

Screening genetic resources of local accessions of *Capsicum* originated from East Java

S Purnomo and Handoko

East Java Assessment Institute for Agricultural Technology, Indonesian Agency for Agricultural Research and Development, Ministry of Agriculture, Jalan Raya Karangploso Km 4, Malang 65105, East Java, Indonesia

E-mail: segenggam68@gmail.com

Abstract. Inventory and collection of local chili varieties in production centers in East Java had been carried out in the period 2013–2015 by East Java Assessment Institute for Agricultural Technology (AIAT). A total of 143 accessions of five chili species (*Capsicum annuum* L., *C. frutescens* L., *C. chinense* Jacq., *C. baccatum* L. and *C. pubescens* L.) was collected from eight chili production centers in East Java and has been maintained by East Java AIAT. A set of 85 local chili accessions was selected and evaluated for agronomic performance and biochemical compounds. Among the five species, *C. annuum* L. and *C. frutescens* L. dominated the distribution of chili species in East Java. The other three species were still found in some spots of farm households and highlands. *C. pubescens*, locally known as “Bodong” or “Wudel” chili, was found on the high slopes of Mount Semeru, whereas *C. chinense*, known as “Cotoh” chili by the locals, was also found in the highlands of Batu City. Based on agronomic performance there were several accessions with high-yielding potential (≥ 12 t/ha). Five accessions of *C. frutescens* collected from planting areas in the dryland with dry climate of Blitar not only had high yield potential, but also had high capsaicinoid content, low-fat content, low quercetin and high flavonoids and polyphenols. Phenotypic diversity and geographic origin may be useful as the criteria for selecting a good set of chili accessions.

Keywords: screening, species, accession, chili.

1. Introduction

Local plants with high diversity but have less massive impact directly on welfare are mostly given less attention by policyholders. However, this trend does not apply to chili commodities. The market for high-value food products in developing countries, and unprecedented, can be created by among others, small-scale farmers. They can make the market transition from traditional low-value commodity production to high value. The diversity of plant species and local varieties can be the basis for building new markets, as shown in the case of potato and chocolate varieties [1].

Chili is one of the most important vegetables and spices in the Indonesian food trade. The price fluctuations of chili can cause national economic inflation which compelled policyholders taking steps to develop local varieties of chili. Local chili varieties have adaptive properties under extreme environmental changes, resistance to pests and diseases, and the ability to grow well under low agricultural inputs so they can thrive in the yard. Although this commodity can cause national economic inflation, the species and genetic diversity of chili are rarely studied. Therefore, inventory



and collection of local varieties in chili production centers in East Java were carried out in 2013–2015 by East Java AIAT [2]. Parts of the result surveys are described in this paper.

Among 38 recognized *Capsicum* species, five are cultivated, namely *C. annuum* L., *C. frutescens* L., *C. chinense* Jacq., *C. baccatum* L. and *C. pubescens* [3]. Two species, *C. annuum* L. and *C. frutescens* L., were the most cultivated chili in East Java, while the other three were rare but were still found in some farm household spots [2]. Based on the report of Purnomo et al. [15], *C. pubescens* was found in Lumajang which is located in the slopes of Mount Semeru. This species is called “Bodong” or “Wudel” peppers by the locals. *C. chinense*, which was known locally as “Cotoh” chili, was found in the highlands of Junggo, Malang.

From a large collection of chili accessions obtained from the survey, it is necessary to select a set of chili germplasms with promising several uses including product development. Indicators such as phenotypic diversity and geographic origin may be useful as good selection criteria for choosing accessions that are rich in function within a specific timeframe. The selection criteria include botanical classification, geographic origin and biochemical properties of the fruit.

The specific objective of this study was to evaluate the agronomic performance and fruit chemical properties of local chili accessions collected in East Java. The expected outcomes from this study are: (i) accessions with desired characteristics which can be used in the development of local chili varieties in East Java, and (ii) selection criteria using phenotypic diversity and geographic origin of accession.

2. Materials and methods

2.1. Inventory and collection of local chili accessions

Chili production centers in eight regencies (Blitar, Kediri, Malang, Tuban, Lamongan and Mojokerto) in East Java were visited in 2013–2015. Local accessions were collected from diverse topography and altitude (from 150 to 1500 m above sea level, m asl). Genetic materials were collected and maintained at East Java AIAT.

2.2. Evaluation of agronomic performance and chemical analysis of chili fruit

A total of selected 85 accessions representing five species from eight production centers were evaluated for agronomic performance (Table 1). The evaluation was carried out at Malang Experimental Field, East Java AIAT, from February until September 2016. Seedlings were transplanted on raised beds (3.0 m long × 2.5 m wide × 0.5 m high) at within-row planting distance of 0.6 m and between-bed distance of 1.5 m. Each bed contained 12 plants of each accession. The experimental design used was a randomized block design with two replications. Fruits from selected accessions of *C. annuum* and *C. frutescens* from each production center were subsequently characterized for their chemical compounds. Chemical analysis was carried out in the Food Laboratory of the Food Technology Faculty, Brawijaya University, Malang.

Table 1. Origin and number of local chilli accessions used in agronomic evaluation.

Origin	<i>Capsicum frutescens</i>	<i>C. annuum</i>	<i>C. chinense</i>	<i>C. baccatum</i>	<i>C. pubescens</i>	Total number
Blitar	5	8	-	-	-	13
Kediri	5	8	-	1	-	14
Lumajang	3	5	-	-	2	10
Malang	3	8	3	1	-	15
Banyuwangi	2	7	-	-	-	9
Tuban	3	5	-	-	-	8
Lamongan	3	6	-	-	-	9
Mojokerto	2	5	-	-	-	7
Total number per species	26	52	3	2	2	85

3. Results and discussion

3.1. Inventory and collection of local chili accessions

The surveys listed 143 chili accessions which were cultivated in diverse topographies and altitudes in East Java. Accessions of *C. annuum* collected from the highlands formed an ellipsoid canopy. Meanwhile, accessions of *C. annuum* taken from the lowlands formed an umbrella canopy. Diversities in the harvesting age within the species were observed among geographic origins, and differences in plant performance were more pronounced among species.

The centers of local chili production in Blitar Regency were drylands with dry climate at an altitude of 150–400 m asl, covering three sub-districts, namely Panggungrejo, Binangun and Wates. The geographic distribution of local chili in Kediri Regency was at lowland and highland up to 1,000 m asl. Air temperature ranged from 23–30°C with an average rainfall of 1,652 mm/day during the rainy season (5–4 months/year). Chili in this region was planted on grey-brown regosol soil in Kepung, Plosoklaten and Puncu Sub-districts. The production center in Lumajang Regency was Pasuruan and Tosari Districts which are located at the slopes of Mount Semeru from 400 to 1,500 m asl in dryland under dry climate with an average rainfall of 1,578 mm per day during the rainy season (5–4 months/year). The chili species in this region is of most interest because the plant has perennial life cycle. The performance of this species is presented in Figure 1.

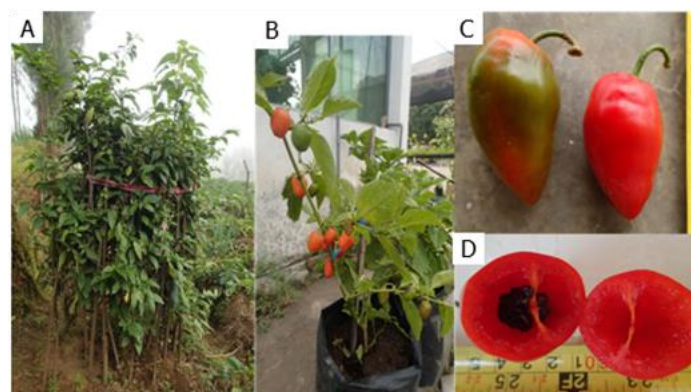


Figure 1. Performance of chili species of *Capsicum pubescens*. (A) Plants in its original habitat in Lumajang Regency. (B) Plants in polybags. (C) Fruit. (D) Transverse section of the fruit.

Local chili in Malang Regency is cultivated on terrain topography at 300–1,500 m asl, in Dau, Pujon, Ngantang and Kesembon Sub-districts, in dryland typology with regosol soil under wet climate with an average rainfall of 2,617 mm per day during the rainy season (7–8 months/year). The production centers of local chili in Banyuwangi Regency is in the lowlands in some districts such as Wongsorejo, Purwoharjo and Cluring. In Tuban Regency local chili is cultivated in three districts, namely Grabagan, Bancar and Soko; whereas in Lamongan Regency it is planted in two sub-districts, namely Brengkok and Sendangharjo. In Mojokerto Regency local chili is grown in the highlands of Pacet Sub-district.

3.2. Evaluation of agronomic performance and chemical analysis of chili fruit

A set of 85 accessions representing five species from eight chili production centers in East Java was selected for the characterization of the agronomic performance (Table 2). *C. frutescens* produced higher fruit yield compared to the other species when it was planted in lowland area, which is less prospective to be developed as chili production centers in East Java. According to van Zonneveld et al. [4], *C. pubescens* is suitable for highland areas with a wet climate. *C. baccatum* and *C. eximium* are favorite chili species among farmers for their high productivity [5].

Table 2. Agronomic performance of five species of *Capsicum* originated from East Java.

Origin	Species	Number of accessions	Harvesting age (weeks after planting)	Plant height (cm)	Canopy width (cm)	Life cycle	Yield potential (t/ha)
Blitar	<i>C. frutescens</i>	5	15–17	133.8±5.6	72.3 ±12.6	A/P	12.5±3.4
	<i>C. annuum</i>	8	13–16	85.3±4.6	86.0±7.5	A	9.2±4.3
Kediri	<i>C. frutescens</i>	5	15–17	112.6±7.8	75.3±9.4	A/P	12.8±2.6
	<i>C. annuum</i>	8	13–16	9.7±3.1	86.4±5.2	A	8.6±2.6
	<i>C. baccatum</i>	1	-	69.5	83.4	-	-
Lumajang	<i>C. frutescens</i>	3	15–17	138.3±7.6	75.6±5.8	A/P	5.6±1.4
	<i>C. annuum</i>	5	13–16	105.3±9.5	73.4±3.8	A	9.7±4.3
	<i>C. pubescens</i>	2	17–18	218.9±5.1	85.3±4.3	P	5.2±2.1
Malang	<i>C. frutescens</i>	3	15–17	138.7±7.8	74.5±3.2	A/P	8.9±3.8
	<i>C. annuum</i>	8	13–16	103.5±6.7	83.7±4.2	A	10.3±3.1
	<i>C. baccatum</i>	3	15–16	68.9±7.5	85.3±3.2	A	6.4±1.2
	<i>C. chinense</i>	1	12	110.6	43.5	A	3.2
Banyuwangi	<i>C. frutescens</i>	2	15–17	119.6±4.3	73.3±26	A/P	9.8±3.2
	<i>C. annuum</i>	7	13–16	87.9±6.3	83.4±5.3	A	7.3±1.8
Tuban	<i>C. frutescens</i>	3	15–17	115.4±3.2	75.2±4.1	A/P	12.4±4.5
	<i>C. annuum</i>	5	13–16	83.4±5.5	73.4±3.2	A	7.2±2.2
Lamongan	<i>C. frutescens</i>	3	15–17	129.3±4.3	77.5±3.1	A/P	10.4±4.5
	<i>C. annuum</i>	6	13–16	90.1±8.8	83.2±5.5	A	7.3±2.5
Mojokerto	<i>C. frutescens</i>	2	15–17	122.7±4.5	73.5±2.8	A/P	5.4±2.1
	<i>C. annuum</i>	5	13–16	92.7±2.2	68.8±5.2	A	9.3±3.4

A = annual, P = perennial, - = no data available.

Fruit chemical analysis revealed that *C. frutescens* accessions from Blitar have a higher level of capsaicinoid, flavonoids and polyphenol compounds, but a lower level of fat content, and quercetin compounds compared to other accessions (Table 3). They also have a higher productivity of about 12.5 t/ha compared to the yield of the other accessions originated from the other production centers (Table 2). The performance of some of these accessions can be seen in Figure 2.

The yield potential of *C. annuum* accessions from Lumajang Regency are comparable to that of *C. frutescens* accessions from Blitar Regency, but the fruit is not pungent because its capsaicinoid content was as low as 189.6 mg/100 g of ingredients. Mazourek et al. [6] stated that capsaicinoid content affects the spiciness of chili. Spicy flavors are expressed in Scoville Heat Unit Tester units. Spiciness is a unique characteristic of chili caused by a group of alkaloids called capsaicinoids. These alkaloids correlate with antioxidants, polyphenols and fat content in chilli [7,8].

The altitude of planting area may affect chili fruit quality with regard to the levels of capsaicinoids and flavonoids. *C. annuum* and *C. frutescens* accessions from the planting area in the highlands of Lumajang District showed different levels of capsaicinoids and flavonoids contents compared to accessions cultivated in lowland regions (Table 3). Therefore, geographic origin may be used as an indicator for selection criterion of accession with desired character.



Figure 2. Performance of two local accessions of *Capsicum frutescens* originated from Blitar, East Java. (A) BL 1 plants. (B) BL 1 fruit. (C) BL 2 plants. (D) BL 2 fruit.

Table 3. Variation in the biochemical contents of local *Capsicum annum* and *C. frutescens* accessions originated from eight chili production centers in East Java.

Origin	Species	Number of accessions	Capsaicinoids (mg/100g)	Fat (g/100g)	Flavonoids (mg/100g)	Polyphenols (g/100g)	Quercetin (mg/100g)
Blitar	<i>C. frutescens</i>	5	1065.5±142.3	12.3±4.2	11.4±3.4	2.5±0.8	6.6±2.2
	<i>C. annum</i>	8	312.4±56.4	9.1±3.5	6.1±2.4	1.8±0.3	8.0±2.4
Kediri	<i>C. frutescens</i>	5	897.4±123.7	16.3±4.5	9.5±2.3	2.1±0.8	6.7±1.8
	<i>C. annum</i>	8	304.5±48.7	9.7±2.3	5.9±2.1	1.4±0.2	8.5±2.1
	<i>C. baccatum</i>	1	219.2	7.0	9.8	1.7	9.2
Lumajang	<i>C. frutescens</i>	3	575.3±93.8	14.8±5.6	4.2±2.4	1.4±0.6	10.8±2.5
	<i>C. annum</i>	5	189.6±45.6	9.7±2.4	5.3±3.1	1.4±0.2	12.5±3.4
	<i>C. pubescens</i>	2	213.4±56.8	7.2±4.3	2.8±1.8	1.8±0.3	2.2±0.7
Malang	<i>C. frutescens</i>	3	578.2±89.6	16.7±6.8	6.8±3.2	1.8±0.5	8.2±2.5
	<i>C. annum</i>	8	198.6±32.5	10.5±3.3	5.5±2.2	1.4±0.4	8.3±2.6
	<i>C. baccatum</i>	3	143.6	7.2	9.9	2.1	10.3
	<i>C. chinense</i>	1	323.1±42.5	7.2±2.7	4.3±2.4	1.9±0.4	4.2±1.1
Banyuwangi	<i>C. frutescens</i>	2	886.4±121.5	4.2±1.8	12.5±4.2	2.1±0.8	5.6±1.4
	<i>C. annum</i>	7	315.8±43.8		5.2±2.3	2.2±0.7	8.4±2.0
Tuban	<i>C. frutescens</i>	3	945.3±118.7	5.3±2.1	12.4±3.2	2.3±0.7	5.7±1.8
	<i>C. annum</i>	5	323.6±45.5	6.8±3.4	5.7±2.2	2.2±0.5	8.3±2.5
Lamongan	<i>C. frutescens</i>	3	1005.3±123.4	4.4±1.8	12.1±4.5	2.3±0.6	5.7±1.8
	<i>C. annum</i>	6	345.7±45.5	6.3±3.1	5.7±2.4	2.1±0.4	7.8±2.0
Mojokerto	<i>C. frutescens</i>	2	523.4±92.5	16.7±5.6	5.9±3.3	1.6±0.5	10.4±3.4
	<i>C. annum</i>	5	198.4±31.3	14.8±4.7	5.0±2.3	1.6±0.3	8.8±3.0

Results of crossing trials and molecular marker analysis in parallel studies (data not shown) revealed that the five domesticated species of *Capsicum* were associated with three major genetic diversity centres of three species in East Java, i.e. *C. annum*, *C. baccatum* and *C. pubescens*. Based on this finding, it can be stated that East Java has a diverse genetic resource of chili germplasm, which are potential as genetic material for improvement of chili varieties locally. However, *C. annum* is phylogenetically separated from *C. baccatum* and *C. pubescens*, and thus strong interspecific hybridization barriers exist among them [9].

4. Conclusions

Field evaluation on agronomic performance of 85 chili accessions collected from production centers in East Java revealed great differential characters among the accessions. Five accessions of *C. frutescens* from Blitar had high levels of capsaicinoids, with low-fat and quercetin contents, but high flavonoid and polyphenols contents. The yield potential of these accessions can reach up to 12 t/ha when planted on drylands under and dry climate. The high level of genetic diversity in the genus *Capsicum* originated from East Java provides genetic materials for plant breeders to develop new high-yielding varieties. Phenotypic diversity and geographic origin of chili accessions may be useful as the criteria for selecting a set of accessions with desirable characters.

5. Acknowledgements

Many thanks are due to Ir. Wahono Hadi Susanto, a lecturer at the Faculty of Food Technology, Brawijaya University, for conducting biochemical laboratory analysis of chili accessions in this study.

6. References

- [1] Devaux A, Velasco C, López G, Bernet T, Ordinola M, Pico H, Thiele G and Horton D 2007 *Collective Action for Innovation and Small Farmers Market Access: The Papa Andina Experience* (Colombia)
- [2] Purnomo S, Zubaidi T and Hosni S 2015 Kekayaan dan keragaman sumber daya genetik tanaman pangan lokal pada tiga wilayah kabupaten yang berbeda kultur budayanya di provinsi Jawa Timur *Prosiding Seminar Nasional Sumber Daya Genetik Pertanian "Pengelolaan Sumber Daya Genetik Lokal sebagai Sumber Pertumbuhan Ekonomi Daerah"* ed T P Priyatno (IAARD Press) pp 41–9
- [3] Eshbaugh W H 2012 The taxonomy of the genus *Capsicum* *Peppers: Botany, Production, and Uses* vol 47 ed V M Russo (CAB International) pp 1953–66
- [4] van Zonneveld M, Ramirez M, Williams D E, Petz M, Meckelmann S, Avila T, Bejarano C, Ríos L, Peña K, Jäger M, Libreros D, Amaya K and Scheldeman X 2015 Screening genetic resources of *Capsicum* peppers in their primary center of diversity in Bolivia and Peru *PLoS One* **10** 1–23
- [5] Eggink P M, Tikunov Y, Maliepaard C, Haanstra J P, De Rooij H, Vogelaar A, Gutteling E W, Freymark G, Bovy A G and Visser R G 2014 Capturing flavors from *Capsicum baccatum* by introgression in sweet pepper *Theor. Appl. Genet.* **127** 373–90
- [6] Mazourek M, Pujar A, Borovsky Y, Paran I, Mueller L and Jahn M M 2009 A dynamic interface for capsaicinoid *Plant Physiol.* **150** 1806–21
- [7] Hernandez-garcia C and Zhang Z 2013 Pepper heat *eXtension* 1–12
- [8] Albert S 2013 How to choose a chili pepper for heat, or not *Harvest to Table*
- [9] Manzur J P, Fita A, Prohens J and Burruezo R A 2015 Successful wide hybridization and introgression breeding in a diverse set of common peppers (*Capsicum annuum*) using different cultivated ají (*C. baccatum*) accessions as donor parents *PLoS One* **10** 1–18