CHAPTER 11

The aromatic rice of Laos

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A unique feature of many of the traditional glutinous and nonglutinous rice varieties from Laos is their aromatic character. For centuries, there has been conscious selection for this aromatic character within varieties grown and consumed by many of the 48 ethnic groups that constitute the population of Laos. The leading aromatic fine-quality rice of international markets, the basmati rice of the north and northwestern parts of the Indian subcontinent and the jasmine rice (*Khao dok mali*) of Thailand, is very well known. The internationally known aromatic rice is generally all nonglutinous. The aromatic rice varieties of Laos are little known outside the country, despite a diversity that is probably unsurpassed for any single country. The Lao aromatic varieties have both glutinous and nonglutinous endosperm and can be found in both upland and lowland environments.

From 1995 to 2000, a program of rice germplasm collecting was undertaken jointly between the Lao Ministry of Agriculture and Forestry (MAF) and the International Rice Research Institute (IRRI). From this program, 13,193 samples of cultivated rice were collected throughout the country (Appa Rao et al 2002a), and one of the characters recorded was the aromatic character in some of the traditional varieties. This chapter describes the diversity that was recorded for the Lao aromatic rice varieties collected during that program.

The chemical basis of aroma

Aromatic rice varieties differ in their degree of aroma and are broadly classified as strongly, moderately, and weakly scented types (Singh et al 2003). The pleasant aroma associated with aromatic varieties is not only associated with cooked rice but is also often emitted by these varieties in the field at the time of flowering (Weber et al 2000, Widjaja et al 1996). Aroma is caused by an extremely small amount of volatile compounds, which are contained as a complex mixture. The number of compounds that constitute aroma reported by different researchers varies considerably and no individual compound has been identified or can be attributed to be responsible for the aroma of cooked scented rice. Rather, a blend of a number of volatile compounds is believed to impart the characteristic aroma and flavor to the aromatic rice. Among

these, 2-acetyl-1-pyrroline (2-AP) is considered by some researchers to be the most important (Buttery et al 1988, Weber et al 2000).

The genetic basis of aroma

Aroma is a complex character that is genetically determined but whose expression is also strongly influenced by environmental factors. Researchers differ in their assessment of the number of pairs of genes believed to control the inheritance of aroma in rice, with one to four pairs being reported (Dhulappanavar 1976, Tripathi and Rao 1979, Berner and Hoff 1986, Lin 1991, Pinson 1994, Brijal and Gupta 1998). Khush and De La Cruz (1998) believe that aroma is a quantitative character, as segregants with varying levels of aroma have been observed in crosses between aromatic and nonaromatic varieties. They further suspect one major gene to be responsible for aroma and several modifiers or quantitative trait loci (QTLs) also to be involved.

The expression of aroma

Although the genetic background of a variety is very important in determining its aromatic character, several other factors are well known to affect the expression of aroma, such as temperature during the latter stages of crop growth, soil type and related crop nutrition, agricultural factors, and grain storage and processing. The potential effects of many of these factors on the expression of aroma and other grain characteristics have been reviewed by several authors (Goodwin et al 1994, Khush and De la Cruz 1998, Singh RK et al 2000, Singh US et al 2003).

Temperature

Quality traits of aromatic rice are known to be influenced by temperature, particularly at the time of flowering, grain filling, and maturity. It is generally acknowledged that aroma formation (and retention) in grain is better at lower temperature during the grain-filling stage (Singh et al 2003). For example, Juliano (1972) reports that the retention of aroma in basmati rice is best when, during crop maturity, relatively cool day/night temperatures of 25/21 °C are experienced. Cooler temperatures in the period after flowering and during the grain-filling stage are one of the reasons why north and northeast Thailand are regarded as being suited to the growing of the well-known Thai jasmine rice (Sarkarung et al 2000).

Soil factors

Soil factors are known to affect aroma and other quality characteristics in ways not properly defined but that are believed to be related to the interaction of nutrients with aroma-related volatile compounds (Singh et al 2003). Lighter soils and upland conditions are generally perceived to favor aroma formation, with soils low in nitrogen producing better-quality grain (Singh RK et al 2000, Singh US et al 2003). The application of nitrogen fertilizer is also known to adversely affect cooking and eating quality (including aroma) of rice, with the grain quality of the well-known Thai

jasmine rice variety *Khao dok mali 105* (KDML 105) varying inversely with the N content of the grain (Suwanarit et al 1996). On the other hand, potassium and sulfur fertilizers are known to favorably influence the cooking and eating quality of rice, including aroma (Singh et al 2003, Suwanarit et al 1997a,b). Diminishing soil moisture during the grain-filling stage is also believed to significantly affect the expression and accumulation of aroma, and is believed to be important in the expression of aroma by the jasmine rice of Thailand when grown under rainfed lowland conditions rather than in the irrigated environment (Sarkarung et al 2000).

Cropping factors

Time of harvest is also recognized as another factor that could influence aroma and other quality traits in rice. In the case of the photoperiod-sensitive Thai variety KDML 105, Suwanarit et al (2001) demonstrated that increasing maturity time (through earlier planting) significantly improved the quality characteristics of the grain, including aroma. However, a delay in harvesting after maturity is known to reduce aroma and influence the eating quality of aromatic rice (Rohilla et al 2000).

Storage and processing

In most countries, rice is stored and transported as paddy. Rice storage for a few months is usually regarded as having a positive influence on quality. However, storage for longer periods can result in a significant loss of aroma. Stored rice is known to cook relatively drier than freshly harvested rice, which becomes soft, moist, and sticky after cooking. During storage, there is an increase in grain hardness and gelatinization temperature, which enhances the swelling and elongation of rice grain during cooking (Singh et al 2003). The changes that take place in the grain during storage are not well understood.

The origins of aromatic rice in Laos

As with the diversity of traditional cultivated rice in Laos as a whole (Appa Rao et al 2002a), the diversity of the country's aromatic varieties reflects a combination of factors: (1) the ethnic diversity that exists in the country—48 distinct ethnic groups are recognized, all of which grow and consume rice as their staple food, and almost all of them have diverse and specialist uses for rice; (2) the diversity of the growing environments; (3) a past lack of infrastructure throughout the country that limited the movement of varieties (both introduced and traditional); and (4) the Green Revolution of the 1970s and 1980s, which had little impact on Laos and, until the mid-1990s, most rice cultivation throughout the country was still based on the use of traditional varieties with low levels of purchased inputs (UNDP 1998), and this remained the situation in the upland environment in the early 2000s.

Reference is made to the aromatic character of Lao rice as early as the middle of the 17th century, with French and Italian records published in 1663 and 1666 referring to the rice of Laos during that time in the following terms: "*The staple rice is*

Table 1. Descriptor names of ethnic groups indicating that a variety is aromatic.

Resemblance to root name *Hom*	Ethnic group	Descriptor name for aroma
Similar to the most common root name	Laven	*Hoom*
Similar to the most common root name	Yaheun	*Oom*
Similar to the most common root name	Phunoi	*Ahom*
Includes name of ethnic group in variety name	Kor	*Ahom kor*
Includes name of ethnic group in variety name	Kui	*Kui hom*
Has a prefix similar to common root name	Triv	*Thao hum*
Has a prefix similar to common root name	Taoey	*Pa hom*
Has a prefix similar to common root name	Taliang	*Soi hum*
No resemblance to common root name	Pako	*Keepua*
No resemblance to common root name	Katu	*Thamu*
No resemblance to common root name	Katang	*Mahuam*
No resemblance to common root name	Ngae	*Tasang*

Source: Appa Rao et al (1997).

incomparable there and it has a characteristic odor and wildness that is specific to all that grows in this eastern part of the kingdom" (de Marini 1998).

The naming of aromatic rice in Laos

Most rice variety names in Laos have three elements: the basic name, the root name, and a descriptor name (Appa Rao et al 2002b). The basic name *khao* indicates rice; the most common root name for aroma is *hom* (aromatic). All varieties with the root name *hom* are aromatic. The third component, the descriptor name, allows farmers to further identify particular rice varieties within different groups. For example, *Khao hom do* is an aromatic, early-maturing (*do*) variety. Likewise, the variety name *Khao niaw hom do* has two descriptor names: *niaw* means that the variety has glutinous endosperm and *do* again refers to its early maturity.

Among the different ethnic groups in Laos, there is often variation in the word *hom* to indicate that a variety is aromatic (Table 1). Slight variations in the root name *hom* are used by some ethnic groups in Laos to indicate that a variety is aromatic. The Laven use the word *hoom*, whereas the Yaheun use the word *oom*. The Phunoi use *ahom* to indicate an aromatic variety. The name of the ethnic group is also sometimes associated with slight variations of the word *hom* such as in *Ahom kor* by the Kor, *Kui hom* by the Kui, *Soi hum* by the Taliang, and *Thao hum by* the Triv. Other ethnic groups sometimes use names that have no resemblance to the common root name, such as *thamu* by the Katu, *keepua* by the Pako, and *tasang* by the Ngae.

Consumption of aromatic rice in Laos

Aromatic rice, whether glutinous or nonglutinous, is a normal component of the diet of almost all ethnic groups in Laos. Although the names of many traditional varieties may not reflect their aromatic character, the basis for their selection and adoption has usually always included attention to characteristics related to the consumption or quality. This attention to quality is not unique to Laos, but is common in many countries in Southeast Asia. It is also one of the main reasons why the higher-yielding varieties that were originally released by the International Rice Research Institute in the latter part of the 1960s and during the 1970s as part of the Green Revolution were not readily accepted in some countries of the region despite their recognized high yield potential. Rather, the yield potential and other traits of these modern varieties were usually later blended with the quality characteristics of the traditional varieties in national breeding programs to produce improved "national" varieties that had more general acceptability. In the case of Laos, the early introductions of "modern" varieties in the late 1960s and early 1970s by organizations such as the Philippines Brotherhood Movement and USAID resulted in very little farmer adoption. However, this was not only because these varieties lacked the "quality characteristics" of traditional varieties but also because the early improved high-yielding varieties were almost exclusively nonglutinous, whereas more than 90% of the rice being consumed in the country at that time was glutinous or "waxy" rice. Similarly, in the latter part of the 1970s and early 1980s, when several varieties were introduced from Vietnam in an effort to improve yields and help achieve national rice self-sufficiency, the only variety to be grown to any significant degree was the nonglutinous variety CR203 (which also has IRRI parentage). However, even for this variety with its recognized high yield potential relative to most of the traditional lowland varieties being grown in Laos at that time, its acceptance was not based on its acceptability for general consumption, but rather its suitability for noodle and alcohol production. The aromatic character that is a characteristic of most traditional Lao rice varieties is expected to remain the basis for acceptability of most improved varieties that might be developed within the Lao National Rice Research Program.

Representation of aromatic rice in the germplasm base for Laos

At the time of collecting samples of traditional varieties for conservation and use in 1995-2000, information on up to 36 descriptors, which also included aroma of cooked rice, was obtained from the farmers who provided samples. Aromatic varieties were identified based on the name of the variety and information provided by the farmers. Agricultural extension officers and Lao scientists who had knowledge of the traditional rice varieties supplemented this information. All the collected samples were classified according to ecosystem, endosperm, and maturity type, in addition to the district and province from where each sample was collected.

Geographic distribution of aromatic varieties

Out of the 13,193 samples collected during 1995-2000, variety names were available for 12,411 samples (Appa Rao et al 2002). Among these, 477 samples (3.84%) had names identifying them to be aromatic. These samples were collected in all 136 districts of the country where collecting was done. However, variation was considerable among regions, provinces, and districts in the number and proportion of aromatic samples collected (Table 2). Among the provinces, Houaphanh in the northern region had the highest number (51 samples), followed by the provinces of Vientiane (46) and Khammouane (44) in the central agricultural region. Among regions, the central agricultural region had the highest proportion (47%) of aromatic varieties collected, followed by the northern region (38%). The proportion of aromatic varieties was greatest among samples collected from the rainfed lowlands (66.6%), suggesting a greater preference for aromatic varieties by lowland farmers and consumers.

More glutinous samples were aromatic (79.7%) than nonglutinous samples (20.3%). This is consistent with findings reported by Champagne et al (2004), who found that grain flavor and aroma of rice varieties are often correlated highly and negatively with amylose content; glutinous (or waxy) varieties are more likely to display more grain flavor. This, in turn, is reflected in the fact that the Hmong ethnic group, the primary consumers of nonglutinous rice in Laos, appear to be less concerned with aroma as a sought-after characteristic in the varieties they grow.

Distinct variety names for aromatic varieties

Among the 477 aromatic samples collected, 98 distinct variety names designating aroma were used by Lao farmers (Table 3). Besides the use of designations specifically indicating aroma, Lao farmers use a range of other names to indicate that a variety has aromatic qualities. These names may include reference to aromatic flowers or plants, country of origin, endosperm type, maturity time, and other grain and plant characters, singly or in combination. Names used to indicate aroma relating to plants include aromatic jasmine (*Hom mali*), jasmine flower *(Dok son*), and Arabian jasmine flower (*Dok phut*). Some variety names relate to aromatic plants, such as sandalwood (*Hom chan*) and sandalwood oil (*Namman chan*). Grain size is also sometimes reflected in combination with the aromatic character—aromatic large grain (*Hom gnay*) and aromatic small grain (*Hom noy*). The soft texture and aroma of the grain after cooking are also sometimes referred to in a romantic way—*Hom nang nuan* (sweet-smelling soft lady, Photo 11.1) and *Hom nuan* (sweet and soft). Aroma is also linked to grain color—red aromatic (*Deng hom*), white aromatic (*Hom khaw*), and aromatic striped (*Hom lay*). Aromatic names can also be linked to agronomic traits—aromatic and excessively tillering (*Hom phae phalo*) and dwarf aromatic (*Hom tam*). The name may also indicate the country from where a variety was introduced—aromatic Myanmar *(Hom Phama*), aromatic Thailand (*Hom Thai*), and aromatic Cambodia (*Hom Kampuchea*). The intensity of aroma is reflected by names such as highly aromatic (*Hom oudom)* and mildly aromatic (*Hom noi*). It is interesting to note that some aromatic rice varieties exhume aroma not only from grains but also from culms and leaves. This is also sometimes reflected in the name—*Hom thong* (aromatic field) and *Hom bay (*aromatic leaf).

Table 2. Geographic distribution and classification of aromatic samples collected in Lao PDR from 1995 to 2000.[a]

Region and province	Samples (total)	Samples (aromatic)	Aromatic		Lowland					Upland				
			% Total	% Aromatic	G	N	E	M	L	G	N	E	M	L
Northern region	5,919	181	44.9	37.9	87	19	17	34	55	47	28	27	27	21
Bokeo (BO)	689	17	5.2	3.6	7	2	2	3	4	3	5	2	1	5
Houaphanh (HP)	631	51	4.8	10.7	36	1	0	6	31	7	7	1	8	5
Luang Namtha (LN)	857	19	6.5	4.0	8	5	4	4	5	5	1	2	3	1
Luang Prabang (LP)	1,243	29	9.4	6.1	7	6	2	7	4	8	8	10	5	1
Oudomxay (OD)	849	12	6.4	2.5	3	1	2	2	0	7	1	7	0	1
Phongsaly (PS)	667	20	5.1	4.2	5	2	1	4	2	11	2	2	6	5
Sayabouly (SB)	983	33	7.5	6.9	21	2	6	8	9	6	4	3	4	3
Central region	4,623	224	35.0	47.0	164	20	34	103	47	36	4	23	15	2
Xieng Khouang (XK)	561	30	4.3	6.3	28	0	0	10	18	1	1	0	1	1
Borikhamxay (BK)	595	36	4.5	7.5	24	2	7	18	1	9	1	9	1	0
Khammouane (KH)	866	44	6.6	9.2	41	2	10	26	7	1	0	0	1	0
Savannakhet (SV)	988	26	7.5	5.5	21	3	3	17	4	1	1	1	0	1
Vientiane M. (VM)	485	36	3.7	7.5	15	11	6	15	5	10	0	5	5	0
Vientiane P. (VP)	787	46	6.0	9.6	31	2	5	17	11	12	1	7	6	0
Saysomboun (SB)	341	6	2.6	1.3	4	0	3	0	1	2	0	1	1	0
Southern region	2,651	72	20.1	15.1	37	9	5	35	6	23	3	8	14	4
Attapeu (AT)	639	6	4.8	1.3	1	5	0	4	2	0	0	0	0	0
Champassak (CS)	842	28	6.4	5.9	20	4	3	20	1	3	1	0	4	0
Sekong (SK)	396	12	3.0	2.5	4	0	1	3	0	6	2	5	2	1
Saravane (SV)	774	26	5.9	5.5	12	0	1	8	3	14	0	3	8	3
Grand total	13,193	477	100.0	100.0	288	48	56	172	108	106	35	58	56	27

[a]G = glutinous, N = nonglutinous, E = early, M = medium, L = late.

Table 3. Distinct aromatic variety names in Laos and their classification.[a]

Variety name	Meaning of variety name	Coll. no.	LG no.	Ec	En	Mt	Pv
Hom mali (L/N)	Aromatic jasmine	LR-1375	108	L	N	L	AT
Chao hom (L)	Nonglutinous aromatic	LR-1384	117	L	N	M	AT
Dokson	Jasmine small	LR-2115	220	L	G	M	CS
Deng dok chan (L/G)	Red aster	LR-2139	244	L	G	M	CS
Intok hom	From heaven aromatic	LR-2307	276	L	G	M	CS
Hom chan (L/N)	Aromatic aster	LR-2611	365	L	N	M	CS
Tok hom	Aromatic from heaven	LR-2635	389	L	G	M	CS
Kang hom	Medium aromatic	LR-2813	467	L	G	M	CS
Chao mali	Nonglutinous jasmine	LR-21003	482	L	N	M	CS
Do ngieng	Early aromatic	LR-21030	509	L	G	E	CS
Dok ket	Pandanus flowers	LR-21031	510	L	G	M	CS
Chao hom (U)	Nonglutinous aromatic	LR-3213	537	U	N	E	SG
Ea hom (L)	Aromatic	LR-3216	540	L	G	M	SG
Ahom (U)	Aromatic	LR-3225	549	U	G	E	SG
Ahom (L)	Aromatic	LR-3226	550	L	G	M	SG
Ea hom (U)	Aromatic	LR-3354	619	U	G	E	SG
Hom thong (L/G)	Aromatic field	LR-4105	635	L	G	M	SV
Niaw mali	Glutinous jasmine	LR-4411	661	L	G	L	SV
Hom mali niaw	Aromatic jasmine glutinous	LR-4442	692	L	G	L	SV
Hom do (L)	Aromatic early	LR-5109	856	L	G	M	SK
Ken chan	Seed of aster	LR-5515	959	L	G	M	SK
Hom (L/G)	Aromatic	LR-5518	962	L	G	M	SK
Hom noi	Aromatic small	LR-5736	1053	L	G	M	SK
Hom ngan	Aromatic late	LR-5763	1,080	L	G	L	SK
Hom vieng	Aromatic vieng	LR-5807	1,089	L	G	M	SK
Hom phae (L)	Aromatic many tillers	LR-5816	1,098	L	G	M	SK
Om lay	Aromatic striped	LR-6126	1,235	L	G	M	KM
Om noi	Aromatic small	LR-6127	1,236	L	G	M	KM
Do hom (L)	Early aromatic	LR-6337	1,311	L	G	E	KM
Hom khav	Aromatic white	LR-6468	1,385	L	G	M	KM
Hom lay (L)	Aromatic striped	LR-6516	1,399	L	G	L	KM
Ma teun (L)	Dog wakes up	LR-6805	1,452	L	G	M	KM
Hav hom	Cracks aromatic	LR-6867	1,514	U	G	M	KM
Kay noi (L)	Chicken small	LR-7103	1,529	L	G	M	BK
Kay noi (U)	Chicken small	LR-7118	1,544	U	G	E	BK
Hom bay	Aromatic leaves	LR-7324	1,589	L	G	M	BK
Hom do (U)	Aromatic early	LR-7350	1,615	U	G	E	BK
Hom Nang nuan	Sweet-smelling soft lady	LR-7506	1,655	L	G	M	BK
Hom sed thi	Aromatic rich man	LR-7519	1,667	L	G	M	BK
*Dok phoud**	Arabian jasmine	LR-7611	1,700	L	G	M	BK
Hom (U/G)	Aromatic	LR-8121	1,740	U	G	E	LP
Phae hom (U)	Many tillers, aromatic	LR-8301	1,891	U	G	E	VP
Hom phae phalo	Aromatic, too many tillers	LR-8666	1,996	L	G	M	VP
Hom chan (L/G)	Aromatic aster	LR-8809	2,012	L	G	M	VP
Hom nuan chan	Aromatic soft aster	LR-8821	2,024	L	G	M	VP
Sanpatong do hom	Sanpatong early aromatic	LR-9302	2,055	L	G	L	VM
Hom Phama	Aromatic Myanmar	LR-9805	2,112	L	G	L	VM

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Table 3 continued.

Variety name	Meaning of variety name	Coll. no.	LG no.	Ec	En	Mt	Pv
Hom mali (L/N)	Aromatic jasmine	Hv-19	2,341	L	G	M	HP
Dok hom	Flower aromatic	Bkt-03	2,473	U	G	E	BK
Nam yen/kay noi	Cold water/chicken small	Lac-229	2,692	L	G	L	HP
Kay noi deng	Chicken small red	H-14	2,727	L	G	L	HP
Cham hom	Nonglutinous aromatic	H-20	2,733	L	N	L	HP
Kay noi leuang	Chicken small yellow	Hs-13	2,746	L	G	L	HP
Kay noi dam	Chicken small black	Hs-22	2,755	L	G	L	HP
Chao hom khav	Nonglutinous aromatic white	Lac-278	2,808	U	N	L	HP
Khai hom	Hairy aromatic	Lac-260	2,851	L	G	M	HP
Hom keaw	Aromatic bottle	Kmm-14	2,918	L	G	M	KM
Khav hom	White aromatic	Ll-53	3,322	L	G	M	LP
Nuan chan	Soft aster	Ln-62	3,419	L	G	L	LP
Hom dang	Aromatic variable	Lac-153	3,442	U	G	E	LP
Namman chanh	Sandalwood oil	Lp-02	3,480	U	G	E	LP
Hom (L/N)	Aromatic	Lp-24	3,502	L	N	E	LP
Hom oon	Aromatic soft	Lac-945	3,808	U	G	M	LN
*Mak khen**	Fruit of khen	Nl-13	3,823	U	G	L	LN
Thoua hom	Cowpea aromatic	*On-23*	*4,089*	*U*	*G*	*E*	*OD*
Hom kang (U)	Aromatic medium	Lac-628	4,191	U	G	M	PL
Mak khen dam*	Fruit of khen black	Pb-27	4,227	U	G	L	PL
Mak khen khav*	Fruit of khen white	Pb-28	4,228	U	G	L	PL
Ahom ko	Aromatic ko	Lac-583	4,282	U	G	L	PL
Hom nga	Aromatic sesame	Pp-18	4,396	U	G	M	PL
Deng om	Red aromatic	Sp-21	4,503	U	G	E	SB
Hom oudom	Aromatic highly	Lac-1021	4,534	L	G	E	SB
Om (U)	Aromatic	Lac-1070	4,591	U	G	E	SB
Ba hom	Rice aromatic	Lac-1607	4,707	U	G	L	SG
Ea ham	Ea ham (ethnic name)	Lac-1557	5,250	U	G	E	SV
Kou hom	Kou aromatic	Lac-1504	5,350	U	G	M	SV
Aham	Aromatic	Svs-08	5,422	U	G	M	SV
Hom dok dou	Aromatic flower dou	L-134	5,532	L	G	M	VM
Hom mali deng	Aromatic jasmine red	Vmk-03	5,568	L	N	M	VM
Hom mali kang	Aromatic jasmine medium	Vmk-10	5,575	L	N	M	VM
Hom phae (U)	Aromatic many tillers	L-121	5,607	U	G	E	VM
Ma teun (U)	Dog wakes up	Ns-42	6,001	U	G	M	LN
Kay noi hay	Chicken small, upland	Abc-377	6,742	U	G	M	HP
Kay noi hang	Chicken small, awned	Abc-440	6,798	L	G	M	XK
Do hom (U)	Early aromatic	Abc-643	6,989	U	G	E	OD
Hom thong (L/N)	Aromatic field	Abk-1233	7,514	L	N	L	VM
Hom saa ngiem	Aromatic pleasant	Abv-1241	7,521	L	G	L	VP
Hom huan	Aromatic huan	Abv-1243	7,523	L	G	E	VP
Hom thong khav	Aromatic field white	Abv-1268	7,548	L	G	L	VP
Hom gnay	Aromatic big	Abv-1328	7,602	L	G	M	BK
Hom ka	Aromatic crow	Abv-1401	7,671	L	G	M	KM
Deng dok chan (L/N)	Red aster	Csb-18	8,958	L	N	M	CS
Deng hom (L)	Red aromatic	Kmg-14	9,175	L	G	M	KM
Do om	Early aromatic	Sk-27	9,616	L	G	L	SB

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Table 3 continued.

Variety name	Meaning of variety name	Coll. no.	LG no.	Ec	En	Mt	Pv
Om do	Aromatic early	Sn-23	9,661	L	G	M	SB
Hom Thai	Aromatic Thai	Svl-22	9,970	L	G	M	SV
Kay noi khav	Chicken small white	Xt-09	10,134	L	G	L	XK
Hom lay (U)	Aromatic striped	Xsh-34	10,162	U	G	E	XS
*Do dok phoud**	Early Arabian jasmine	Sp - 43	10,211	L	G	E	SK
Ma kheu	Dogs rush	Abs-201	10,417	U	G	E	BO
Dok keaw (L)	Keaw flower aromatic	Abs-718	10,910	L	G	E	XS
Om (L)	Aromatic	Abp-1089	11,251	L	G	L	SB
Kay noi hom	Chicken small aromatic	Abs-05	11,742	U	G	E	BK
Dok om	Flower aromatic	Bop-81	12,010	L	G	M	BO
Hom deng (U/N)	Aromatic red	Lnl-64	12,269	U	N	M	LN
Hom kang (L)	Aromatic medium	–	12,359	L	G	M	LN
Do mali gnay	Early jasmine big	svp-111	12,822	L	G	E	SV
Chao hom mali	Nonglutinous jasmine	vmt-113	12,842	L	N	M	VM
Deng hom (U)	Red aromatic	vpm-107	12,868	U	G	E	VP
Phae hom (L)	Many tillers aromatic	vpm-112	12,873	L	G	M	VP
Dok keaw (U)	Flower of keaw	vpn-125	12,907	U	G	M	VP
Hom sam heuan	Aromatic three houses	boo-147	12,997	L	G	E	BO
Chao lay hom	Nonglutinous striped aromatic	boo-150	13,000	U	N	L	BO
Hom saa nga	Aromatic highly	bkv-109	13,224	L	G	M	BK
Mali do	Jasmine early	bkv-134	13,249	L	N	E	BK
Mali	Jasmine	bkv-135	13,250	L	N	L	BK

[a]Coll. no. = collector number, LG no. = Lao genebank accession number, Ec = ecosystem, L = lowland, U = upland, End = endosperm, G = glutinous, N = nonglutinous endosperm, Mt = maturity, E = early, M = medium, L = late, Pv = province from where the variety was collected (refer to Table 2).

Distinct aromatic variety names

Among the 477 aromatic samples, Lao farmers give 98 distinct variety names for aroma (Table 3). Among them, in 87 cases, all the samples with a particular variety name have similar characters, such as adaptation to the ecosystem or endosperm type. However, in 11 cases, they differ for either the ecosystem or endosperm or both. Since these two characters are very important, such varieties should be considered as different; if so, there are 120 distinct variety names.

The highest number of 21 aromatic varieties was found in Borikhamxay and Vientiane provinces, followed by 19 in Khammouane and 18 in Sayabouly provinces and Vientiane Municipality (Table 4). This high frequency of aromatic varieties in these provinces may be because of easy access to markets in the neighboring country and the high premium price commanded by them. During crop maturity of aromatic varieties, combines are commonly found in these areas. In the northern region, the maximum number of varieties found was 18 in Sayabouly and 13 in Phongsaly. In the southern region, the maximum number of aromatic varieties found was 16 in Saravane and 15 in Champassak. Relatively more aromatic varieties were found in the lowlands than in the uplands. This may be because lowland farmers grow aromatic varieties for

Table 4. Diversity of characteristics within the collection of named aromatic rice varieties.

Trait	Minimum	Maximum	Mean
Seedling vigor[a]	2	9	3.5
Days to flowering	79	145	107.5
Culm length (cm)	50	210	113.9
Panicle length (cm)	3	9	4.7
Panicles per hill	15	31	24.0
Plant aspect score[a]	3	8	5.2
100-grain wt (g)	1.8	7	6.2

[a]Visual score of 1–9.

marketing, whereas most upland farmers produce for domestic consumption. However, Phongsaly grows the highest number of 8 upland varieties probably because of the strong preference for aromatic varieties. In the southern region, though the farmers have a commercial outlook, improved varieties with higher yield potential are grown. From the Saysomboun Special Region, only one aromatic variety was collected probably because the collection is not complete in this area. Other factors responsible may be inaccessibility to large markets, the lack of an urban population that can buy, and the recent migration of most of the people from other areas. The rainfed lowlands have 55 varieties, 46 glutinous and 9 nonglutinous. The uplands have 27 varieties, 24 glutinous and 3 nonglutinous. As expected, glutinous varieties outnumber nonglutinous ones because of the strong preference for such types. The number of variety names is only a proxy for varietal diversity. Though the names of varieties are mostly distinct and unique characters are associated with the name, we have also found varieties that appear identical but are named differently by different ethnic groups. Conversely, varieties that are clearly distinct morphologically and physiologically are called by the same name by some other ethnic groups. It is also recognized that there is a need for further confirmation of the aromatic varieties as they were selected based on the names given by the farmers.

Relation between number of distinct varieties and number of samples

In general, there is a very close relation between the percentage of samples and varieties collected (Table 2). The total samples collected and the number of aromatic samples and varieties differed considerably. For instance, out of the 36 samples, 21 distinct variety names were found in Borikhamxay and 12 varieties out of 17 in Bokeo, whereas in Houaphanh only 14 varieties out of 51 were found and 3 out of 6 samples collected from Attapeu. There seems to be no relation between the total samples and aromatic samples and varieties. Out of the 1,243 samples from Luang Prabang, the largest number collected, only 29 were aromatic samples, consisting of

only 13 varieties, whereas, in Borikhamxay, out of the 595 total samples, 36 samples were aromatic, consisting of 21 varieties.

Characterization of the diversity within Lao aromatic rice varieties

During the 1999 wet season, aromatic varieties were characterized at the Agricultural Research Center (ARC) in Vientiane Municipality. For characterization, both lowland and upland varieties were grown under good management conditions. Data were recorded according to the standard evaluation system for rice (IRRI 1996) or descriptors for rice (IRRI and IPGRI 1980). It is acknowledged that some of the characteristics of the varieties recorded under these conditions could have differed from when the same varieties were grown in the environment where they were collected (for example, in addition to the evaluation being made under a favorable moisture regime, the prevailing temperature may have been higher, particularly at the end of the growing season, relative to that which prevailed in the "home" environment, particularly for upland varieties grown at higher elevations and in more northern areas). Even for lowland varieties, it has been shown that varieties normally grown in lowland areas of the Mekong River Valley can take up to 3 or 4 more weeks to mature when grown in more northern areas, the difference being largely a reflection of the influence of lower temperatures, particularly at the end of the growing season.

Considerable variation was observed among the 370 samples evaluated from different provinces: days to flowering varied from 83 to 135, culm length from 62 to 147 cm, panicle number from 3 to 7, and 100-grain weight from 2.3 to 4.2 g. Variation was similar in many other varieties. This observed variation within a variety might be due to changes brought about by the environmental conditions under which the variety was grown. It would be interesting to determine whether there are differences in aromatic characteristics among different samples of this variety and other samples. In some varieties, the more limited variation may be due to adaptation to specific environmental conditions. Grain size, which is a highly heritable character also, showed considerable variation among different samples.

Considerable diversity was observed for all the characters studied (Table 4), for example, days to flowering varied from 79 to 145, with a mean of 108. However, most of the accessions flowered within 120 days. In general, upland varieties flowered earlier than lowland varieties probably because of adaptation to available soil moisture conditions. Culm length ranged from 50 to 210 cm, with a mean of 114 cm. Most accessions grew very tall, and only nine accessions were shorter than 70 cm. Very late and strongly photoperiod-sensitive varieties grew taller than the early-maturing varieties. The number of productive tillers varied from 3 to 9 per hill. In general, upland varieties produced fewer tillers as it is a normal practice to dibble up to 15 seeds per hill. Flowering was synchronous and the number of productive tillers was more in the photoperiod-sensitive varieties. Panicle length varied from 15 to 31 cm, with a mean of 24 cm. Grain size, as inferred by the weight of 100 grains at around 11% moisture content, varied from 1.8 to 7.0 g. Considerable variation was observed for spikelet characters such as shape, length, width, and thickness; color of glumes; and pericarp

color. However, the expression of upland varieties is not realistic and possibly may be different when they grow under upland conditions. Many of the glutinous aromatic varieties are globular in shape, which is in contrast to other aromatic varieties reported that have slender long grain with enormous elongation after cooking (Khush and de la Cruz 1998).

Aromatic varieties with nonaromatic names

As the Lao aromatic varieties reported in this chapter were identified, based on variety name, we recognize that probably a significant number of aromatic varieties in the 13,139 samples (for which names were recorded) collected throughout Laos in 1995-2000 have names that do not reflect their aromatic character. For example, variety *Khao kai noi* (small chicken rice) has a name that reflects its small grain size and globular shape rather than the aromatic character for which it is particularly well known. The 3.84% of the collection identified as aromatic is therefore probably a significant underestimate of the number of aromatic samples in the collection.

Future use of aromatic rice of Laos

Using results from the characterization of the aromatic varieties undertaken at the Agricultural Research Center in Vientiane Municipality in 1999, the Lao rice improvement program has already selected several accessions for use in the varietal improvement program. These include accessions that are particularly vigorous and have early flowering, short stature, a high tillering capacity, and a desirable phenotypic acceptability, long panicles, and heavy grains. These accessions will undergo further assessment for either direct introduction to farming areas and/or use in the ongoing breeding program.

By 2002, Laos was close to achieving rice self-sufficiency. In the near future, it may have a rice surplus, which could mean potential for export (Schiller et al 2001). However, it is recognized that it may be difficult for Laos to compete on the export market with other significant rice-exporting countries in the region, particularly Thailand and Vietnam. In particular, it is unlikely that Laos would be able to produce premium nonglutinous rice for the general export market and be able to compete with the well-known jasmine rice of Thailand and the basmati rice of the Indian subcontinent. It may be more appropriate for the country to develop export markets for "boutique" rice (Schiller et al 2000). In pursuing such an objective, the breeding program would need to largely focus on the development of aromatic nonglutinous rice rather than the more common aromatic glutinous rice collected from 1995 to 2000 (Appa Rao et al 2002a,b). The information contained in the variety names, including the aromatic varieties, would assist in the more effective use of traditional varieties in the Lao breeding program. It is generally acknowledged that the potential export market for glutinous rice is limited, largely on account of a lack of awareness in potential importing countries of the various ways in which glutinous rice can be prepared for consumption.

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