Mutant promising lines of black-seeded soybean for soy sauce preparation

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Abstract. Mutation through radiation can be used in soybean breeding to generate the plant genetic variability. Some mutant promising lines of black-seeded soybean have been selected, namely PA-3-PSJ, A-5-PSJ, A-7-PSJ, and B-4-PAIR and it is essential to study their quality for soy sauce preparation. Detam 1 and Mutiara 3 were used as variety checks. The results showed that all soybean lines belonged to large-seeded with the largest seed obtained in A-7-PSJ line (17.41g/100-grain), while Detam 1 and Mutiara 3 had smaller seed sizes than those of four lines. Conversely, both varieties had the highest protein contents (38.56-39.36% dw), followed by A-7-PSJ (37.79% dw), whereas the rest had lower contents. A considerable increase in protein content was observed in the koji, which about 88% to 93% existed as soluble protein. The protein contents of soy sauce were slightly different, ranging from 2.35% to 2.57% (dw). Detam 1 showed the highest score for color, aroma, taste and viscosity of soy sauce preferences, followed by B-4-PAIR and Mutiara 3 that had the same score and A-7-PSJ, which also gave the highest protein content and had the largest seed size. This suggests that B-4-PAIR and A-7-PSJ lines are promising for ingredients of soy sauce.

1. Introduction
In terms of increasing the national soybean production, breeding is continuously performed in order to release new improved varieties with desired characters, particularly high yielding, resistant to main pest and disease attacks as well as tolerant to particular marginal soils. In addition, the physical and nutritional characteristics, such as seed size and color as well as protein content are also essential with respect to the use of soybean as ingredients for tempe, tofu, soy milk and soy sauce. Large and yellow-seeded of soybean is favored for tempe, yellow and small to large-seeded with high protein content (> 40% dw) is suitable for tofu and soymilk, while the black-seeded is particularly tailored for soy sauce preparation [1, 2].

In addition to conventional methods, mutation in soybean breeding is commonly performed to generate or modify the plant genetic variability in terms of release new varieties with desired traits [3, 4, 5]. Mutagenesis can be physically performed through X and gamma rays, UV light, neutron, alpha and beta particles, proton and neutron as well as using chemical agents, such as ethyl methane sulfonate (EMS) [6, 7]. Radiation using gamma ray has been extensively used for inducing mutations in plant breeding, including soybean. The effects of such radiation in accelerating the germination time, reducing chlorophyll and carotenoid contents in the leaves, increasing the plant height, seed yield per plant and 100-seed weight have been studied [5] as well as the morpho-agronomic characteristics [4], changing the seed color from yellow to black [7], increasing the protein content and...
quality, improving the plant resistance to disease, drought and cold [3]. Similar studies have been conducted in Indonesia with more concern on the specific characters, such as early maturity [8], high yield and protein content [9], tolerant to drought and saline soil [10, 11] and black-seeded soybean [12].

The National Nuclear Energy Agency of Indonesia (NNEAI) has released about 12 soybean varieties as a result of gamma ray application in breeding process [8, 13, 14]. Mutiara 2 dan Mutiara 3 are mutant black-seeded varieties derived from Cikuray variety using 200 gray of gamma ray [12]. Both varieties have higher yield potential and protein content as well as larger seed size compared to Cikuray [15) and suitable for ingredients of soy sauce [16]. In addition, four black-seeded varieties have been also released by the Ministry of Agriculture through conventional breeding, namely Detam 1 and Detam 2 (2008) with large seed size and high protein content (45-46% dw), followed by Detam 3 Prida and Detam 4 Prida (2013) which have shorter maturity (75-76 days). Previously, Merapi (1938), Cikuray (1992), and Mallika (2007) have been released with smaller seed sizes [15]. This reflects that the number of black-seeded soybean varieties is limited relative to yellow-seeded varieties. Therefore, NNEAI puts efforts on breeding new black-seeded varieties to improve the seed size and protein content of Detam 1 as the parent through mutation. About four mutant promising lines have been selected, thus need to be studied their physical and chemical characteristics to provide supportive data for variety description once they are released as new varieties.

It is obvious that black-seeded soy bean is highly preferred as an ingredient for soy sauce preparation due to its good color and taste as well as high protein content [1]. Some of soy sauce manufacturers in Indonesia maintain the quality of soy sauce using black seeded soybean [18]. The use of soybean for soy sauce and tauco (another salted-fermentation soybean product) constitutes about 14.7% of the total domestic need (3.5 million ton), the second rank after tempe and tofu (83.7%) with an annual increase rate of 5.7% [19, 20]. The consumption level of soy sauce is about 0.8 kg/capita/year and is projected to be as high as 0.95 kg/capita/year in 2021 [19]. In order to response such needs for soy sauce ingredient, more number of black-seeded soybean varieties with better desired characteristics (high yield and protein content with large seed size) is warranted, including the mutant varieties. Therefore, it is essential to study the quality of selected mutant promising lines derived from Detam 1 variety as ingredients for soy sauce in terms of enhancing their utilization by the food industry and adoption by farmers.

2. Materials and methods

Four mutant promising lines, namely PA-3-PSJ, A-5-PSJ, A-7-PSJ, and B-4-PAIR as a result of gamma ray application (400 Gray) toward Detam 1 variety and two check varieties (Detam 1 and Mutiara 3) were grown in Citayam, Bogor, West Java from October until January with optimal cultivation practices, including fertilizer application, weed, pest and disease controls. About 200 g of the seeds were processed into soy sauce in the Food Chemistry and Technology Laboratory of Iletri, Malang, East Java, Indonesia. The processing steps included soaking (12 h), boiling (2 h), spreading and cooling (3 h), inoculation of Aspergillus sojae powder culture with a concentration of 2 g/kg of soybean seed, covered with teak and banana leaves and let them fermented for 90 h at room temperature (first fermentation). The fermented seeds (koji) were then sun-dried and winnowed to separate the mold mycelia. The dried koji were soaked in brine solution (20% w/v) for one month (second fermentation). The fermented seeds (moromi) were pressed and filtered, then blended with brown sugar solution and spices, boiled for 7 min and finally filtered to obtain the sweet soy sauce.

The trial used a randomized complete design with four mutant lines and two varieties as the treatments and three replicates. Observations included the physical properties of soybean seed (100-seed weight and lightness/L*) and chemical composition: (a) moisture (gravimetric), ash (muffle furnace) and fat (Soxhlet) contents [21], (b) protein content using Micro Kjeldhal method [22] as well as the chemical composition of koji. The physical and chemical characteristics of soy sauce were analyzed as well as the sensorial acceptances toward color, aroma, viscosity, and taste using a Hedonic test with 22 untrained panelists. Samples of three commercial soy sauce sold in the market
were also observed as a comparison in this study.

3. Results and Discussion

3.1. Physical and chemical properties of soybean seeds

The 100-seed weight, which reflects the size of soybean seeds, significantly different between lines/varieties (Table 1). A-7-PSJ line had the largest seed size, followed by B-4-PAIR, A-3-PSJ and A-5-PSJ, while Mutiara 3 and Detam 1 showed the smallest seed size. According to [23], the soybean seed is grouped to be small if the weight is 8-10 g/100 seeds, medium for 10-14 g/100 seeds, and large for the weight > 14 g/100 seeds. Detam 1 and Mutiara 3 varieties, which was reported to have seed size of 14.8 g and 13.1 g/100 seeds, respectively [15], seemed to have smaller seed sizes at present study. This may due to a slight drought stress occurred in this study as well as differences in growing season and environmental conditions. Previous studies [24, 25] revealed that drought stress resulted in smaller size of the seed. However in such conditions, A-7-PSJ and B-4-PAIR lines yet showed larger seed sizes, particularly compared to Detam 1 as the parent. This trait is necessary from soybean production point of view as large seed size would increase the yield per ha of planted area.

The lightness color (L*) of soybean seed coat was significantly different between lines/varieties with the darkest color seen in Mutiara 3, followed by three lines (B-4-PAIR, A-7-PSJ, A-5-PSJ), while Detam 1 had the lightest color. The presence of anthocyanin pigment in the seed coat considerably dictated the soybean seed color intensity [7]. Genetic and growth environment conditions of the crop, particularly temperature and altitude would influence the anthocyanin content [26]. However, genetic factor is more likely predominant in this study as they were grown in the same location.

| Soybean line Varieties | 100-seed weight (g) | Lightness level (L*) | Moisture (%) | Ash (% dw) | Protein (% dw) | Fat (% dw) |
|------------------------|---------------------|---------------------|--------------|------------|----------------|------------|
| A-3-PSJ                | 14.05 c             | 38.33 b             | 6.86 a       | 5.97 a     | 35.68 c        | 16.70 a    |
| A-5-PSJ                | 13.90 c             | 37.13 c             | 6.46 b       | 5.69 b     | 35.47 c        | 16.66 a    |
| A-7-PSJ                | 17.41 a             | 36.73 c             | 6.27 b       | 5.77 b     | 37.79 b        | 15.31 b    |
| B-4-PAIR               | 15.23 b             | 36.73 c             | 6.21 b       | 5.62 b     | 35.30 c        | 17.06 a    |
| Detam 1                | 12.52 e             | 40.03 a             | 6.73 a       | 5.96 a     | 38.56 ab       | 15.08 b    |
| Mutiara 3              | 13.29 d             | 35.87 d             | 6.87 a       | 5.97 a     | 39.36 ab       | 15.59 b    |

CV (%) 1.66 1.07 2.15 1.49 1.23 1.90
LSD 5% 0.43 0.73 0.26 0.16 0.82 0.55

Values followed by the same letters are not significantly different (P<0.05)
dw = dry weight, L*: Lightness level that ranges from dark/black (0) to light/white (100)

The moisture contents of soybean seeds ranging from 6.21 to 6.87% (Table 1) have met the national quality requirements for soybean, c.a. <12% [27]. A slight variation of ash content was noted between soybean lines/varieties with a range of 5.62-5.97% dwb (Table 1). This figure was yet in the range of ash contents of five black soybean varieties (5.13-5.72%) [16]. Ash content is highly influenced by the mineral content of seeds, such as calcium, phosphate, sodium, potassium, iron, and magnesium which may differ between varieties and growth environment [28, 29].

Significant differences in seed protein contents occurred between soybean lines/varieties (Table 1) with the highest values seen in Mutiara 3 and Detam 1, followed by A-7-PSJ, while the rest three lines gave the lowest values. In addition to genetic factor [30], the growing environmental factors, such as season, water availability and fertilizer application may affect the seed protein content [31, 32]. This can be seen in Detam 1 and Mutiara 3, which showed lower protein contents relative to the values listed in the variety description [15].

High protein content is needed for soy sauce ingredient in order to meet a minimum requirement...
value of 1% (fw) [33]. According to [34], soybean seed with protein content > 35% is suitable for soy sauce preparation. The protein contents of soybean in this study have met such value, however they were relatively lower compared to those of six black-seeded soybean varieties (37.66-42.56% dwb) [16] and five Korean black soybean varieties (41.4-43.9%) [26].

A slight variation in fat content was noted between soybean lines/varieties (Table 1). Three lines had the highest fat contents, while the lowest contents were seen in Detam 1, Mutiara 3 and A-7-PSJ. B-4-PAIR line which contained the lowest protein, in contrast had the highest fat content. Negative correlation between protein and fat contents ($r = -0.64$) was reported for 20 soybean genotypes tolerant to acid soil [35]. Similar fat contents (14.90-18.57% dw) were also reported for six black-seeded soybean varieties [16]. However, [26] reported slightly higher values, c.a. 17.7-21.8% in five black-seeded soybean varieties grown in Korea.

### 3.2. Chemical composition of koji

Table 2 presents that the moisture contents of koji were significantly different between lines/varieties. This may due to differences in fermentation rate as the amount of inoculated mold and fermentation time were the same for all treatments. Increased moisture content in koji is a result of fermentation process that produces heat and water vapor in anaerob condition. The results were approximately the same with the previous study [36] with a range of 57.16% to 60.60%. Meanwhile, the ash content did not change much compared to the initial contents in soybean seeds (Table 1). The ash content is likely decreased during soaking and boiling due to leaching out into the water, however the growth of mold may increase the ash content of koji.

| Soybean line/variety | Moisture (%) | Ash (% dw) | Protein (% dw) | Soluble protein (% dw) |
|----------------------|--------------|------------|----------------|------------------------|
| A-3-PSJ              | 55.50 c      | 6.11 a     | 53.21 a        | 49.34 a                |
| A-5-PSJ              | 57.76 bc     | 4.88 c     | 49.64 b        | 39.88 d                |
| A-7-PSJ              | 59.06 ab     | 5.69 ab    | 51.90 ab       | 46.23 bc               |
| B-4-PAIR             | 60.49 a      | 5.20 bc    | 45.56 c        | 41.05 d                |
| Detam 1              | 59.51 ab     | 6.00 a     | 53.00 a        | 47.05 b                |
| Mutiara 3            | 58.02 abc    | 5.78 a     | 51.05 ab       | 44.94 c                |

| CV (%)               |              |            |                |                        |
|                      | 3.05         | 6.65       | 3.90           | 1.45                   |
| LSD 5%               | 2.68         | 0.56       | 2.98           | 1.66                   |

Values followed by the same letters are not significantly different ($P<0.05$)
dw = dry weight

The protein contents of koji increased significantly compared to soybean seeds (Table 1) and significantly different between soybean lines/varieties (Table 2). The highest values were seen in A-3PSJ, Detam 1, A-7-PSJ, and Mutiara 3. Mutiara 3 and Detam 1, which had the highest seed protein contents also showed the highest protein contents of koji, followed by A-7-PSJ. However, koji of A-3PSJ had much higher content of protein compared to its seed protein content. This is greatly influenced by the activity of mold and the enzyme produced to hydrolize protein during fermentation. The protein contents of koji were relatively similar to those reported by [36] that ranged between 48.9% to 52.2% (dw) and slightly higher compared to those processed from three black-seeded soybean varieties, c.a. 44.69-46.78% (dw) [18].

There was a significant increase in soluble protein content of koji as a result of protein hydrolysis by protease produced by A. sojae, which is mostly in the form of amino acids. Amino acids have higher bioavailability than protein, thus they can be directly absorbed by the body. The soy sauce prepared from A-3-PSJ showed the highest soluble protein content, followed by A-7-PSJ and Detam 1. Meanwhile, the lowest soluble protein content was observed in A-5-PSJ and B-4-PAIR. This may
due to the ease of koji protein hydrolysis that is associated with the profile of protein and the length of protein molecular chain. Previous study reported a slightly lower of soluble protein content in koji, c.a. 32.5% to 41.5% (dw) [36] with a shorter fermentation time (48-72 h) compared to this study (90 h).

3.3. Physical and chemical properties of sweet soy sauce

The moisture contents of soy sauce prepared from five soybean lines/varieties varied from 29.26% to 31.09% (Table 3). Previously, [16] reported similar moisture contents of soy sauce prepared from five black-seeded soybean varieties, c.a. 26.84-30.43%. As a comparison, three commercial soy sauce had a slightly lower moisture content (25.15-29.97%) (Table 3). A study on soy sauce made from Detam 1, Detam 3 Prida, and Detam 4 Prida varieties by two commercial manufacturers also showed different levels of moisture that ranged from 32.9-33.4% and 25.0-25.97%, respectively [18]. The boiling time and amounts of soluble solids in the filtrate, particularly protein and starch considerably affected the moisture content of soy sauce as well as the concentration of salt solution used in the second fermentation and sugar solution added to the filtrate.

Table 3. Chemical and physical properties of soy sauce prepared from six black-seeded soybean lines/varieties

| Soybean line/variety | Moisture (%) | Protein (% fw) | Protein (% dw) | Volume (mL) a | Lightness level (L*) | Viscosity (cps) |
|----------------------|--------------|----------------|---------------|---------------|---------------------|-----------------|
| A-3-PSJ              | 30.97 ab     | 1.75 a         | 2.54 ab       | 1957.5 a      | 23.1 a              | 481.3 d         |
| A-5-PSJ              | 31.09 a      | 1.62 b         | 2.35 c        | 1943.5 a      | 22.8 a              | 481.3 d         |
| A-7-PSJ              | 31.09 a      | 1.77 a         | 2.57 a        | 1991.5 a      | 22.6 a              | 431.3 cd        |
| B-4-PAIR             | 29.64 cd     | 1.78 a         | 2.53 ab       | 1795.0 a      | 23.0 a              | 580.0 bc        |
| Detam 1              | 30.23 bc     | 1.73 a         | 2.49 b        | 1763.5 a      | 22.6 a              | 612.5 b         |
| Mutiara 3            | 29.26 d      | 1.76 a         | 2.50 b        | 1683.0 a      | 23.0 a              | 912.5 a         |
| CV (%)               |              |                |               |               |                     |                 |
| LCD (%)              | 0.76         | 0.04           | 0.06          | ns            | ns                  | 67.9            |
| Soy sauce 1 b        | 25.80        | 0.93           | 1.26          | -             | 21.7                | 1150            |
| Soy sauce 2 b        | 25.15        | 0.69           | 0.92          | -             | 22.0                | 1483            |
| Soy sauce 3 b        | 29.97        | 0.95           | 1.36          | -             | 21.3                | 425             |

Values followed by the same letter are not significantly different (P<0.05)
fw = fresh weight, dw = dry weight, ns = not significant; cps = centipoise
L*: brightness level from the range of dark/black (0) to light/white (100)
a obtained from 200 g of soybean seeds
b commercial soy sauce

A slight difference in soy protein content was observed between treatments (2.35-2.57% dw) (Table 3). In addition to seed protein content, the protein contents of both koji and filtrate highly contribute to the final protein content of soy sauce [16]. However, 2-4% differences in seed protein contents between lines/varieties only gave a slight effect on the protein contents of soy sauce produced. The same phenomenon was also observed on soy sauce prepared from Detam 1, Detam 3 Prida, and Detam 4 Prida varieties [18]. A slightly higher of soy sauce protein contents than this study (2.60-2.91% bk) was reported from five black-seeded soybean varieties that could be related to higher protein content of the seeds (37.66-42.56% dw) [16].

The national quality standard for soy sauce established a minimum protein content of 1% (fw) for sweet soy sauce [33]. The soy sauce produced in this study with a protein content of 1.62-1.78% (fw) (Table 3) has met such requirement. Three commercial soy sauce samples showed lower protein contents (0.69-0.95% fw) relative to present study (Table 3). Similar findings were also noted for five, two and 30 commercial soy sauce samples that had protein contents of 0.44-1.23% (fw), 1.2% (fw),
0.68-1.83% (fw), respectively [18, 16, 37]. Fermentation process, the ratio of filtrate to sugar solution, the spices used and boiling time may be attributed to such differences in protein content of soy sauce.

The volumes of soy sauce ranged from 1763.5 up to 1991.5 mL, however they were not significantly different for all treatments (Table 3), as the volume of filtrate, sugar solution and boiling time applied were the same. The volume of soy sauce is related to its economic value because it would affect the yield of soy sauce produced per unit weight of soybean seed. Meanwhile the viscosity is slightly different, that may be affected by the volume and moisture content of soy sauce as the highest level of viscosity was seen in Mutiara 3 soy sauce. The viscosity levels were within the range values of commercial soy sauces (Table 3) that highly varied depending upon the ratio of filtrate to sugar solution, type and concentration of sugar used, and boiling time [18].

There was no significant difference in the lightness color of soy sauce (L*) between soybean lines/varieties (Table 3), even though Mutiara 3 had the darkest seed coat color (Table 1). The higher the L* value, the lighter the soy sauce color and is less preferred. Similar L* values (22.23-23.47) were also reported for soy sauce prepared from five black-seeded soybean varieties [16]. However, the commercial soy sauce had a slightly darker color compared to those of present study (Table 3), as well as five commercial soy sauces reported by [18] with L* values of 20.96-21.97. In addition to the color of soybean seed coat, the final color of soy sauce is considerably influenced by the color of the filtrate, types of spices and sugar, sugar solution, and the possibility of using food colorant [18, 37].

3.4. Sensorial attributes of soy sauce

The soy sauce colors of A-5-PSJ, A-7-PSJ, and B-4-PAIR lines as well as Detam 1 and Mutiara 3 varieties were moderately liked, but A-3-PSJ soy sauce was slightly liked (Table 4). This may due to the colors that were marked as slightly dark, while the commercial soy sauce, particularly soy sauce 1 and 2 were dark (Table 4). However, the commercial sauce yet had the same criteria of color preference with those prepared in this study (moderately liked). This suggests that the soy sauce colors prepared in this study were well accepted as the commercial soy sauce.

The aroma of soy sauce produced from A-7-PSJ, B-4-PAIR, Detam 1 and Mutiara 3 were moderately liked, relatively the same as the aroma of commercial soy sauce 1 and 2 (Table 4). The other two soy sauces (A-3-PSJ and A-5-PSJ) were slightly liked. In addition to the aroma of fermented filtrate, the aroma of soy sauce is also influenced by the type of spices and sugars added, particularly the cooked sugar (caramel) [18].

The taste scores of soy sauce were slightly liked for all treatments (Table 4) and similar to those of commercial soy sauce 2 and 3, while the commercial soy sauce 1 was fairly liked. This reflects that the taste of soy sauce produced in this study was approximately similar to soy sauce sold in the market. The taste of sweet soy sauce is particularly dictated by soybean variety, the flavor components of the fermented filtrate, especially glutamic acid as well as by the types of spices and sugars added to the soy sauce [34]. According to panelists, soy sauce taste in this study was slightly salty, thus less preferred compared to those prepared from five black soybean varieties [16]. Soy sauce is normally not consumed alone, but as a condiment for food ingredients or consumed together with other foods, thus the level of saltiness would highly affect the panelists' preferences. Therefore, a decrease in salt concentration for second fermentation might need to be observed in future studies. Optimal salt concentration applied was 17-19% [37], thus can be slightly reduced as 20% was used in this study.

| Soybean line/variety | Preference score of a | Total of preference score | Evaluation score of a |
|----------------------|-----------------------|--------------------------|-----------------------|
|                      | Color b               | Aroma b                  | Taste b               | Viscosity b | Color c | Viscosity d |
| A-3-PSJ              | 3,4                   | 3,3                      | 2,8                   | 2,6         | 12,1    | 2,8        | 2,6        |
| A-5-PSJ              | 3,5                   | 3,4                      | 2,7                   | 3,1         | 12,7    | 2,9        | 2,7        |
| A-7-PSJ              | 3,5                   | 3,6                      | 2,7                   | 3,1         | 12,9    | 3,0        | 2,7        |
B-4-PAIR  3.5  3.6  2.8  3.4  13.3  3.1  2.9  
Detam 1     3.6  3.5  2.9  3.7  13.7  3.1  3.5  
Mutiara 3   3.6  3.5  2.6  3.6  13.3  2.9  3.5  

| Soy sauce 1  | 4.1 | 4.1 | 4.0 | 4.3 | 16.5 | 4.4 | 4.2 |
| Soy sauce 2  | 3.8 | 3.7 | 3.0 | 3.8 | 14.3 | 3.8 | 3.8 |
| Soy sauce 3  | 3.6 | 3.3 | 3.4 | 3.4 | 13.7 | 2.9 | 2.9 |

a The value is a mean score of 22 panelists  
b Score for color, aroma, taste and viscosity:  
c Color/appearance:  
d Viscosity:  
1: Very disliked  
2: Disliked  
3: Slightly liked  
4: Moderately Liked  
5: Very liked  

The value is a mean score of 22 panelists  

The soy sauce processed from four soybean lines was considered slightly viscous and therefore was slightly liked by panelists and relatively had the same score as the commercial soy sauce 3 (Table 4). Meanwhile the soy sauce from Detam 1 and Mutiara 3 varieties was viscous and moderately liked, giving the same scores as the commercial soy sauce 1 and 2. This was in accordance with the viscosity values measured for each soy sauce (Table 3). Previous study [18], also reported varying levels of viscosity that was slightly viscous to viscous for five commercial soy sauces. This suggests that the soy sauce at present study had similar viscosity levels with those of selected commercial soy sauces in the market.

Based on the overall evaluation, Detam 1 showed the most preferred soy sauce in terms of color, aroma, taste, and viscosity, followed by B-4-PAIR which had the same total score as Mutiara 3, then A-7-PSJ, A-5-PSJ, and A-3-PSJ, which had the lowest total score (Table 4). The soy sauces prepared from four soybean lines were less viscous than those processed from Detam 1 and Mutiara 3 varieties. This can be improved through prolonged the boiling time (± 1 min) in order to be more viscous. Meanwhile, the scores for soy sauce color were relatively the same for all lines/varieties. A-7-PSJ and B-4-PAIR were also superior in soy sauce protein contents that were slightly higher than those of Detam 1 and Mutiara 3 (Table 3).

4. Conclusion
B-4-PAIR and A-7-PSJ mutant black-seeded soybean lines are promising for soy sauce ingredients based on their sensorial attributes and protein contents as well as the larger seed sizes compared to their parent Detam 1. In addition to their agronomic superiority, this information would be useful as a supportive data for the release of new soybean variety.

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