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Survey of Recent Innovations in Aromatic Rice

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Orachos Napsintuwong

Annotation: This paper provides situations of aromatic rice demand, and international standards. The history and recent developments of traditional and evolved aromatic rice varieties, namely Basmati rice and Jasmine rice, are reviewed. The emerging aromatic rice innovations from developed countries such as the U.S. and other Asian countries generate a threat to these traditional aromatic rice producers such as India, Pakistan, and Thailand. Under WTO Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, Geographical Indication (GI) provides a means to protect traditional knowledge and products that are recognized as quality or reputation attributable in the geographical areas, but only if the GI is also protected in the country of origin. India and Pakistan governments still have not registered Basmati rice as GI product though the attempt has been made by NGO, and is still pending. Thailand, on the other hand, already registered GI Thung Kula Ronghai Jasmine rice to specific areas in Northeast Thailand where the best quality jasmine rice is attributable to the location. Yet, Thung Kula Ronghai Jasmine rice is not protected under GI in other countries. Economic issues related to GI rice are reviewed and discussed.

Key words: Aromatic Rice, Innovation, Research and Development, Breeding, Geographical Indication, Trade Related Aspects of Intellectual Property Rights

1 Introduction

Rice is a staple food in Asia. Its production is also concentrated in Asia. The ten largest rice producers, namely China, India, Indonesia, Bangladesh, Viet Nam, Myanmar and Thailand are located in Asia. While China and India alone supply nearly half total world rice production, Thailand and Vietnam are the two largest rice exporters (FAOSTAT 2012). In 2009, Thailand and Vietnam exports accounted for 48% of total world milled rice exports (FAOSTAT 2012). Philippines, Saudi Arabia, Malaysia, Cote d'Ivoire, Iran, Iraq, Cameroon, Brazil, Yemen and China are the ten largest importers of milled rice. Although most of largest importers of milled rice in terms of quantity are located in Asia and South Africa, the import values of milled rice in France and United Kingdom are among the largest (the 7th and 10th) in the world (FAOSTAT 2012).

The productions and exports of rice from major countries are increasing over time, and more prominently in Vietnam. This is due to the success of rice breeding to improve productivity. The developments in rice varieties have been focusing on yield improvement to meet with the demand of the poor, particularly in developing countries. The most prominent technology breakthrough is the green revolution of high yielding semi-dwarf rice varieties developed by International Rice Research Institute (IRRI) that has been rapidly adopted in several Asian countries during the 1960s.

However, recent rice breeding programs also aim at improving traits to cope with both biotic stresses such as pest resistant and abiotic stresses such as drought and heat tolerant that become increasingly prominent due to the global warming problems. Nevertheless, because rice producing and exporting countries continue to face more competition from stringent trade regulations and changes in consumers' preferences towards higher quality rice, new developments in rice breeding increasingly emphasize on improving quality. Grain quality is one of the major objectives of national rice breeding programs in countries that are self-sufficient in rice production (Juliano and Duff, 1990). Quality rice varieties are notable by high market price. These varieties receive more attentions in the niche markets such as aromatic rice, low amylose rice (for diabetes), and nutrient enriched rice (i.e. golden rice for

vitamin A deficiency). Though market for quality rice might be smaller than regular rice, it could generate high value thus more income for farmers.

Among quality attributes of milled rice such as amylose content (AC), gelatinization temperature, gelatinize consistency, kernel length and breadth, shape, size, endosperm, kernel color and kernel elongation, protein content, vitamins and minerals, aromatic attribute receives much attention in the breeding programs recently. This is due to an increasing demand of importing countries towards aromatic rice. Currently, there is still a lack of information on available innovations, for adopters and imitators, and there is insufficient economic analysis to provide policy recommendations for countries interested in promoting aromatic rice research. The objective of this paper is to review recent innovations in aromatic rice varieties. The surveys economic impact studies of recent aromatic rice innovations are discussed. Special attention is on the protection of aromatic rice varieties in the context of geographical indication under Trade Related Intellectual Property Rights (TRIPS).

2 Aromatic rice demand and markets

Aromatic rice contains several biochemicals, but the most significant one is identified as 2-acetyl-1-pyrroline (2AP). It gives a popcorn-like or pandan (*Pandanus amaryllifolius*)-like odor. In Asia, particularly in Thailand, pandan extract is used in several Thai sweets to add flavor. This pandan-like odor makes aromatic rice highly desirable in particular countries. Aromatic rice is perceived as premium quality in several rice-consuming countries though consumer preferences towards aromatic rice are different in among countries. Aromatic rice fetches high prices in some international markets including South Asia, the Middle East, and particularly India, Pakistan, and Thailand (Kaosa-ard and Juliano, 1992). The Middle Eastern consumers highly prefer long grain, well-milled rice with strong aroma while European consumers prefer long grain rice with no scent. To them, scent indicates spoilage and contamination (Efferson, 1985). However, recent studies show that European consumers demand for aromatic rice varieties, particularly Basmati, significantly increases since the early 1990s, primarily in the U.K., and expect a further increase in aromatic rice consumption throughout Europe due to increasing number of immigrants from far-east countries and the growing interest in ethnic cuisine (Ferrero and Nguyen, 2004).

In Asia, Chinese consumers prefer semi-aromatic rice to pure aromatic rice (Singh *et al.*, 2000); however, Chinese Hong Kong consumers prefer Thai rice for its fragrance with intermediate AC. Thai rice supplied to Hong Kong also is superior (i.e. more carefully selected and milled) than what supplied elsewhere (Kaosa-ard and Juliano, 1992). Damardjati and Oka (1992) found that large proportion of urban Indonesian consumers, particularly in Medan and Ujung Pandang, preferred aromatic local variety but not necessarily purchased as they had to trade off between quality and price. On the contrary, Philippines consumers do not give preferences to aroma, particularly among medium income group, and only less than one third in the low and high income groups give preferences towards aromatic characteristics (Abansi *et al.* 1992). For Indians, aroma is rated the highest desired trait followed by taste and elongation after cooking.

The study by Suwannaporn and Linnemann (2008) found that consumers from rice-eating countries have higher preferences for Jasmine rice than non-rice-eating countries, and it is most preferred by Thais. The unique texture and aroma gives Jasmine rice from Thailand a perception of expensive quality rice among most Chinese and Taiwanese. Furthermore, the U.S. and Canadian consumers have high preferences for long grain rice, and Jasmine rice is well preferred. Suwansri *et al.* (2002) also found that Asian American consumers prefer imported Jasmine rice to American grown aromatic rice.

Two prominent aromatic rices in the world market include Basmati grown in India and Pakistan, and Khao Dawk Mali or Jasmine rice grown in Thailand. Among rice traded in the world market, aromatic rice (Pakistan Basmati and Jasmine rice--Thai fragrant) has been given the highest value. Table 1 shows that the price of Thai Jasmine rice is nearly double the price of regular Thai white rice while the price of Basmati rice is almost the same and frequently valued higher than Jasmine rice. Jasmine rice is continuously being an important export commodity of Thailand; it generates highest value of exports among all rice export commodities from Thailand. Since 2002 Jasmine rice has accounted for more than 20% in quantity and more than 30% in value of total rice exports from Thailand (Table 2).

The U.S., Hong Kong, China, Singapore and Côte d'Ivoire are major export markets of Thai Jasmine rice during the past five years. These five export destinations alone hold more than 50% of total Jasmine rice exports from Thailand (Table 3).

Table 1. Export price of rice. USD/□one, F.O.B.

Year	Thai White		U.S. Long		Pak Basmati		Thai
	100% Second Grade	U.S. Long Grain 2.4%	Viet 5%	Thai 5%*	Ordinary	Fragrant 100%	
2011	565	577	505	549	1008	1054	
2010	518	510	416	492	881	1045	
2009	587	545	432	555	937	954	
2008	695	782	614	682	1077	914	
2007	335	436	313	325	677	550	
2006	311	394	266	307	516	470	
2005	291	319	255	289	473	404	
2004	244	372	224	238	468	443	
2003	201	284	183	198	357	449	
2002	197	207	187	193	366	306	

Source: FAO Rice Market Monitor, June 2007 & Jan 2012

*Data from 2002-2006 are collected from Thai Rice Exporters Association (USD/MT, F.O.B.)

Table2. Export quantity and value of Thai rice

Year	Quantity ('000 tons)		% of Jasmine	Value (million Bahts)		% of Jasmine
	Jasmine	Total		Jasmine	Total	
2011	2,358.96	10,706.23	22.03	63,584.10	196,117.05	32.42
2010	2,358.23	8,939.63	26.38	63,520.76	168,193.06	37.77
2009	2,631.13	8,619.87	30.52	68,577.67	172,207.65	39.82
2008	2,515.93	10,216.13	24.63	60,281.85	203,219.08	29.66
2007	3,067.57	9,192.52	33.37	47,921.45	119,215.43	40.20
2006	2,599.29	7,494.14	34.68	40,341.86	98,179.00	41.09
2005	2,311.07	7,495.90	30.83	34,904.35	92,993.72	37.53
2004	2,259.83	9,976.59	22.65	35,555.04	108,328.33	32.82
2003	2,202.80	7,346.27	29.99	31,304.75	76,700.72	40.81
2002	1,493.00	7,334.45	20.36	19,038.62	70,064.61	27.17

Source: Office of Agricultural Economics of Thailand, 2012.

Basmati rice is the major rice exports of India. The export values and quantities of Basmati rice are accounted for almost all rice exports from India (Table 4). The major export markets of Indian Basmati rice are Saudi Arabia, United Arab Emirates (UAE) and Iran. The exports of Basmati rice to these three countries accounted for more than 70% of total Basmati exports from India (Table 5). Though exports of Basmati rice from India to Saudi Arabia, UAE, the U.K. and the U.S. have decreased during the past few years, exports to Iran, Kuwait, Yemen Republic, Iraq, Jordan, and Netherland increased dramatically. This implies that not only the Middle Eastern countries have preferences towards Basmati rice, but the preferences seem to increase in the recent years.

Table 3. Value and growth rate of Jasmine rice exports from Thailand by destination, 2007-2011

Country	Value (million USD)					Average	Export Share (%)	Growth Rate 07-11 (%)
	2007	2008	2009	2010	2011			
The U.S.	200.27	301.38	340.77	406.48	451.73	340.12	22.70	125.56
Hong Kong	125.31	149.31	166.32	166.02	165.01	154.39	10.30	31.68
China	132.80	119.50	108.58	126.47	110.13	119.50	7.98	-17.07
Singapore	70.97	91.95	100.86	103.41	106.87	94.81	6.33	50.58
Côte d'Ivoire	64.54	57.61	141.70	116.25	84.83	92.99	6.21	31.43
Gana	46.43	79.63	67.42	83.01	124.52	80.20	5.35	168.19
Canada	40.11	66.21	70.46	83.59	82.36	68.55	4.58	105.34
Malaysia	58.13	80.12	88.86	53.99	36.34	63.49	4.24	-37.48
Australia	31.29	58.23	65.33	69.72	66.92	58.30	3.89	113.87
France	24.53	37.65	42.17	43.43	41.11	37.78	2.52	67.59
Others	290.93	375.94	418.44	434.20	421.15	388.13	25.91	44.76
Total	1,085	1,417	1,610	1,686	1,690	1,498	100	55.80

Source: ESAAN Center for Business and Economics Research, 2012

Table 4. Quantity and value of rice exports from India, 2008/09-2010/11

Year	Quantity ('000 tons)		% Basmati	Value (million USD)		% Basmati
	Basmati	Total		Basmati	Total	
2008/09	1,556.41	2,488.29	62.55	2,060.68	2,427.57	84.89
2009/10	2,016.77	2,156.32	93.53	2,297.30	2,374.38	96.75
2010/11	2,183.50	2,282.79	95.65	2,320.86	2,369.60	97.94

Source: APEDA, 2012

Table 5. Value of Basmati rice exports from India by destination, 2008/09-2010/11

Country	Value (million USD)				Share of Exports (%)	Growth Rate 08-11 (%)
	2008/09	2009/10	2010/11	Average		
Saudi Arabia	674.67	695.25	636.50	668.81	30.04	-5.66
United Arab Emirates	605.83	652.88	597.99	618.90	27.80	-1.29
Iran	213.26	433.14	416.63	354.34	15.92	95.36
Kuwait	159.59	217.33	223.18	200.03	8.99	39.85
The U.K.	93.72	41.33	70.95	68.67	3.08	-24.30
Yemen Republic	38.09	62.34	57.77	52.73	2.37	51.67
The U.S.	59.27	32.38	48.74	46.80	2.10	-17.77
Iraq	7.50	7.57	30.73	15.27	0.69	309.73
Jordan	5.32	10.53	22.50	12.78	0.57	322.93
Netherland	14.20	4.99	21.92	13.70	0.62	54.37
Others	189.23	139.56	193.95	174.25	7.83	2.49
Total	2060.68	2297.30	2320.86	2226.28	100.00	12.63

Source: APEDA, 2012

Table 6. Quantity and value of Basmati rice exports from Pakistan by country, 2009/10-2011/12

Country	July 2009/June 2010		July 2011/May 2012	
	Quantity ('000 MT)	Value (million USD)	Quantity ('000 MT)	Value (million USD)
United Arab Emirates	233.45	206.83	209.99	194.07
Iran	171.38	105.34	127.21	73.56
Oman	58.51	56.68	73.81	77.63
Yemen	70.42	58.41	57.40	53.31
Saudi Arabia	91.78	77.06	56.59	49.37
Qatar	52.97	45.32	48.45	47.51
United Kingdom	59.00	48.44	39.55	34.66
Turkey	4.62	4.08	31.19	15.97
Bahrain	31.19	30.01	17.90	18.02
Australia	20.84	18.94	17.10	17.27
Others	255.88	215.56	199.75	199.75
Total Basmati	1,050.05	866.66	878.94	761.64
Total Non-Basmati	3,557.50	1,399.15	2,608.31	1,169.89
% Basmati	22.79	38.25	25.20	39.43

Source: prepared from REAP, 2012

In 2009/10 crop year, Basmati rice represents about 1,050 thousand tons (22.8%) in quantity and about 867 million USD (38.2%) in value of all rice export from Pakistan. The main markets of Basmati rice from Pakistan are United Arab Emirates, Iran, Oman, Yemen, Saudi Arabia, Qatar and the United Kingdom in recent years (Table 6). Overall, aromatic rice is traded at about 10% in the world market.

3 Distribution of aromatic rice

Rice maybe classified into six groups based on allelic combinations at 14 isozyme loci (Glaszmann, 1987). A few cultivars belonging to group I (indica) and group VI (japonica) are aromatic while most of cultivars in group V are aromatic. Table 7 summarizes the distribution of aromatic cultivars of different taxonomy by country of origin. Most of aromatic rice cultivars are in group I, V, and VI. Jasmine rice belongs to group I whereas Basmati rice belongs to group V. Most of landraces aromatic rice is native to Asia. Only a few of them are found in the Middle Eastern countries, and the U.S.

Though there are several aromatic cultivars, only a few of them have made it to the world market. One of the reasons is because traditional aromatic rice has low yield and susceptible to diseases and insects. Basmati rice, for example, is susceptible to blast, bacterial leaf blight, stem borer and white backed plant hopper. Jasmine rice is also susceptible to brown plant hopper, blast, and bacterial leaf blight. Both traditional Basmati rice and Jasmine rice are photosensitive. They require short day length during flowering; thus, the harvest season is limited to only one crop per annum. Another important reason is because the market of aromatic rice is highly competitive; import regulations and technical trade barriers have made it difficult for newly developed aromatic rice.

4 Aromatic rice standards

Since Jasmine rice and Basmati rice are two most important aromatic rice cultivars in the world. This section will emphasize their standards and regulations in international market.

Table 7. Distribution of aromatic rice belonging to different taxonomy groups, by country

Country	I	II	V	VI	*	Total
India	11	7	62	21	32	133
Pakistan	-	1	60	-	4	65
Indonesia	19	-	1	24	4	48
Thailand	29	-	-	4	1	34
Bangladesh	3	3	17	7	3	33
Malaysia	9	-	1	9	2	21
Iran	-	-	17	-	1	18
Nepal	1	2	6	1	6	16
Vietnam	6	-	-	2	7	15
Philippines	1	-	-	11	-	12
China	3	-	-	8	-	11
Myanmar	4	-	4	-	-	8
Laos	-	-	1	2	-	3
Sri Lanka	-	2	1	-	-	3
Korea	-	-	-	2	-	2
The U.S.	-	-	-	1	-	1
Japan	-	-	-	1	-	1
Afghanistan	-	-	1	-	-	1
Total	86	15	171	93	60	425

Source: Singh, 2000 p. 143

* does not belong to any groups

4.1 Jasmine rice standard of Thailand

The National Bureau of Agricultural Commodity and Food Standards of Thailand have set separate standards for Thai aromatic rice for general aromatic cultivars, and Thai Hom Mali (Jasmine) rice. *Thai aromatic rice standard*, TAS 4001-2008, is declared as the Notification of the National Committee on Agricultural Commodity and Food Standards, Thai Aromatic Rice B.E. 2551 (2008). It covers both non-glutinous aromatic rice and glutinous aromatic rice from *Oryza sativa L.*, of the genus *Gramineae* or *Poaceae* which contain a natural fragrance. The standard is voluntary. Several varieties are classified into groups as in Table 8 (National Bureau of Agricultural Commodity and Food Standards, 2008). The use of certification mark for Thai aromatic rice shall be in compliance with the provisions and conditions established by the Committee on Agricultural Standards. In case the varietal name is intended to be specified on the package, at least 90% by weight has to be the specified variety. The procedure to test for aroma is simply, boiling in 10% salt solution for three minutes, cooling down, and smelling.

Thai Hom Mali Rice (or Jasmine) rice standard, TAS 4000-2003, was announced in November 2003. It applies to Jasmine rice produced from *Oryza sativa L.* which including paddy, brown rice and white rice derived from the paddy of the fragrant non-glutinous rice varieties which are photoperiod sensitive and cultivated as a main crop in Thailand. The Department of Agriculture, Ministry of Agriculture and Cooperatives, has certified only two Jasmine rice varieties: Khao Dawk Mali 105 (KDML105) and RD15 (National Bureau of Agricultural Commodity and Food Standards, 2003). The standard is also voluntary. KDML105 was locally screened and registered in 1959. Its grains contain a natural fragrance depending on its age, and when cooked retains a soft texture.

The paddy of qualified Thai Jasmine rice shall be in compliance with several requirements. Among them, it has to contain no less than 95% of Thai Jasmine rice. The official certification mark shall be in compliance with the provisions and conditions of inspection or certification agencies recognized by the Ministry of Agriculture and Cooperatives or other regulatory. The alkaline spreading is used as a method for analysis contaminant of rice varieties other than Thai Jasmine rice. The alkaline spreading value between one and five is considered not Thai Jasmine rice.

Since 2005 the Department of Foreign Trade of Thailand certifies “Thai Hom Mali Rice” for exports by using a certification mark (Figure 1). It says “Thai Hom Mali

Rice•Originated in Thailand•Department of Foreign Trade” around a picture of rice plant with a word in Thai stating “ข้าวหอมมะลิไทย”. The qualified products have to meet the Jasmine rice standard and contain at least 92% of Jasmine rice (Office of Commodity Standard, 2012). As of September 2011, there were 178 exporters who received the license to use the “Thai Hom Mali Rice” certification mark.

The Ministry of Commerce of Thailand defines the criteria for Thai Hom Mali Rice commodity standards in 2002, but not until 2006 that the DNA-based test is mentioned for alternative test for adulterant level of Jasmine rice. In 2007, the Office of Commodity Standard of Thailand is made responsible for the test of authentication of Jasmine rice. The cost of DNA inspection at the Biotechnology Research and Development Office (Department of Agriculture) is 1,500 THB (about 48 USD) while at the DNA Technology Laboratory (Kasetsart University at Kamphaengsaen) is 2,500-3,500 THB (about 80-112 USD) depending on the coverage of the analysis (UNESCAP, 2010).

Table 8. Authorized Thailand’s Aromatic Rice Varieties

Category	Variety	Year of Registration	Photoperiod Sensitivity
Covered in Thai Hom Mali (Jasmine) Rice Standards ²			
Soft Non-Glutinous Aromatic Rice	KDML 105	1959	yes
Aromatic Rice	RD 15	1978	yes
Covered in Thai Aromatic Rice Standards ¹			
Soft Non-Glutinous Aromatic Rice	Khao Jow Hom Khlong Luang 1	1997	no
	Khao Jow Hom Suphan Buri	1997	no
	Khao Jow Hom Pitsanulokel	1998	yes
	Pathum Thani 1	2000	no
	RD33 (Hom Ubon80)	2007	no
Loose Non-glutinous Aromatic Rice	Nhang Mon S-4	1965	yes
	Dok Pa-yom	1979	yes
Hard Non-glutinous Aromatic Rice	Pathum Thani 60	1987	yes
	Chai Nat 2	2004	no
White Glutinous Aromatic Rice	RD 6	1977	yes
	Khao Pong Krai	1987	yes
	R 258	1987	no
	Sakon Nakorn	2000	no

Source: ¹National Bureau of Agricultural Commodity and Food Standards, 2008

²National Bureau of Agricultural Commodity and Food Standards, 2003



Figure 1. Jasmine rice (Thai Hom Mali Rice) certification mark

Source: Office of Commodity Standard, Department of Foreign Trade, Thailand.

4.2 Basmati rice standards

Basmati rice has special characteristics. Though specific to India and Pakistan location, there are several new bred varieties derived from historic land race varieties. European countries are major export destinations of Basmati rice following the Middle Eastern countries. The import regulations of Basmati rice in the U.K. and in the European Union are considered important for Basmati rice exports due to expanding market demand.

The imports of Basmati rice varieties from India and Pakistan into the European Community is eligible for zero duty. The eligible Basmati varieties are listed in Table 10. The regulation is applied to husked Basmati rice. The authentic certificate of these varieties must be verified by authorized body of each country via DNA-base variety test. In the context of random checks or checks targeted at operations entailing a risk of fraud, EC member states shall take representative samples to be sent to the competent body in the country of origin, as listed in Table 10, for a DNA-based variety test, and the member states may also carry out variety tests on the same sample in a Community laboratory (EUROPA, 2006).

The British Retail Consortium, the Rice Association, and British Rice Millers Association in consultation with Local Authorities Coordinators of Regulatory Services (LACORS) and Association of public Analysts (APA) has made the *Code of Practice on Basmati rice*. The Code of Practice is restricted to the labelling of Basmati rice, and is voluntary. The minimum specifications for Basmati rice (*Oryza sativa* L.) sold in the U.K. are certain varieties of rice that are grown exclusively in specific areas of Indo Gangeric Plains, which currently includes the Punjab (on both sides of the Indian and Pakistani border), Jammu, Haryana, Uttaranchal, and Western Uttar Pradesh in India (British Retail Consortium, 2005). Varieties listed in Table 11 are certified varieties of Basmati rice, that at least one parent is Historic Land Race variety, and having unique properties specified in Table 12.

The labelling of “Basmati rice” requires that the adulterant level must not exceed 7% of Basmati varieties. If the variety is labelled with a variety name, at least 97% of that variety is constituted. Furthermore, if the country of origin is marked, at least 97% of grains must originate from the referred country. The certified Basmati rice varieties are the same as ones eligible for zero import duty under European Commission regulation, and include other varieties originally approved by India and Pakistan. It is mandatory that all imported Basmati consignments must have the authentication certificate based on DNA test. In India, a joint Agricultural Processed Food Products Export Developmental Authority (APEDA)-Center for DNA Fingerprinting and Diagnostics (CDFD) performs DNA testing and certification of Basmati exports. The protocol tests are capillary electrophoresis based microsatellite DNA profiling protocol which can rapidly detect adulteration from 1% upward with an accuracy of $\pm 1.5\%$, and currently are pending for US patents (Siddiq *et al.*, 2012).

Evidently leading exporters of aromatic rice attempt to make the varieties a trademark in the world market so that they have less competition from other new aromatic rice producers. At the same time, the imports of aromatic rice into major large countries such as the EU, and the U.S. are not without restriction. Basmati rice exported to the EU and the U.K. and Jasmine rice exported to the U.S., for examples, need to authenticate the varieties, and as a result incur high cost of testing, particularly when genetic-base test is used.

Though India, Pakistan, and Thailand continue to be leading producers and exporters of aromatic rice, recent developments of aromatic rice varieties are starting to come from emerging countries like the U.S., Myanmar, and Cambodia.

Table 10. Certified Basmati Rice Varieties and Authorized Body under European Commission Regulation*

Exporting country	Certified variety	Authorized body to issue authenticity certificates
India	Basmati 370	Export Inspection Council (Ministry of Commerce, Government of India)
	Basmati 386	
	Type-3 (Dhradun)	
	Taraori Basmati (HBC-19)	
	Basmati 217	
	Ranbir Basmati	
	Pusa Basmati	
Pakistan	Kernel (Basmati)	Trading Corporation of Pakistan (Pvt) Ltd
	Basmati 370	
	Pusa Basmati	
	Super Basmati	

Source: EUROPA, 2006

* Commission Regulation (EC) No 972/2006 of 29 June 2006

Table 11. Certified Basmati Rice Varieties under the U.K. Labeling Regulation

Country of Origin	Basmati rice varieties eligible for a zero import duty under Regulation (EC) 1549/2004	Other Basmati rice varieties approved by India and Pakistan
India	Basmati 217	Kasturi (IET 8580) Mahi Suganda Haryana Basmati (HKR 228/IET 10367) Punjab Basmati (Bauni Basmati)
	Basmati 370	
	Basmati 386	
	Type-3 (Dhradun)	
	Taraori Basmati (HBC-19 Karnal Local)	
	Ranbir Basmati (IET 11348)	
	Pusa Basmati	
Pakistan	Kernel Basmati (Basmati Pakistan)	Basmati 198
	Basmati 370	Basmati 385
	Pusa Basmati	
	Super Basmati	

Source: British Retail Consortium, 2005

Table 12. Minimum Characteristics for Basmati Rice Varieties (milled raw) under the U.K. Regulation

Minimum elongation ratio on cooking	1.7
Minimum average pre-cooked length	6.5 mm
Amylose content	Intermediate 19-26%
Length/breadth ratio	greater than 3.5
Gel Length	60-100 mm
Alkali spreading value	4-5
Typical Basmati Aroma	Present

5 Recent innovations in aromatic rice

Thailand, India, and Pakistan are competitive producers and developers of aromatic rice in the world. However, many of farmers in these countries grow specific varieties mainly for export markets. One of the reasons is the limitation in aromatic rice production is yield improvement. The first high-yielding Basmati rice cultivars are Pusa Basmati1 and Kasturi; they yield 4.5 and 4.0 ton/ha (about 1.5 and 1.0 tons/ha) higher than traditional Basmati varieties (Bhattacharjee *et al.*, 2002). Pusa Basmati 1, the world's first high yielding semi-dwarf Basmati and being good quality, was released in 1989. Until 2007, it was accounted for 40-60% of Basmati rice exports from India (Siddiq *et al.*, 2012). Hybridization technology has been used in several high-yielding grains breeding including rice. It could provide a much

higher yield than conventional inbred breeding yet challenging because Basmati quality shall not be much compromised. The first hybrid Basmati rice was developed by Indian Agricultural Research Institute. It gave 20-25% higher yield than the best yielding Basmati rice ((Bhattacharjee *et al.*, 2002). Pusa RH10 was the world's first superfine grain aromatic rice hybrid was released in 2001. Though high-yielding Basmati rice exists, none of them could match popular Basmati varieties in cooking and eating quality. Thus, the Union Government of India distinguish the different between traditional and hybrid Basmati varieties under the Seed Act. This resulted in a significant price differential between two categories. Indian and Pakistan approved Basmati varieties that did not meet E.C. zero duty (Table 11) are evolved Basmati, and several of them are high-yielding varieties i.e. Kasturi, Haryana Basmati, and Punjab Basmati. Details of Basmati quality rice varieties released in India until 2008 could be found in Siddiq *et al.* (2012).

As of Jasmine rice, Table 8 above shows registered aromatic and Jasmine rice by the Rice Department. Although recent aromatic rice developments aim to improve the resistance to biotic and abiotic stresses as well as quality and photoperiod sensitivity, success cultivars are not registered as Jasmine, but aromatic rice instead. A good example of success non-photoperiod sensitive breeding of aromatic rice in Thailand is Pathum Thani 1 in 2000; however, due to its inferior quality, it is not considered as Jasmine rice. Pathum Thani production is concentrated in irrigated Central areas of Thailand, and because it is non-photoperiod sensitive, it became popular among farmers. This somewhat created problems in the export markets as it got mixed with Jasmine rice. Other registered aromatic rice, particularly non-glutinous varieties are genetically close to Jasmine rice. RD33, for example, was released in 2007. It has good cooking quality close to KDML105, non-photoperiod sensitive, early maturity, and resistant to blast, but does not covered by Jasmine rice standard. This somewhat limit the potentials of Jasmine rice production.

Conventional breeding has been important tool in aromatic rice breeding, but new breeding programs are engaging in molecular breeding such as marker-aided selection (MAS) and genetic engineering. *Indica* rice genome sequencing was completed in 2002 by China though the genome sequencing of *Japonica* rice was completed in 2004 by International Rice Genome Sequencing Project (IRGSP). The members of the IRGSP include Japan, China, Taiwan, Korea, India, Thailand, France, Brazil, the U.S. and the U.K. Understanding the pathway of the biosynthesis of 2AP is the key information in aromatic rice breeding. As genome sequencing became available to IRGSP countries, this makes molecular breeding more competitive.

MAS has been increasingly used in rice breeding; it fastens the process of screening for desired traits. *Betain aldehyde dehydrogenase (BADH2)* or *fgr* locus was found to be the fragrance causing gene in aromatic rice (Shi *et al.*, 2008). In June 2008, the National Science and Technology Development Agency of Thailand received the U.S. patent for “*transgenic rice plants with reduced expression of Os2AP and elevated levels of 2-acetyl-1-pyrroline*”. This is patent is claimed to be the discovery of genes controlling the 2AP of Jasmine rice using genetic engineering technology (US Patent and Trademark Office, 2008). However, the first commercial transgenic aromatic rice was *Tarom molaii+cryI ab*. This improved aromatic rice variety was developed by Agricultural Biotech Research Institute of Iran to integrate insect resistant gene using genetic engineering technology, and was commercially released in 2005 (ISAAA, 2011).

Aside from traditional aromatic rice producing countries, the U.S. is among the emerging aromatic rice breeding countries. This is mainly because over 10% of rice consumption in the U.S. is imported, and the majority of them is Jasmine rice from Thailand. Because aromatic rice, particularly Jasmine rice, takes a large share in rice imports, and because Asian American consumers prefer it more than domestic produce, the U.S. is becoming more interested in aromatic rice breeding to compete with imports from Asia. The

standard of aromatic rice defined by the U.S. Department of Agriculture (USDA) is given as “special varieties of rice (*Oryza sativa L.* scented) that have a distinctive and characteristic aroma; e.g., Basmati and Jasmine rice” (USDA, 2009).

The first adapted aromatic rice release in the U.S. was *Jasmine 85*, the cultivar derived from International Rice Research Institute (IRRI), in 1989. Due to its off-white grain color, creamy grain appearance, weak aroma and flavor, it was not popular among U.S. consumers. The breeding of aromatic rice suitable for U.S. temperate climatic conditions continue, mostly done by the public university research centers in Southern states such as Arkansas, Louisiana, and Florida, and California. Early successful public developments of aromatic rice in the U.S. were contributed to American long grains (Table 13). The U.S. Department of Agriculture (USDA) also makes a large contribution in terms of joint collaborator and funder. USDA’s “Stepwise Program for Improvement of Jasmine Rice” was initiated to breed Jasmine-type rice for U.S. in 1999. The collaboration between Everglades Research and Education Center of University of Florida and Research and Extension Center of University of Arkansas obtained Jasmine rice germplasm from IRRI, and successfully introduced two important Jasmine-type characteristics via gamma radiation. Semi-dwarf which is preferred for combine harvesting and non-photoperiod sensitive which expand the cropping period are prominent traits. The program released Jasmine-type rice, *JES*, which became available to farmers in 2010 (University of Arkansas, 2009).

Table 13. US Long grain aromatic rice varieties and developers

Developer		US Basmati	US Jasmine	American long grain	
Public	USDA, Agricultural Research Service	Sierra (2002)	Jasmine85 (1989)	Lotus (2002)	
	LSU Agricultural Center		Jazzman (2009)	Della (1973)	
				Jazzman-2 (2011)	Dellmont (1992)
					Dellrose (1995)
					Dellmati (1999)
			Della-2 (2012)		
California Cooperative Rice Research Foundation, Inc.	Calmati201 (1999)			A201 (1997)	
	Calmati202 (2009)				
University of Arkansas, University of Florida, USDA			JES (2010)		
Private	Rice Tec, Inc.	Texmati (1977)	Jasmati (1993)		
		Kasmati (1994)			

Source: USA Rice Federation, 2010 and USDA 2005, and others.
numbers in parentheses are years of release

Though successfully bred, American long grain aromatic rice was not popular among U.S. consumers. Until recently *Jazzman* is released by LSU AgCenter. It is believed to be close to Jasmine rice of Thailand. The marketing of *Jazzman* by Jazzmen Rice, LLC in 2010 makes it becomes more recognized by using Louis Armstrong logo. LSU AgCenter continues to release *Jazzman-2* in 2011. It has higher aromatic fragrant than Thai Jasmine rice, and also has other characteristics such as color and softness as close as Thai Jasmine rice, and is expected not only to substitute imported Jasmine rice, but also to reach the export markets.

The private company, Rice Tec, Inc., was previously more active in aromatic rice breeding. However, it has been targeted in several biopiracy cases by the Indian government. Rice Tec Inc. was granted varietal patent for aromatic rices grown outside India and Pakistan as Basmati by U.S Patent and Trademarks Office (USPTO) in September 1997. Twenty claims of novel and superior varieties of *Texamati*, *Kasmati*, and *Jasmati* than traditional Basmati rices of India and Pakistan in quality and that they can be grown outside sub

Himalayas region were included in the patent (Siddiq *et al.*, 2012). Later, USPTO disallowed 15 out of 20 claims, and amended the title from '*Basmati Lines and Grains*' to *Rice Lines Bas 267, RT 1117, and RT 1121*.

6 Geographical indication of aromatic rice

Goodwin *et al.* (1996a) found that Asian American, particularly Southeast Asian consumers in Texas prefer Jasmine-type rice that demand higher price than typical American long grain varieties. Similarly, Goodwin *et al.* (1996b) found that Filipino and Southeast Asian consumers in the U.S. are strongly willing to pay more for Thai aromatic rice while Taiwanese consumers are willing to pay less. The surveyed and estimated prices of rice imported from Thailand are higher than American varieties, including Jasmine 85. The inverted U-shaped curves of Jasmine 85 and Thai Jasmine rice in terms of aroma attribute imply that both varieties were beyond maximum desire—wrong aroma or too much of the right one, but the combination of traits such as flavor and texture or color and texture are desire traits in Thai imported rice. In the study by Suwannaporn and Linnemann (2008a) of Jasmine rice preferences, they found that consumers in non-rice eating countries are not concerned about the country of origin. However, it is shown that consumers of not the same country of origin prefer rice from Thailand the most (31% of respondents), followed by India (11%). Other major exporters such as U.S., Vietnam, China and Pakistan are not highly recognized. Suwannaporn and Linnemann (2008b) show that Jasmine rice is highly differentiated between consumers who prefer and do not prefer it. Aroma is also a desirable attribute for those who specifically prefer Jasmine rice. These studies reveal that consumers do have specific preferences towards specific aromatic rice varieties.

It is known that the best quality of aromatic rice is location specific. Jasmine rice is grown solely in Thailand, and the highest quality Jasmine rice is produced in Thung Kula Ronghai Plain--literally translated to "rice from plateau of crying Kulas – ancient minority tribe-- in Northeast Thailand. The plain includes Roi Et, Maha Sarakham, Sisa Ket, Yasothon and Surin provinces. Its arid and salinity and climatic condition makes aromatic and other good traits of Jasmine rice more prominent. Basmati rice is grown in West Punjab and Baluchistan of Pakistan, East Punjab, Uttar Pradesh, Haryana, and Bihar state in India. Among these areas, Haryana is known to produce supreme quality of Basmati (Bhattacharjee *et al.*, 2002). Aroma in Basmati rice is vastly developed when grown in cooler temperature at maturity. Increasing in climatic temperature also decreases AC which in turn decrease translucency of the grains. Furthermore, temperature at the time of ripening affects grain elongation during cooking, which is a distinct characteristic of Basmati rice. The temperature of 25/21 Celsius (day/night) at ripening has a positive effect on grain elongation of Basmati rice. Therefore, Basmati rice is grown at about the same latitude in India, Pakistan, and the U.S. Thus climatic and soil conditions of the Punjab of Pakistan, Haryana, Punjab and western Uttar Pradesh of India are most suitable for expression of aroma and other quality traits of Basmati rice (Bhattacharjee *et al.*, 2002). This is important because Basmati rice grown outside Punjab region in Pakistan may not be aromatic.

At present, aromatic rice is recognized as high valued than normal rice in the world market. While the supply of aromatic rice does not meet its demand, consumers cherish it from paying the premium. Traditional aromatic rice producers, namely India, Pakistan, and India, continue to be leading developers of new evolved aromatic rice, and the best quality of traditional Basmati and Jasmine rice cultivars are attributed by their geographical origins. There are several new evolved aromatic rice varieties as discussed above. Several of these new aromatic rice varieties possess traits to cope with production stress and to increase yield while maintaining aromatic and other cooking characteristics. Though Basmati and Jasmine rice are preferred among consumers that have specific taste form them, recent innovations of

aromatic rice varieties, particularly in the U.S., are getting closer to match with the cooking quality of traditional cultivars. Furthermore, recently developed aromatic rice varieties have diminished production limitations in non-traditional climatic and environmental conditions. Currently organic Basmati rice from Italy is already sold in the European market (Giraud, 2008). This creates threats to traditional aromatic rice producing countries.

Evidently, in order to protect aromatic rice varieties produced from developing countries such as Jasmine rice from Thailand and Basmati rice from India and, it is important that the country of origin must be recognized as a quality trademark. Under WTO Trade-Related Aspects of Intellectual Property Rights (TRIPS), Geographical Indication (GI) is defined as '*indications which identify a good as originating in the territory of a member, or a region or locality in that territory, where a given quality, reputation or other characteristics of the good is essentially attributable to its geographical origin*' (Article 22(1)) (WTO, 1994). GI does not protect a product like plant variety rights or other intellectual property rights, but identifies special characteristics, most frequently quality, of products associated with its origin. TRIPS agreement set aside that all parties must provide means to prevent the use of any indication which misleads the consumer as to the origin of goods, and any use which would constitute an act of unfair competition. However, names that have already become generic are exempted. Furthermore, '*there will be no obligation under this agreement to protect geographical indications which are not or cease to be protected in their country of origin*' (Article 24) (WTO, 1994). GI would make it possible for traditional aromatic rice varieties for not being mistaken as generic products from competing countries, but only if the country of original embraces GI registration domestically.

Though GI became into effected in 1995, Rice Tec did receive a patent titled '*Basmati rice lines and grains*' on September 2, 1997 from the United States Patent and Trademark Office (USPTO). Claims 15-17 out of 20 were for rice grains without any limit to GI of Basmati (Mulik and Crespi, 2011). Furthermore, Rice Tec applied a trademark registration for '*Texmati*' and marketed as '*American Basmati*' with the U.K. Trademark Registry in 1997. The opposition by Indian government resulted in a withdraw of trademark application though the company tried to convinced that Basmati did not imply any GI for rice grown in the Indian sub-continent. It appeared that Rice Tec patent and trademark of '*Texmati*' were threatening Indian and Pakistan Basmati rice exports. This is contributed mainly by the fact that India and Pakistan did not register GI for Basmati in their countries at the time. In response to Rice Tec Basmati rice patent, Indian government through Indian Agricultural and Processed Food Products Export Development Authority (APEDA) filed a petition to with the USPTO in 2000. The Indian government eventually won the case against Rice Tec; no patent on Basmati rice is granted, and the term '*Basmati*' is prohibited.

In India, the Geographical Indications of Goods Act was passed in 1999. GI is defined as '*an indication which identifies such goods as agricultural goods, natural goods or manufactured goods as originating, or manufactured in the territory of a country, where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin*', and is precisely of TRIPS GI definition (Marie-Vivien, 2008). The GI Act of India emphasizes the objective of protecting traditional knowledge which essentially what has been used against Rice Tec's Basmati patent along with protecting genetic resources. APEDA was designated by Indian government to be the legitimate applicant for Basmati GI in January 2003. However, as of now APEDA has not applied for GI registration. However, the attempt to register GI Basmati rice was initiated by NGO '*The Heritage*' in August 2004. The application is still pending.

In Pakistan, the GI is protected under the Trade Mark Law as of April 2005. GI is defined as '*Geographical indication is in relation of goods originating in a particular country or in a region or locality of that country means a mark recognized in that country as a mark indicating that the goods-* (a) originated in that country, region or locality; and (b) have a

quality, reputation or other characteristic attributable in the geographical region' (Marie-Vivien, 2008). Unlike TRIPS or GI Act of India, GI of Pakistan does not emphasize quality attributable to geographical origin. One of the reasons that India and Pakistan are reluctant to register GI Basmati is due to debatable definition of Basmati varieties and the geographical areas to be covered by GI. As traditional Basmati growing area involved both Pakistan and India, the GI registration of Basmati requires that both countries comply on the same protection. The EU granted zero duty exemption to certain traditional varieties of Basmati rice from India and Pakistan to ensure best quality rice imports. However, India and Pakistan negotiated to include two evolved varieties, *Pusa Basmati* and *Super Basmati*, on the list. These varieties, to scientists, are not legitimate landrace or traditional Basmati, whereas the pressure of high export demand put Ministry of Commerce of India to notify *Improved Pusa Basmati-1* under Seed Act 1966, the Act that defines legitimate Basmati rice in India. In December 2007, India defined 'newly evolved Basmati varieties' as 'through direct parentage or having the characteristics and the genes of the traditional Basmati such as aroma, length and elongation in cooking to comply with the expanded definition'. Eventually for the benefits of farmers, scientists support the expansion of Basmati definition. Furthermore, in May 2006, India notified the approved Super Basmati as evolved variety for export purpose; the variety was in fact developed and was only cultivated in Pakistan. The tension between two countries from this incidence will continue to make GI Basmati difficult.

With current technology, it is possible that to identify geographical location where Basmati rice is produced by employing isotopic and multi-element analyses. The ratio of carbon 13/12 and oxygen 18/6, concentration of certain trace elements and isotopes of samples are compared with those of Basmati rice grown in India and Pakistan, the U.S. and Europe to distinguish the country of origin (Siddiq *et al.*, 2012). It is costly and suspected to be difficult to employ in the importing countries without GI system in exporting countries.

Thailand has passed Act on Geographical Indications Protection in 2003. Under this Act, Thung Kula Ronghai Khao Hom Mali Rice is the first registered GI rice in 2007. As of August, 2012, There are five other rice varieties under Thailand's GI protection; none are aromatic rice varieties. In 2012, Thung Kula Ronghai Khao Hom Mali Rice GI registration changes the specific locations to be only five provinces in the Thung Kula Ronghai (Department of Intellectual Property, 2012). Thailand attempted to register GI Jasmine rice with the EU in 2011. Five countries including the UK, France, Italy, the Netherlands and Belgium cited that Thailand could not use the phrase "Khao Hom Mali", and questioned whether the rice was packed in a specific area. Thus, at the present, Khao Hom Mali Thung Kula Ronghai failed to gain protection and recognition in the EU market.

7 Evidences from economic aspects of GI rice

The study by Mulik and Crespi (2011) used residual inverse demand curve—the same concept of Lerner index—to determine whether price premium of Basmati rice existed in four selected countries, and whether they diminished after Rice Tec's Basmati-type rice are available in the market. Their findings revealed that price premium of Basmati existed in the U.K. and Kuwait, but not in Canada and the U.S. After the introduction of Rice Tec Basmati-type varieties, product differentiation as determined by price premium of Basmati rice dropped. This implies a negative impact of Basmati substitute in major export markets.

GI was hypothesized to protect small farmers in developing countries, particularly to protect traditional knowledge, specific to geographical area from competing nations. Jena and Grote (2012) found that rice farmers in Uttarakhand state of Northern India were got more profits from growing Basmati rice than other rice varieties. Thus, for rice farmers located in traditional aromatic rice growing areas could be better off growing traditional varieties, and even more so if the varieties are protected by GI.

In reality, competing crops and other factors could influence farmers' decision of growing aromatic rice variety in traditional aromatic rice producing area. Jena and Grote (2012) found that important factors contributing to allocating more land to Basmati varieties are off-farm income and attending Basmati production training program from NGO, and because Basmati rice production is labor intensive, large family allocate more land to Basmati varieties than other normal rice. However, since sugarcane is a competing crop for its much higher yield and net income than rice, those who are intensively cultivate sugarcane in this area are less participated in Basmati rice production. Ngokkuen and Grote (2012) also found that rice farmers in Thung Kula Rong Hai who have access to information about the GI certification and are member of famer's cooperative are more probable to cultivate GI Jasmine rice. Their study implies that the GI can be complicated and created more transaction cost i.e. transportation to GI certified buyers so the social activities that promoting GI certification should be embraced for GI system to function. Furthermore, because Jasmine rice receives high price even without GI certification, Jasmine rice farmers may choose alternative buyers who pay high price to avoid the GI burden.

8 Discussion and Conclusion

Though aromatic rice contributes to a small share in the world market, but is valued at the highest price among all types of rice. The demand for aromatic rice is not expected to decrease if not increase by consumers who have specific taste for them. Because traditional aromatic rice varieties are susceptible to diseases and limited to abiotic stresses, they generate relatively low yield compared to other varieties. Though aromatic rice is mostly originated in Asia, Thailand, India, and Pakistan are predominantly leading producers and exporters of high quality aromatic rice. Nevertheless, recent success developments of new aromatic rice emerge from countries outside Asian continent such as the U.S. as well as other Asian countries. For instance, at the 3rd World Rice Conference in 2011, Myanmar aromatic Pearl Paw San rice won the *World's Best Tasting Rice* over Thailand's Jasmine rice, and Hom Mali rice from China came in fourth. It is the first time that Thai Jasmine rice did not win this contest. Myanmar Pearl Paw San rice is photosensitive variety grown in the Ayeyarwaddy region that has fertile soil. This shows that breeding of new aromatic rice will be increasingly more competitive as Myanmar and China are involved in aromatic rice breeding.

While scientists in Thailand, India, and Pakistan continuously research in evolved aromatic varieties that have improved traits, their innovations to increase yield shall not be compromised with quality as a threat from losing their competitive advantage in aromatic rice production will soon to be realized. Unless Thailand's Jasmine rice and Basmati rice of India and Pakistan could maintain their quality and being recognized in the world market, it will be a challenge for them to maintain their reputation without GI. GI is still new in developing countries and the system can be costly and complex, and the benefits of GI protection under TRIPS may be underestimated by these countries. It will be difficult for farmers who have alternatives of cultivating non-GI rice or other more profitable crops when the participation in GM system does not cover their transaction cost. This implies that even if GI may protect developing countries from losing their traditional knowledge and competitiveness of producing aromatic rice, getting certify GI continue to be a challenge. Currently there is no Basmati rice registered as GI, neither in India or Pakistan whilst Jasmine rice is registered as GI Thung Kula Rong Hai Khow Hom Mali in Thailand. These countries should reexamine whether GI certification is worth to protection their farmers, and pursue that their quality aromatic rice is GI protected in major importing countries as well.

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