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Prospects of Early Maturing Black Soybean as Industrial Raw Material in Indonesia

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Abstract. Soybean is a very popular food in Indonesia, especially tempeh, tofu and soy sauce. Eight black soybean genotypes and two check cultivars (Detam 1 and Mallika) were examined their seed yield potential in 16 soybean production centers in Indonesia from February to May 2011 and from June to September 2011. The research design used at each location was a randomized block design with four replicates. Suitability study of 10 black soybean genotypes for soy sauce was done at ILETRI's Laboratory of Food Chemistry. The seed yield of ten black soybean genotypes grown in 16 environments ranged from 2.46 to 2.88 t/ha with an average of 2.59 t/ha. Genotype W9837 × Cikuray-66 had the highest yield (2.88 t/ha), and early maturing day (75 days). The yield recovery of sweet soy sauce originated from genotype W9837 × Cikuray-66 reached 834.85% with a protein content of 1.91%. According to the sensory test, the soy sauce of W9837 × Cikuray-66 was preferred by the panelists. The high yielding soybean genotypes with early maturity and suitable for raw material of soy sauce, are prospectively developed in areas with limited irrigation in Indonesia or in the dry season.

Keywords: black soybean, early maturity, soy sauce physico-chemical, soy sauce sensory test

1. Introduction

Indonesia's population of around 250 million by 2013 had levels of soy consumption was 10 kg/capita/year. The soybean main utilization for comestibles are as industrial raw materials of tempeh, tofu, and soybean sauce. Black soybean sauce potential as raw material, because have a high nutritional value especially protein, and also could improve the quality of soy sauce [1].

Contributor to Indonesia's largest soybean production comes from soybeans grown in paddy fields following a year cropping pattern of rice - rice - soybean. Rice is planted at the beginning of the rainy season (November/December) and at the beginning of the first dry season (March/April), while soybeans are planted in the second dry season (June/July). The main problem of soybeans grown in the second dry season is susceptible to drought. Various studies show that the economic value of early maturing soybeans are more tolerant to drought and pests through the escape mechanism, and increasing the cropping index.

Soybean grouping based on maturity day is different among countries. In Indonesia, soybean maturity day are classified into late maturity (> 90 days), medium maturity (80 – 90 days), and early maturity (<80 days). The Indonesian government has released as many as seven black soybean varieties, where all of them have medium and late maturity (82 - 95 days). Availability of early maturing black soybean is important to reduce the drought stress and to increase the supply of industrial raw materials. The aim of the research is to identify potential seed yield and maturity day of black soybean genotypes and to find out their suitability for the raw material of soy sauce.

2. Materials and Methods

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A total of eight black soybean genotypes (Cikuray × W9837-171, Cikuray × W9837-105, W9837 × Cikuray-66, W9837 × 100H-236, MLG 3102 × Cikuray-435, Cikuray × W9837-181, Cikuray × W9837-184, and W9837 × Cikuray-26) and two check cultivars (Detam 1 dan Mallika) were examined their seed yield potential in 16 soybean production centers in Indonesia from February to May 2011 and from June to September 2011. The research design used at each location was a randomized block design with four replicates. The treatment is 10 black soybean genotypes (including check cultivars of Mallika and Detam 1). Soybean planting in paddy fields after rice cultivation. Plot size of 2.8 m x 4.5 m, a spacing of 40 cm x 15 cm, two plants per hill. Fertilization with 50 kg Urea, 100 kg SP36 and 75 kg KCl per ha, spread evenly after planting. Plant maintenance in the form of irrigation; pest, disease, and weed control were performed optimally. Suitability study of 10 black soybean genotypes for soy sauce was performed at ILETRI Laboratory of Food Chemistry. The experiment was used completely randomized design, using 10 black soybean genotypes with two replicates. The research was carried out from March to July 2011. The method used for producing the soy sauce following [2].

3. Results and Discussion

3.1. Soybean Seed Yield

The combined analysis showed that location (L), genotype (G), and interaction of genotype × location (GEI) were significant for seed yield. The significant location indicates that there were differences in the productivity of location. The GEI indicates that there are significant differences in genotype superiority in different locations (Table I).

Table I: Seed yield of 10black soybean genotypes grown in 16 locations. 2011.

No	Location code	Seed yield (t/ha)										
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	Average
1	L1	2.72	2.62	3.15	2.83	2.55	2.68	2.73	2.89	2.73	2.26	2.72
2	L2	2.81	2.75	3.09	2.86	2.54	2.77	2.84	2.92	2.74	2.41	2.77
3	L3	2.43	2.46	3.02	2.57	2.56	3.05	2.75	2.31	3.19	2.50	2.68
4	L4	2.40	2.24	2.41	2.14	2.10	2.29	2.12	2.21	2.52	2.63	2.31
5	L5	2.48	2.39	3.14	2.51	2.16	2.99	2.84	2.09	2.99	2.27	2.59
6	L6	2.68	2.66	2.67	2.48	2.60	2.54	2.48	2.65	2.92	2.66	2.63
7	L7	2.62	2.58	2.98	2.60	2.58	2.62	2.60	2.54	2.65	2.58	2.64
8	L8	2.65	2.71	2.75	2.57	2.78	2.64	2.59	2.45	2.63	2.59	2.64
9	L9	2.93	2.49	2.77	2.70	2.68	2.94	2.78	2.54	2.50	2.36	2.67
10	L10	2.84	2.92	2.66	2.54	2.43	2.76	2.58	2.66	2.26	3.00	2.67
11	L11	2.23	2.22	2.85	2.21	2.22	2.25	2.34	2.22	2.44	2.07	2.30
12	L12	2.06	2.88	2.52	2.22	2.63	2.33	2.29	2.63	2.49	2.51	2.45
13	L13	2.83	2.78	2.99	2.86	2.72	2.54	2.79	2.95	2.83	2.65	2.79
14	L14	2.62	2.56	2.92	2.44	2.35	2.74	2.39	2.82	2.50	2.32	2.57
15	L15	2.40	2.59	3.05	2.19	2.73	2.51	2.34	2.08	2.21	2.54	2.47
16	L16	2.43	2.42	3.06	2.89	3.09	2.55	2.48	2.25	3.00	2.07	2.62
LSD (5%)		0.35	0.33	0.70	0.23	0.94	0.42	0.29	0.30	0.40	0.76	0.96
Average		2.57	2.58	2.88	2.54	2.54	2.64	2.56	2.51	2.66	2.46	2.59
MS : Location (L)		0.8440 **										
Genotype (G)		0.8380 **										
G × L		0.1020 **										
CV (%)		12.31										

G1 = Cikuray × W9837-171; G2 = Cikuray × W9837-105; G3 = W9837 × Cikuray-66;
G4 = W9837 × 100H-236; G5 = MLG 3102 × Cikuray-435; G6 = Cikuray × W9837-181;
G7 = Cikuray × W9837-184; G8 = W9837 × Cikuray-26; G9 = Detam 1; G10 = Mallika
MS = mean square; ** significant at p = 0.01.

The average seed yield from 10 genotypes grown in 16 locations was 2.59 t/ha. The seed yield ranged from 2.51 – 2.88 t/ha. Check cultivar of Detam 1 (2.66 t/ha) have higher yield than Mallika (2.46 t/ha). Genotype W9837 × Cikuray-66 (G3) had the highest yield (2.88 t/ha) compared to seven other genotypes and the check cultivars (Table I). Detam 1 is Indonesian black soybean varieties (released in 2008), and has a protein content of up to 45.36% and maturity day of 84 days. While Mallika released as black soybean variety in 2007 with maturity day of 87 days.

3.2. Agronomic Characters

Agronomic characters (maturity days, plant height, number of branches/plant, number of pods/plant, and 100 seed weight) were obtained based on the average of 16 locations (Table II). The eight black soybean genotype had early maturity day (<80 days), more than the check cultivars of Detam 1 and Mallika. Plant height of all genotypes almost equal, except Mallika which had high branch. The average number of pods/plant was 55.27 (range 50.60 - 57.86 pods), while 100 seed weight varied from 10.92 to 13.60 g/100 seeds. Genotype W9837 × Cikuray-66 have both high yield and maturity day of 75 days, showed that the genotype was categorized as early maturing soybean.

Table II: Agronomic character of 10 black soybean genotypes. 2011.

No	Genotype	MD	PH	NB	NN	NP	W100
1	Cikuray × W9837-171	74 g	57.55 b	3.73 a	16.93 cd	57.65 b	11.22 de
2	Cikuray × W9837-105	75 f	58.28 b	3.67 ab	16.50 cde	57.86 b	10.98 ef
3	W9837 × Cikuray-66	75 ef	56.87 bc	3.49 abc	16.22 cde	51.05 c	11.75 c
4	W9837 × 100H-236	76 de	53.16 d	3.13 d	14.90 f	54.52 b	11.01 ef
5	MLG 3102 × Cikuray-435	76 cd	55.41 c	3.43 bc	15.68 ef	54.80 b	11.36 d
6	Cikuray × W9837-181	75 ef	57.49 b	3.74 a	17.36 c	61.25 a	10.92 f
7	Cikuray × W9837-184	75 f	55.04 c	3.50 abc	15.42 ef	57.41 b	10.96 ef
8	W9837 × Cikuray-26	76 c	51.16 e	3.25 cd	15.85 def	50.60 b	12.20 b
9	Detam 1	82 a	57.36 b	3.28 cd	18.84 b	50.98 c	13.60 a
10	Mallika	81 b	63.46 a	3.38 cd	18.95 a	56.55 b	11.32 d
Average		77	56.58	3.46	16.66	55.27	11.53
LSD (5%)		0.41	1.89	0.26	1.22	3.36	0.32

MD = maturity day (days); PH = Plan height (cm); NB number of branches/plant; NN = number of node/plant; NP = number of pods/plant; W100 = 100 seed weight (g).Value within the same column followed by the same letter are not significantly different at the 0.05 level according to LSD test.

3.3. Psyco-chemical of soy sauce

Soybean yield recovery, which was calculated based on soybean seed weight per soy sauce weight, significantly different between soybean genotypes with a range of 811.8 - 910.3 % (Table III). According [3] soy sauce final weights are also influenced by substances dissolved in saline solution during the fermentation proccess, especially protein. Among the 10 genotypes/cultivar tested, Detam 1 showed the highest yield recovery, because had the highest seed protein levels. W9837 × Cikuray-66 had a yield recovery of 834.85%. The water content of soy sauce was significantly different between genotypes with a range of 22.07 - 25.71 %.

Table III shows that soy sauce protein levels were significantly different between soybean genotypes. Highest value obtained in soy sauce prepared from varieties Detam 1 and W9837 × Cikuray-26. Mallika had the lowest protein content. Soy sauce protein content of genotype W9837 x Cikuray-26 was 1.91%. This difference is mainly due to differences in protein levels of different raw materials between soybean genotypes. The higher protein content of soybean seeds resulting a higher soy sauce protein [4]. The color or brightness level of soy sauce (L*) were significantly different between soybean genotypes with the brightest obtained in Detam 1.

The sweet soy sauce flavor which is commonly consumed in Indonesia more influenced by the types of spices and sugar to make soy sauce, hence the different types of raw materials are hard to detect its effect on flavor. This is in contrast with the processed soy sauce in Japan or China that is not flavored and sugar, so that the sense of taste is influenced by the type of raw materials and components flavors that arise during the process of fermentation II as esters, organic acids and amino acids, especially glutamic acid [5].

Table III: Physicochemical properties of soy sauce from 10 black soybean seeds. 2011.

Genotype	Water content (%)	Protein (% bb)	Yield recovery (%)	Brightness level (L*)
Cikuray × W9837-171	22.29 fg	1.93 cde	814.60 d	24.60 c
Cikuray × W9837-105	22.07 g	1.96 cde	812.00 d	23.90 de
W9837 × Cikuray-66	23.43 efg	1.91 de	834.85 cd	23.85 de
W9837 × 100H-236	22.60 efg	1.98 cd	811.80 d	23.30 ef
MLG 3102 × Cikuray-435	22.39 fg	1.96 cde	830.20 cd	23.80 def
Cikuray × W9837-181	25.15 bcd	1.94 cde	851.05 bc	23.20 f
Cikuray × W9837-184	25.71 ab	2.02 bc	852.25 bc	23.80 def
W9837 × Cikuray-26	25.48 bc	2.10 ab	847.20 bcd	23.95 d
Detam 1	23.90 cdef	2.19 a	910.25 a	26.55 a
Mallika	23.70 defg	1.87 e	842.45 bcd	25.75 b
CV (%)	4.09	2.84	2.39	1.42
LSD (5%)	1.77	0.10	36.25	0.62

Value within the same column followed by the same letter are not significantly different at the 0.05 level according to LSD test. (*L): the higher the brightness value indicates the pale color of soy sauce.

Sensory evaluation of the soy sauce from genotype W9837 × 100H-236 was the most preferred color, aroma and taste; followed by genotype W9837 × Cikuray-66. According to the panelists, soy sauce produced from genotype Cikuray × W9837-171, Cikuray × W9837-105, W9837 × 100H-236, and the MLG 3102 × Cikuray-435 were quite thick, while the other eight were a bit lumpy (Table IV).

Table IV: The sensory evaluation of soy sauce from 10 black soybean seed. 2011.

Genotype	Soy sauce color	Soy sauce aroma	Soy sauce taste	Total preference score	Soy sauce thickness
Cikuray × W9837-171	3.7	3.5	2.9	10.1	3.9
Cikuray × W9837-105	2.7	3.5	3.2	9.7	3.8
W9837 × Cikuray-66	3.5	3.6	3.2	10.3	3.1
W9837 × 100H-236	4.2	4.0	3.1	11.3	3.7
MLG 3102 × Cikuray-435	3.9	4.0	3.2	11.1	3.9
Cikuray × W9837-181	3.1	3.4	2.9	9.4	2.6
Cikuray × W9837-184	3.6	3.6	3.0	10.2	2.8
W9837 × Cikuray-26	3.6	3.9	3.4	10.9	2.8
Detam 1	3.3	3.2	2.9	9.4	3.2
Mallika	2.7	3.3	2.9	8.9	2.7

Information:

Assesment score of color, aroma, and taste :	Thickness :
1 = dislike very much	1 = very thin
2 = dislike	2 = thin
3 = nor like nor dislike	3 = rather thick
4 = like	4 = thick
5 = like very much	5 = very thick

4. Conclusion

Genotype W9837 × Cikuray-66 had high seed yield (2.88 t/ha) and very early maturity day (75 days) has prospected to be developed in areas with limited irrigation in Indonesia or in the dry season. Genotype W9837 × Cikuray-66 has a soy sauce yield recovery of 834.85% with soy protein content of 1.91%.

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