Yield quality and performance of three strains black rice from gamma ray irradiation

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Abstract. Black rice is one of the local Indonesian rice varieties contains high anthocyanins. This research used the treatment of three different strains resulting from gamma ray irradiation (strain 8, 44 and 51) and control (without irradiation). The data was analyzed descriptively and qualitatively to compare three strains of black rice irradiated by gamma ray with control (without irradiation). The result showed that the three strains of black rice “Cempo Ireng” irradiated by gamma ray had better yield quality and performance compare to control (without irradiation). Strain 44 was the strain with the highest anthocyanin content of 75.11 ppm and the best performing strain (organoleptic score of 3.53 and seed pericarp color of 4). Strain 51 had the best amylose content (8.43%), the highest protein content (7.48%), the highest fat content (1.59%), the best vigor (80%) and seed viability (64%).

1. Introduction

Black rice “Cempo Ireng” is one of the local Indonesian rice varieties that contains high anthocyanins. The anthocyanins content of black rice is found in the pericarp, aleurone and endosperm layer that are deep red-blue-purple [1]. Anthocyanins are antioxidant compounds that have the potential to increase the body’s resistance to diseases such as inhibiting tumor cells, preventing diabetes, preventing premature aging, preventing obesity, increasing brain memory, warding off free radicals, as anti-inflammatory and anticancer compounds [2]. Black rice (Oryza sativa L.) has weaknesses including the protein content of black rice (7.917%) lower than white rice (8.167%) [3], the amylose content is high at 25.49% which causes the texture of the rice to become dry [4].

Based on these problems, there are several ways to solve the problem of black rice. One of the modern ways to improve yield quality and reduce the weakness of black rice is by mutating plants using gamma ray irradiation. The use of gamma ray irradiation can help in the process of plant breeding. Radiation is an illumination of radioactive light that can cause mutations. Mutations with radiation can increase genetic variation. Cells exposed to irradiation will experience changes between genotypes and the condition of the plat when irradiated varies greatly [5]. The purpose of this study was to obtain information on the yield quality and the performance of three strains (8, 44 and 51) of black rice Cempo Ireng M7 generation as a result of gamma ray irradiation.
2. Materials and methods
The research was conducted from December 2019 – January 2021. Black rice cultivation was conducted in the Faculty of Agriculture Experiment Field located in Ngijo Village, Tasikmadu District, Karanganyar Regency with upwards of 157.6 meters above sea level. The quality of the result was conducted in Chem-Mix Pratama Laboratory Jambidan Village, Banguntapan District, Bantul Regency, Special Region of Yogyakarta. The experiment used a different treatment of strains consisting of 4 treatments, namely 3 strains of black rice *Cempo Ireng* gamma ray irradiation results (strains 8, 44, and 51) and black rice *Cempo Ireng* without gamma ray irradiation (control) as a comparison. The preparation of the experiment strain without a replay. Each strain used *jajar legowo* 8:1 system (every 8 rows of plants interspersed with 1 empty row with a width of twice the row), with a spacing of 24 cm x 24 cm. Determination of research samples in the paddy field was used simple random sampling techniques by selecting 30 plants per strain. The quality test of the results included anthocyanin content (spectrophotometry method), amylase content (spectrophotometry method), protein content (kjeldahl method), fat content (soxhlet method), vigor and seed viability (red brick method), organoleptic (panelist preference level test method) and seed pericarp color (scoring method) can be seen at Table 1. The data were analyzed descriptively and qualitatively to compare the three strains of black rice irradiated gamma ray with the strain without gamma ray irradiation (control).

| Characteristic | Score | Traits |
|---------------|-------|--------|
| White         | 0     | White color domination in one grain of rice 100%, categorized as White |
| White-Brown   | 1     | White color domination in one grain of rice ≥ 50% than brown color, categorized as White-Brown |
| Brown-Black   | 2     | Brown color domination in one grain of rice ≥ 50% than black color, categorized as Brown-Black |
| Black-Brown   | 3     | Black color domination in one grain of rice ≥ 50% than brown color, categorized as Black-Brown |
| Black         | 4     | Black color domination in one grain of rice 100%, categorized as Black |

Source: [6]

3. Results and discussion
3.1. Anthocyanin content
Anthocyanins are color pigments contained in pericarp, aleurone and endosperm. According to Samber *et al.* [7] anthocyanins are flavonoid compounds that have the ability as antioxidants that have the potential to increase the body's resistance to disease, warding off free radicals, as anti-inflammatory and anticancer compounds. The results of the anthocyanin content can be seen in Table 2.

| Strain | Anthocyanin Content | Average (ppm) |
|--------|---------------------|---------------|
|        | Deuteronomy 1 | Deuteronomy 2 |                  |
| GH 8   | 73.45               | 71.03          | 72.24            |
| GH 44  | 74.90               | 75.31          | 75.11            |
| GH 51  | 66.33               | 62.16          | 64.25            |
| Control| 45.21               | 44.39          | 44.8             |
According to Nandariyah et al. [8] the anthocyanin content is a very important chemical content to know, because the higher anthocyanin content in black rice, darker the color of the pericarp. The application of gamma ray irradiation had the effect of increasing the anthocyanin content of the control (without irradiation). Based on Table 2, it can be seen that the highest anthocyanin content was found in the GH 44 at 75.11 ppm, and the lowest anthocyanin content was found in control at 44.8 ppm. Based on the data obtained that the increase in the anthocyanin content in black rice caused by gamma ray irradiation is supported by research conducted by Rahmawati et al. [9] which states that the dose of gamma ray irradiation in black rice Cempo Ireng gave the effect of increasing anthocyanin levels compared to plants without irradiation (control).

3.2. Amylose content
Amylose content in black rice determines the quality of rice. The content of amylose determines the properties of starch in black rice which will affect the taste of rice. The results of the amylose content can be seen in Table 3.

| Strain | Amylose Content | Average (%) |
|--------|-----------------|-------------|
|        | Deuteronomy 1   | Deuteronomy 2 |   |
| GH 8   | 9.83            | 9.89         | 9.86 |
| GH 44  | 9.86            | 9.89         | 9.88 |
| GH 51  | 8.4             | 8.46         | 8.43 |
| Control| 11.84           | 11.77        | 11.81|

Gamma ray irradiation treatment give effect to the result of the amylose content. Table 3, shows that the results of the analysis of amylose content in black rice Cempo Ireng with gamma ray irradiation were lower than plants without irradiation (control). The highest amylose content was found in the control at 11.81%, while the lowest amylose content was found in the GH 51 at 8.43%. The decrease in the amylose content of black rice due to gamma ray irradiation was proven by research conducted by Masruroh et al. [10] which states that gamma ray irradiation treatment causes a decrease in amylose content from 14.41% to 12.84%. The decrease in amylose content according to Mardiah et al. [11] this affects the texture of rice, namely the smaller the amylose content, the soft and sticky texture the rice obtained. The higher the amylose content of rice will be dry the texture of rice. It was concluded that the black rice GH 51 had a fluffier rice texture, while the control (without irradiation) had a dry texture.

3.3. Protein content
One of the nutritional contents that reflects the yield quality of black rice is the protein content. The results of the protein content can be seen in Table 4.

| Strain | Protein Content | Average (%) |
|--------|-----------------|-------------|
|        | Deuteronomy 1   | Deuteronomy 2 |   |
| GH 8   | 6.97            | 6.96         | 6.96 |
| GH 44  | 6.62            | 6.68         | 6.65 |
| GH 51  | 7.12            | 7.84         | 7.48 |
| Control| 6.97            | 6.93         | 6.95 |

Table 4, shows that the dose of gamma ray irradiation increased the protein content of black rice. The largest protein content was found in the GH 51 of 7.48%, while the lowest protein content was...
found in the GH 44 of 6.65%. The increase in the protein content of black rice is evidenced by the research of Putri [12] which said that the irradiation treatment on black rice "Cempo Ireng" caused a significant increase in protein content and increased with increasing irradiation dose. Based on the data obtained, it was shown that the protein content of the GH 44 was 0.3% lower than the control (without irradiation). One of the factors causing the decrease in protein levels is genetic traits. This is stated by Baye et al. [13] that the chemical composition of seeds such as proteins and lipids is more influenced by genetic traits.

3.4. Fat content
Fat content in rice is one of the nutritional contents that reflects the yield quality of black rice. So that the damage to fat results in a decrease in the quality of rice. Hermanto et al. [14] stated that fat is an important food substance that functions to maintain the health of the human body, because fat serves as an energy source, dissolves vitamins so that it is absorbed by the intestines, and prolongs satiety. The results of the fat content can be seen in Table 5.

| Strain   | Fat Content   | Average (%) |
|----------|---------------|-------------|
|          | Deuteronomy 1 | Deuteronomy 2 |     |
| GH 8     | 1.55          | 1.62         | 1.58 |
| GH 44    | 1.61          | 1.42         | 1.52 |
| GH 51    | 1.59          | 1.58         | 1.59 |
| Control  | 1.55          | 1.55         | 1.55 |

Table 5. shows that the dose of gamma ray irradiation can affect the fat content of black rice. This is evidenced in the research of Istanti et al. [15] that the application of gamma ray irradiation was able to increase the fat content of black rice from 2.5% to 2.6%. The largest fat content was found in the GH 51 at 1.59% while the lowest fat content was found in the GH 44 of 1.52%.

3.5. Vigor and seed viability
The use of gamma ray irradiation techniques in agriculture is an effort to increase productivity. Bramasto et al. [16] stated that increasing productivity starts from seed, that increases the vigor and seed viability. Hence, this irradiation technique is used as a seed treatment. Vigor and seed viability are elements in determining the physiological quality of seeds. The results of the DK and KK can be seen in Table 6.

| Strain   | DK (%) | KK (%) |
|----------|--------|--------|
| GH 8     | 71     | 54     |
| GH 44    | 55     | 41     |
| GH 51    | 80     | 64     |
| Control  | 29     | 25     |

Table 6. shows the effect on germination power and germination speed due to gamma ray irradiation treatment. The highest germination power and speed was found in the GH 51 of 80% and 64% while the lowest germination power and speed was found in the control of 29% and 25%. The increase in the value of germination power and speed of black rice “Cempo Ireng” result from gamma ray irradiation is in accordance with research by Nurrachmamila and Saputro [17] which concluded that the dose of gamma ray irradiation gave the effect of increasing percentage compared to plants without a dose of gamma ray irradiation. The increase percentage of germination according to Minisi
et al. [18] can increase oxygen absorption so that it has a direct effect on breaking dormancy.

3.6. Organoleptic test

One way to determine the yield quality of black rice Cempo Ireng as a result of gamma ray irradiation is by using organoleptic tests. Organoleptic test was conducted to determine the level of consumer preference for the color, scent, taste and texture of black rice Cempo Ireng. In general, organoleptic tests are subjective so they are closely related to consumer acceptance. Wuryani et al. [19] said in his research that although organoleptic tests are subjective, they are related to consumer acceptance. In this test 10 untrained panelists were represented, the panelists were students of the Faculty of Agriculture, Sebelas Maret University. The scale used is 1 (dislike), 2 (less likes), 3 (like), 4 (prefer) and 5 (very likes). The results of the organoleptic test can be seen in Table 7.

Table 7. The average scores of organoleptic tests of black rice (Oryza sativa L.) the results of gamma ray irradiation and without irradiation.

| Strain | Color | Scent | Taste | Texture | Average |
|--------|-------|-------|-------|---------|---------|
| GH 8   | 4     | 2.7   | 3.3   | 3       | 3.25    |
| GH 44  | 4.8   | 3.3   | 3.3   | 2.7     | 3.53    |
| GH 51  | 3.2   | 2.4   | 3.4   | 3.5     | 3.13    |
| Control| 2.2   | 2.8   | 2.9   | 2.1     | 2.50    |

Table 7. shows that the highest average color scoring result are found in the GH 44 of 4.8 and the lowest is found in the control of 2.2. So, the color parameters are related to the anthocyanin content in black rice. This is in accordance with the research Kristamtini et al. [20] that the higher the anthocyanin content value, the more purple / black the color of rice. Table 7. shows that the highest average scent scoring result are found in the GH 44 of 3.3 and the lowest is found in the GH 51 of 2.4. Table 7. shows that the highest average taste scoring result are found in the GH 51 of 3.5 and the lowest is found in the control of 2.9. Table 7. shows that the highest average texture scoring result are found in the GH 51 of 3.5 and the lowest is found in the control of 2.1. Texture parameters are related to the content of amylose in black rice. This is in accordance with research conducted by Luna et al. [21] that rice with low amylose content is soft and sticky texture, while rice with high amylose content then dry texture. After testing the 4 parameters of organoleptic test, there is an overall favorite value. According to the panelists, black rice Cempo Ireng GH 44 most preferred of 3.53.

3.7. Seed pericarp color

Pericarp is a thin layer that covers the entire seed. The results of the seed pericarp color can be seen in Table 8. The color of each strains seed pericarp can be seen in Figure 1.

Table 8. The color of black rice seed pericarp (Oryza sativa L.) the result of gamma ray irradiation and without irradiation.

| Strain | Seed Pericarp Color |
|--------|---------------------|
| GH 8   | 3.0                 |
| GH 44  | 4.0                 |
| GH 51  | 3.0                 |
| Control| 2.0                 |

Figure 1. The color of the black rice seed pericarp “Cempo Ireng” with a different strains number.
Table 8 and Figure 1 shows that the seeds pericarp colors of the strains were darker than the control (without irradiation). The larger of the number, then the darker seed pericarp color, so it can be known that the GH 44 has a darker color. This is supported by Rahmawati et al. [9] in her research that GH 44 has a darker pericarp color than to other strain. GH 8 and GH 51 showed the number 3.0, which means that the pericarp color dominates the color black compared to brown, then called blackish brown. The control (without irradiation) shows the number 2.0 which means that the pericarp color dominates the color brown compared to black, so it is called brownish black It was concluded that the administration of gamma ray irradiation dose influenced the density of seed pericarp color. The color of seed pericarp is related to the large content of anthocyanins in black rice.

4. Conclusion
The quality and performance of the results of the three strains black rice “Cempo Ireng” generation M7 gamma ray irradiation results showed better compared to strain without gamma ray irradiation (control).

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