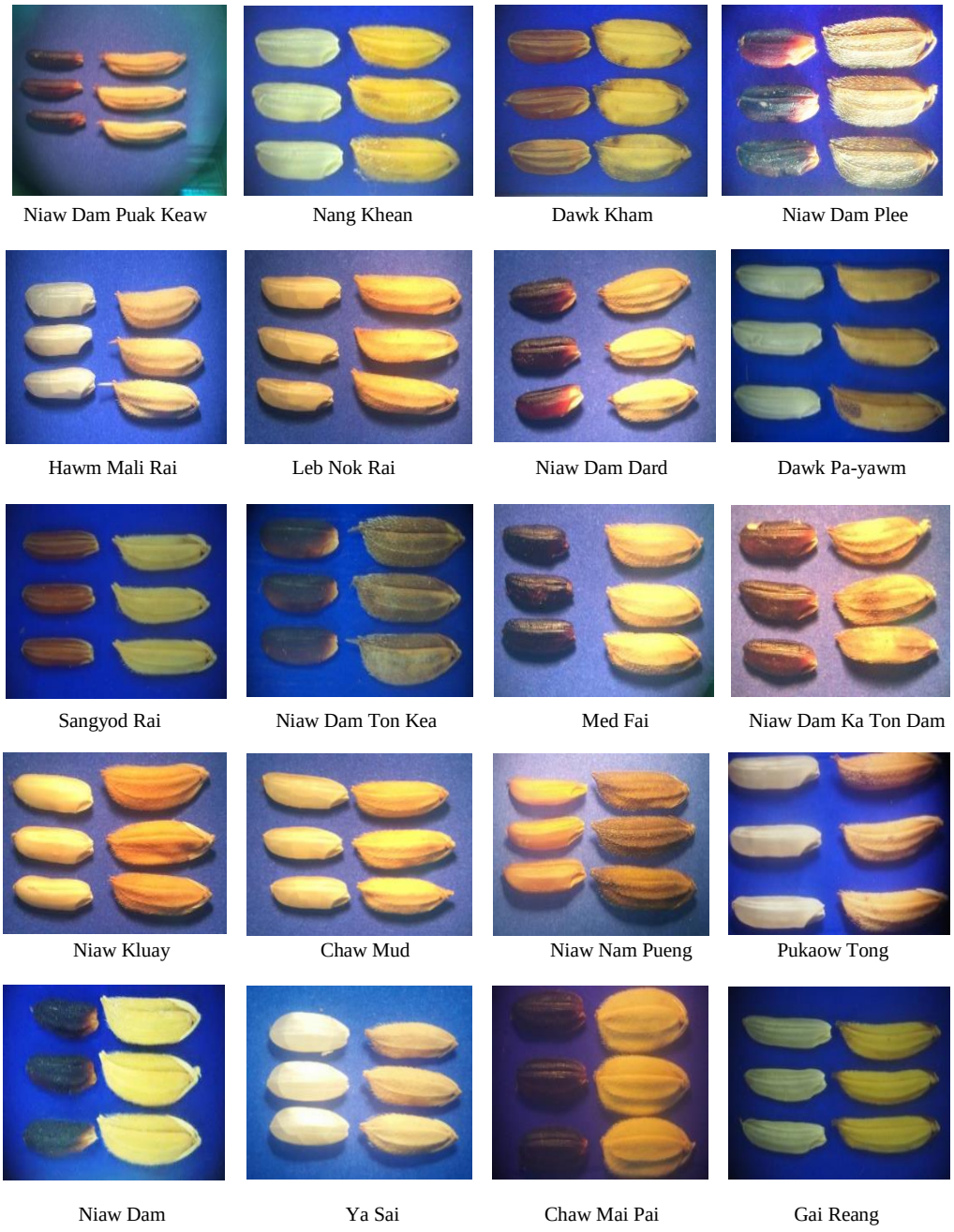

Figure 2. Samples of brown rice seeds (left) and paddy seeds (right) used for estimating seed morphology in Nakhon Si Thammarat Province

Cultural utilization

The utilization of indigenous upland rice in Nakhon Si Thammarat is based on features that can be divided into six areas: foods and drinks, medicine, tradition and culture, cosmetics, agriculture, and economy and networks. These are further illustrated in Table 4 and Figures 2-5.

Table 4. Indigenous rice utilizations in Nakhon Si Thammarat Province

Category	**Varieties**	**Local wisdom/Utilization**
Foods and drinks	Dawk Kham, Leb Nok Rai, Sangyod Rai, Hawm Mali Rai, Dawk Pa-yawm, Ya Sai, Gai Reang and Chaw Mud	Main dish /Consume in daily life
		Processed powder for making desserts
		Kanom Kee Mod (germinated rice used due to being small in size)
		Kanom Duen Sib, Kanom Krok (fine texture/medium)
	Med Fai	Madhupayas rice stir ceremony (Yacu Rice), Grain drink with millet, poppy, and beans
		Kanom Thong Muan (powder mixed with millet and beans)
	Med Fai, Dawk Pa-yawm, Sangyod Rai, Gai Reang and Chaw Mud	Healthy five-colored rice (Figure 3)
	Niaw Dam and Niaw Dam Plee	Khao Mak powder, Khao Mao, Kanom Tod, Kanom Kom
Medicine	Med Fai	Food for cancer patients in the alternative hospitals
	Niaw Dam Ka Ton Dam	1) Ya Lom for postprandial colic remedy 2) Cha Ngao sticky rice (sticky rice cooked with poppy and sugar) to be consumed with boiled Jik treetop to cure diseases, control blood pressure, and manage diabetes
Tradition and cultures	Niaw Kluay, Niaw Dam Dard and Nheaw Dam	An ingredient of the following desserts in Boon Duen Sib Festival held annually from September to October purposely to give alms to ancestors: 1. Kanom Pong (Figure 5. A) is produced at the Sart Duen Sib Festival. It has a flat appearance and is used to invite ancestors to the event. The dessert is made of Niaw Dam and Niaw Kluay .

Table 4. (conted.)

Category	Varieties	Local wisdom/Utilization
		2. Kanom La (Figure 5. B) is produced at the Sart Duen Sib Festival as a sign of clothes. It is made of rice, sugar, honey, coconut oil, and yolk. 3. Kanom Kong or Kanom Kai Pla (Figure 5. C) is produced at the Sart Duen Sib Festival as a sign of ornaments for ancestors. 4. Kanom Bar (Figure 5. D) is produced at the Sart Duen Sib Festival as a sign of Saba to play on Songkran days for fun. 5. Kanom Jor Roo, Kanom Jor Hoo, or Kanom Dee Sum (Figure 5. E) is produced as a sign of money used in daily payments.
Cosmetics	Dawk Pa-yawm	Month-five honey soap (Dawk Pa-yawm is pleasantly aromatic and can melt fat)
	Leb Nok Rai	1. As a bar of soap, it can be used to clean the body and face. It also has anti-rash and anti-aging properties. 2. As a shampoo, it strengthens hair and has an anti-hair-fall property.
Agriculture	Leb Nok Rai, Sangyod Rai, Hawm Mali Rai, Dawk Pa-yawm, Gai Reang, Chaw Mud and Ya Sai	Rice bran is used as animal feed. Rice straw is used as fuel and animal feed for cows and buffalos and compressed into bars for mushroom cultivation. Rice husk is used as fuel, ice block covers to maintain temperature, and fertilizer by mixing husk with molasses.
Economy and networks		Rice is sold by community enterprises. Rice varieties are exchanged for agricultural development.

Figure 3. A. Five-colored rice, B. Khao Niaw Kaew Guan, C. Brown rice soap, and D. Shampoo

Figure 4. Decks in the Sart Duen Sib Festival annually held in Nakhon Si Thammarat Province

Figure 5. Sart Duen Sib's desserts A. Kanom Pong, B. Kanom La C. Kanom Kong, D. Kanom Bar, E. Kanom Jor Roo or Kanpm Dee Sum

Discussion

The biodiversity of indigenous rice in Nakhon Si Thammarat Province was high based on 20 collected varieties, including Dawk Kham, Hawm Mali Rai, Leb Nok Rai, Niaw Dam Dard, Dawk Pa-yawm, Sangyod Rai, Niaw Dam Ton Keaw, Med Fai, Niaw Dam Plee, Niaw Dam Ka Ton Dam, Niaw Kluay, Chaw Mud, Niaw Nam Pueng, Ya Sai, Nang Khean, Pukaow Tong, Niaw Dam Puak Keaw, Chaw Mai Phai, and Gai Reang. In line with Chuthammarach (1998), over 50% of southern Thai farmers grow indigenous rice. Furthermore, Thongtawai and Kongkuea (2010) reported that from 114 rice varieties, 40 were cultivated in high country land, 35 in low country land, 6 in high and low country land, 18 in low country clay, 12 in farms, 1 in muddy water clay, and 1 in high country clay. Currently, only 18 varieties remain. However, this study discovered 20 varieties remained planted and conserved in Nakhon Si Thammarat, the South of Thailand. Many varieties of indigenous rice were no longer present (Bunsuaykwan, 2006) due to their textures being deemed unsuitable for consumption. Therefore, public support is recommended to encourage the conservation efforts of these original varieties of indigenous rice and formulate plans to regrow them further.

The morphological study revealed that the most significant factor suggesting the diversity of indigenous rice in Nakhon Si Thammarat was brown rice shape (H'=2.91743), followed by seed membrane color (H'=2.90832),

brown rice length (H'=28553). The least valid factor was brown rice color (H'=2.79396). Consistently, Somjai *et al*. (2011) studied rice in Na Tawee River Basin, Songkhla, and revealed that seed membrane color (H'=0.8418) was the most significant factor. Similarly, studies investigated rice varieties in Talay Noi Basin, Phatthalung, and indigenous rice varieties in Mae Fah Luang District, Chiang Rai, and suggested that seed membrane color was the most prominent indicator of diversity, whereas seed shape was the least crucial one (Tajai and Kaladee., 2007).

The heredity diversity of seed membranes was influenced by crossbreeding during the flower-blooming season (Deb, 2006). The quantitative seed biodiversity of the 20 indigenous rice varieties was estimated by 100-seed weight, paddy width, paddy length, paddy thickness, brown rice width, brown rice length, and brown rice thickness at a level of statistical significance ($P<0.05$). On this note, Somjai *et al*. (2011) published a similar high-diversity result indicating that the width and the length of 100 paddy seeds were statistically different and varied based on changes in the environment and required adaptation. Frankel *et al.* (1995) suggested that farmers can use the knowledge of these features to improve rice varieties and control the quality of rice (including seed contamination) in future cultivation.

In terms of utilization, all the 20 indigenous rice varieties had different use cases, such as being consumed as a daily main dish (i.e., Leb Nok Rai, Sangyod Rai, Hawm Mali Rai, Dawk Pa-yawm, Gai Reang, and Chaw Mud), a medicinal ingredient (i.e., Niaw Dam Ka Ton Dam), and desserts in festivals where participants give alms to their ancestors (i.e., Niaw Dam, Niaw Dam Dard, Niaw Dam Ton Keaw, Med Fai, Niaw Dam Ka Ton Dam, Niaw Kluay, and Niaw Nam Pueng). Besides, rice can use for agricultural purposes. For instance, rice bran and treetops are used as animal feed (i.e., Leb Nok Rai and Sangyod Rai). Furthermore, community enterprises can also turn rice products, such as five -colored rice, to be positioned and sold as healthy food. These activities can also change the choices of rice species in their network.

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