Chemical and sensory properties of local Aceh rice (Oryza sativa L.) M4 mutant resulting from Gamma-ray irradiation

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Abstract. The chemical characteristic of Aceh local rice (Oryza sativa L.) is largely determined by the moisture content, protein, ash and amylose. On the other hand, sensory indispensable to determine the level of acceptance of a product. This study aims to determine chemical analysis and sensory of Aceh local rice mutant M4 from gamma-ray irradiation results. The results showed that M4 mutant rice had a very significant effect on the chemical characteristic, amylose and protein, and significantly affected to the ash content. The best amylose content was the USK-Snb-RGO-238-063-057e-217 strain, while the protein content in rice was USK-Snb-RGO-238-094-088j-140 and the best ash content was USK-Snb-RGO-238-016-057d-106. The Aceh local rice mutant M4 has a significant effect on inner color, outer color, texture and overall acceptence and has a significant effect on the shape of rice. The rice received by the panelists, namely rice USK-Snb-RGO-238-063-057e-217.

1. Introduction

Rice (Oryza sativa L.) is one of the food plants that functions as a staple plant besides wheat and corn in Indonesia. Rice contains nutrients needed by the body such as carbohydrates (46.45%), protein (2.09%), water (49.15%) and fat (2.05%) [1]. The average consumption of rice is 139 kg/capita/year with a total rice requirement 32.66 million tons/year. Increasing in population causes an increase in rice demand [2]. It is necessary to make new varieties that can improve the quality of rice in the future to make ends meet. Therefore, breeding technology is needed that can meet these criteria. One of the well-known breeding technologies today is the chromosome mutation induction using irradiation. According to [3] mutation induction using irradiation is able to produce the most mutants (around 75%) rather than using other methods and one of the uses of irradiation technology is gamma rays. Gamma-ray irradiation of Aceh local varieties is still quite done by researchers. Aceh local varieties of rice have advantages such as greater yield potential [4] and potential results and physicochemical characterisation of M3 mutants [5] Local rice varieties are rice varieties that are able to adapt to be tolerant of various biotic and abiotic stresses. Local rice varieties have a good taste and are in accordance with the tastes of the local community [6].

Sensory assessment is an important tool for measuring product characteristics and determining product acceptance. Sensory assessment is done because there is a product that does not have a prototype, so producers need information about sensory quality and product acceptance as inputs in marketing. Sensory assessment of Aceh local rice mutant M4 results from gamma irradiation is needed by the people in Aceh Province to find out the relationship between chemical analysis and sensory responses.
Therefore, this study aims to determine the chemical analysis and sensory testing of Aceh local rice mutant M4 is resulting from gamma-ray irradiation. The data obtained in this study are very useful for the development of other Aceh local rice varieties in terms of quantity and quality.

2. Materials and methods

2.1. Place and time of research
This research was carried out at the Laboratory of Food and Agricultural Products Analysis, Faculty of Agriculture, Syiah Kuala University in Darussalam Banda Aceh, and the Laboratory of Food Science and Technology, Bogor Agricultural Institute (IPB). This research began from April - July 2018.

2.2. Tools and materials research
The tools that have been used in this study were: Digital Scales, Ruler, Mortar, Spectrophotometer, Sieve, Oven, Blenders, Pienometers, Porcelain Dish and Petri Dish.

2.3. Materials
This research used the Sambei Simeulue rice variety in Aceh Province, which consist of 5 strains, namely: USK-Snb-RGO-238-016-057d-106, USK-Snb-RGO-238-045-039e-103, USK-Snb-RGO-238-063-057e-217, USK-Snb-RGO-238-094-088j-140 and i-Snb Rice Sambei first parent as a control. The rice, which used for this research was obtained from the Faculty of Agriculture, Syiah Kuala University, which was cultivated with an organic system in the experimental garden, Faculty of Agriculture, Syiah Kuala University in Darussalam Banda Aceh. Besides that, the chemicals were used for analysis of amylase content, namely potato amylase, aquades, 9 ml NaOH 1M, 1 ml ethanol 95%, 0.2% iodine solution and 1N acetic acid, while the protein analysis were aquades, 2.5 g Kjeldahl, 10 ml sulfuric acid (H2SO4) 95 - 97%, 4% borax acid, 10 ml NaOH 45%, 0.1N sulfuric acid and 3 drops of the indicator mix (methyl red and broom gresol green).

2.4. Features extraction (colour, shape and texture)
This research used a Completely Randomized Design (CRD) non factorial with 3 replicates. The treatments studied were of a strain (G) which consists of 5 levels, namely: G0 = Sambei first parent i-Snb, G1 = USK-Snb-RGO-238-016-057d-106, G2 = USK-Snb-RGO-238-045-039e-103, G3 = USK-Snb-RGO-238-063-057e-217, and G4 = USK-Snb-RGO-238-094-088j-140. Based on 5 treatments with 3 replications, 15 units of experimental units were obtained. The data obtained were analyzed by the F test, using the mathematical model as follows:

\[ Y_{ij} = \mu + \tau_i + \beta_j + \epsilon_{ij} \]  

The comparison of the average treatment test in this research used the Least Significant Different test (LSD) at the level of 5%.

\[ \text{LSD}_{0.05} = t_{0.05} (\text{df}) \sqrt{\frac{2KTg}{r}} \]

2.5. Observation Parameters
2.5.1. Moisture content
Determination of moisture content is done by the oven method (Air Oven Method). Put the cup into the oven at 105 °C for 15 minutes and chilled it in the desiccator for 15 minutes. Then weighed the
weight of the empty cup and then put the sample into the cup and weighed it again. Put the cup containing the sample into the oven at 105 °C for 6 hours, then chilled it in the desiccator for 15 minutes and weighed the weight. Water content is calculated by using below:

\[
\text{\% water Content of Rice} = \frac{B-C}{B-A} \times 100\% 
\]

(3)

2.5.2. Protein Levels

Determination of crude protein content using the Kjeldahl method. This method is carried out in 3 stages, namely: destruction, distillation, and titration. The flour from the rice sample was weighed 0.50 g and then put into the Kjeldahl flask. Next, 2.5 g (0.5 grains) of catalyst (Kjeldahl tablet) and 10 ml of sulfuric acid (H2SO4) 95-97% were added to the Kjeldahl flask. On the destruction stage, the Kjeldahl digestion apparatus is used until the solution in the flask becomes clear and soaked in running water until it is cold. The results of the destruction were homogenized with 50 ml of distilled water, taken 10 ml and put into a distillation device with 10 ml of 45% NaOH added. Furthermore, the distillate is accommodated in the 50 ml erlenmeyer which has added 4% borax acid and 3 drops of the mix indicator (methyl red and broom gresol green) to the boundary mark. The distillation results are then titrated with 0.1N sulfuric acid to change color and note the amount of sulfuric acid that has been used for titration (titration number). Determination of protein content is calculated by the following equation:

\[
\text{\% N} = \frac{0,1N \times \text{Titration Number} \times 0,014 \times 6,25 \times 5}{\text{Sample Weight (g)}} \times 100\% 
\]

(4)

2.5.3. Ash content

Porcelain dish is inserted into the furnace at 5500 °C. Then chilled in the desiccator for 15 minutes. Weighed the empty cup weight, then put the sample into a cup and weighed the weight. The cup containing the sample was put into the furnace at 5500 °C for 5 hours. Then the cup was chilled in the desiccator for 15 minutes then weighed. The ash content is calculated by the following equation:

\[
\text{\% Ash Content} = \frac{D-A}{B-A} \times 100\% 
\]

(5)

2.5.4. Amylose

Amylase content test using iodine calorimetry method. Amylase content was measured by weighing quantitatively 100 mg of rice flour (particles > 80 mesh) which was put into a 100 ml volumetric flask. Add 1 ml of 95% ethanol and 9 ml of NaOH 1N respectively, and the solution is left for 23 hours at room temperature. The solution is then diluted by adding distilled water to a volume of 100 ml. Piped a solution of 5 ml of the solution put into a 100 ml volumetric flask, then added 2 ml of 2% iodine solution and 1 ml of 1N acetic acid then diluted again with distilled water. Measurement of the absorbance of the solution using a spectrophotometer at a wavelength of 620 NM. The same was done for making standard amylase from potato amylase ingredients and made at several levels of amylase concentration. Amylase rice levels are then calculated from the comparison of the sample absorbance measurements with the standard, multiplied by the dilution factor. Amylase content is calculated using the formula:
2.5. Sensory assessment [7]
Sensory assessment is done by the descriptive analysis method. The analysis is a sensory method on attributes by identifying and measuring, which used panelists who have been trained. It aims to determine the level of consumer acceptance of the product being tested, namely in the form of rice before cooked and rice after cooked. The quality attributes of rice (uncooked rice) tested were in the form of aroma, the color of the inner and outer rice, the texture, the shape and the overall level of acceptance of rice. The uncooked rice and cooked rice tested were given several strains of code for each sample, then questionnaires were presented to the panelists to be assessed using rice and comparable rice, namely from the first parent i-Snb. The panelists used were semi-trained panelists from 15 Syiah Kuala University students.

3. Results and discussion

3.1. Chemical characteristic of Aceh Local Rice
The results of the variance analysis (F test) showed that several mutant rice strains resulting from gamma-ray irradiation (M4) had a very significant effect on the chemical characteristic of rice, namely water, protein, amylase and significantly affected ash content.

Table 1. The Average Water Content, Protein, Ash Content, and Amylase of Some Aceh Local Rice Mutants M4 Results of Gamma-Ray Irradiation.

| Aceh Local Rice | Water Content (%) | Protein (%) | Ash Content (%) | Amylase (%) |
|----------------|------------------|-------------|-----------------|------------|
| i-Snb (G0)     | 11,95 <sup>bc</sup> | 7,13 <sup>a</sup> | 1,68 <sup>ab</sup> | 18,05 <sup>b</sup> |
| O-39e (G1)     | 11,04 <sup>a</sup>  | 7,76 <sup>b</sup>  | 1,79 <sup>b</sup>  | 17,33 <sup>a</sup> |
| O-57d (G2)     | 12,09 <sup>c</sup> | 8,66 <sup>c</sup> | 1,86 <sup>b</sup> | 17,54 <sup>a</sup> |
| O-57e (G3)     | 17,76 <sup>d</sup> | 7,24 <sup>a</sup> | 1,49 <sup>a</sup> | 18,51 <sup>c</sup> |
| O-88j (G4)     | 11,14 <sup>ab</sup> | 10,23 <sup>d</sup> | 1,46 <sup>a</sup> | 17,91 <sup>b</sup> |
| LSD <sub>0.05</sub> | 0.88 | 0.13 | 0.25 | 0.22 |

Description: Numbers followed by the same letters in the same column are not significantly different at the level of 5% (LSD 0.05).

The results of the variance analysis (F test) showed that several mutant rice strains from gamma-ray irradiation (M4) had a very significant effect on water content. The average water content of several mutant rice strains resulting from gamma-ray irradiation (M4) is seen in Table 1. The average water content obtained in the table is not significantly different from the O-88j (G4) strain with the O-57e (G3) strain, but is significantly different from the O-57d (G2), O-39e (G1) and i-Snb (G0) strains. The results of variance showed that the water content of the M4 strain had a very significant effect. The lower water content was found in the O-39e (11.04%) strain, while the highest water content was in the O-57e (17.76%) strain. Water content is influenced by drying temperature, the higher temperature the less water content obtained [8]. This is due to the faster evaporation process so that the loss of water components is getting faster. [9] shows that the best water content for rice storage is below 14%, while higher water content causes rice to be easily damaged microbiologically which affects shorter shelf life which can reduce its quality [10] and [8]. The results of variance analysis (F test) showed that several mutant rice strains from gamma-ray irradiation (M4) had a very significant effect on protein content.

The average protein content of several mutant rice strains resulting from gamma-ray irradiation (M4) in Table 1. The average protein content is shown in Table 1 which is significantly different from...
the O-88j (G4), O-57e (G3) strains, but differs not significantly from the O-57d (G2), O-39e (G1) and i-Snb strains (G0) strains. Rice protein is a secondary component for quality determination or quality. The results of testing the protein content obtained ranged from 7.24% - 10.23%. The high protein content was found in the O-88j (G4) strain, while the lowest protein content was found in the O-57e (G3) strain. The higher and lower levels of protein affect the quality of rice and taste because it inhibits water absorption [11], [12]. Rice with high protein content tends to produce hard rice [13] and yellowish white and not flavorful [14] However, rice with high protein content is very well consumed by children [15]. The results of the variance analysis (F test) showed that several mutant rice strains resulting from gamma ray irradiation (M4) significantly affected the ash content. The average ash content of several mutant rice strains resulting from gamma-ray irradiation (M4) can be seen in Table 1.

The average ash content of the O-88j (G4) strain is not significantly different from O-57e (G3), but is significantly different from the O-57d (G2), O-39e (G1) and i-Snb (G0) strains. Based on the testing of ash content that has been carried out on the M4 mutant strain resulting from gamma radiation obtained results of 1.46% - 1.86%. The aims of determination ash content is to determine the mineral content which contained during the initial process to form a product. In addition, it is also to control the level of pollution of organic compounds carried during the supply of food ingredients [16]. According to [17], the greater amount of ash produced from a food material proves that the worse the quality of the food. The M4 mutant strain from gamma-ray radiation was declared feasible as a food ingredient because it was in accordance with the Food and Drug Monitoring Agency standard, the ash content of a food was <4% [18].

The results of the variance analysis (F test) showed that several strains of mutant rice from gamma-ray irradiation (M4) had a very significant effect on amylase levels. The average amylase content of several mutant rice strains resulting from gamma-ray irradiation (M4) in Table 1.

The table above shows that the average amylase content was significantly different in the O-88j (G4), O-57e (G3) strain, but it was not significantly different from the O-57d (G2), O-39e (G1) and i-Snb (G0) strains. The results of the analysis showed that the average amylase content had a very significant effect on several M4 mutant strains resulting from gamma-ray radiation ranging from 17.33% - 18.51% (including low amylase levels). [19] state that amylase content is divided into 3, namely low amylase (8-20%), moderate amylase (21-25%) and high amylase (> 25%). Amylase content has an effect on the level of fluffier rice, the lower the amylase content, the higher the fluffier rice and the other way around [20]. Amylase content is influenced by water content, high water content can increase amylase levels and the other way around [21].

3.2. Sensory Assessment

The results of the variance analysis (F test) showed that several mutant rice strains resulting from gamma-ray irradiation (M4) had a significant effect on rice sensory attributes of inner color, outer color, texture and overall acceptance and had a very significant effect on the shape of rice, but were not significantly different from the aroma of rice. The average shape, aroma, inner color, outer color, texture and overall acceptance of several lines of the mutant rice from gamma-ray irradiation (M4) to the sensory rice can be seen in Table 2.

| Acceh Local Rice | Shape | Texture | Aroma | Inner Color | Outer Color | Overall Acceptance |
|------------------|-------|---------|-------|-------------|-------------|-------------------|
| i-Snb (G0)       | 8.67 a| 6.53 a  | 5.98  | 12.72 ab    | 17.41 bc    | 10.60 ab          |
| O-39e(G1)        | 8.33 a| 7.90 bc | 7.09  | 13.08 b     | 18.31 d     | 10.37 a           |
| O-57d(G2)        | 8.46 a| 6.37 a  | 7.17  | 12.25 a     | 16.62 a     | 11.62 bc          |
(G2) and O
or the receipt of rice in the market
s, the results of the study show that the
food reserve
be transparent or not is influenced by the comparison of the composition of starch, which is the main
compound obtained are also in accordance with the statement of
morphology caused by the release of the bran/aleurone layer from the grain of rice. The results
17.54% amyl (G2) strain, while the O
of the inside and outside of the rice. The whitest inner and outer color of the ric

g software, the panelists were given different rice samples of mutant rice strains from gamma irradiation (M4), it has the flavour of rice, which tends to
very important to improve the taste and attractiveness of a product. Based on the results of sensory
tests of several mutant rice strains from gamma irradiation (M4), it has the flavour of rice, which tends

Based on the results of the sensory testing of M4 mutant rice, it has a significant effect on the
sensory of inner color rice, outer color, texture and overall acceptance and has a very signific
Table 2 shows that the average shape in the sensory rice in the O-88j (G4) strain is significantly
different from O-57e (G3), but differs not significantly from i-Snb (G0), O-39e (G1) and O-57d (G2).
The average sensory texture of rice in the i-Snb (G0) strain with O-39e (G1) was not significantly
different, but was significantly different from O-57d (G2), O-57e (G3) and O-88j (G4). Whereas there
is no significant effect on the aroma of rice on the O-88j (G4) O-57e (G3), O-57d (G2), O-39e (G1)
and i-Snb (G0) strains. The average color of the sensory rice in the i-Snb (G0) and O-39e (G1) strains
was not significantly different, but was significantly different from the O-57d (G2), O-57e (G3) and
O-88j (G4) strains. The average sensory color of the i-Snb (G0) strain, O-39e (G1) and O-57d (G2)
strains are significantly different and not significantly different from the O-57e (G3) and O-88j (G4)
strains. The average reception of the whole sensory rice in the i-Snb (G0) strain with O-39e (G1) is
different, but not significantly different from O-57d (G2), O-57e (G3) and O-88j (G4).

Rice texture is one of the attributes that can affect its acceptance. Texture can be determined
through the surface area such as smooth, rough, hard or soft and oily [22]. Rice that has been stored
has a harder texture than the rice without storage [23]. The results of the rice texture test of several M4
mutant rice strains according to rice panelists with the hardest or roughest texture O-57d (G2), while
the texture is the most soft or oily O-88j (G4) strain. Another attribute that supports is the aroma of
rice.

The texture also affects the texture of rice.

Table 2 shows that the average shape in the sensory rice in the O-88j (G4) strain is significantly
different from O-57e (G3), but differs not significantly from i-Snb (G0), O-39e (G1) and O-57d (G2).
The average sensory texture of rice in the i-Snb (G0) strain with O-39e (G1) was not significantly
different, but was significantly different from O-57d (G2), O-57e (G3) and O-88j (G4). Whereas there
is no significant effect on the aroma of rice on the O-88j (G4) O-57e (G3), O-57d (G2), O-39e (G1)
and i-Snb (G0) strains. The average color of the sensory rice in the i-Snb (G0) and O-39e (G1) strains
was not significantly different, but was significantly different from the O-57d (G2), O-57e (G3) and
O-88j (G4) strains. The average sensory color of the i-Snb (G0) strain, O-39e (G1) and O-57d (G2)
strains are significantly different and not significantly different from the O-57e (G3) and O-88j (G4)
strains. The average reception of the whole sensory rice in the i-Snb (G0) strain with O-39e (G1) is
different, but not significantly different from O-57d (G2), O-57e (G3) and O-88j (G4).

Based on the results of the sensory testing of M4 mutant rice, it has a significant effect on the
sensory of inner color rice, outer color, texture and overall acceptance and has a very significant effect
on the shape of rice. Based on the results of rice shape, the more rounded shape is found in the O-57e
(G3) strain. Another attribute that supports is the aroma of rice.

It is influenced by genetic traits
that the rice grains contain protein
role of flavour is very important to improve the taste and attractiveness of a product. Based on the results of sensory
tests of several mutant rice strains from gamma irradiation (M4), it has the flavour of rice, which tends
to be fragrant, namely O-57d (G2) and O-88j (G4) strains. In addition, color attributes can also
determine. Color is the main attribute seen by the panelists. The color attribute is focused on the color
of the inside and outside of the rice. The whitest inner and outer color of the rice is found in the O-57e
(G3) strain, while the O-39e (G1) and O-88j (G4) strains are yellow. O-88j (G4) protein and amylase
levels were higher (10.23% protein and 17.91% amylase) than O-57d strains (8.66% protein and
17.54% amylase). According to [20] the white color of rice is determined by the degree of
morphology caused by the release of the bran/aleurone layer from the grain of rice. The results
obtained are also in accordance with the statement of [27] that the rice grains contain protein
compounds which found in the aleurone and pericarp layers. The determination of the color of rice to
be transparent or not is influenced by the comparison of the composition of starch, which is the main
food reserve [28], [29], [30]. Based on the agreed attributes, the results of the study show that the
overall panelists chose rice on the O-57e (G3) strain.

\[ \begin{array}{cccccc}
\text{O-57e(G3)} & 12.4^b & \text{7.12 } & \text{6.85} & \text{12.67 } & \text{17.48 } \\
\text{O-88j(G4)} & 7.75^a & \text{8.62 } & \text{7.16} & \text{13.18 } & \text{17.26 } \\
\text{LSD }_{0.05} & 1.43 & 1.51 & \text{bc} & 0.54 & 0.62 \\
\end{array} \]

Description: Numbers followed by the same letters in the same column are not significantly different
at the level of 5% (LSD 0.05).
4. Conclusions
Based on the results of the study, the best chemical characteristics amylase is an O-57c strain (18.51%), protein content O-88j strain (10.23%) and the best ash content O-57d strain (1.86%). Sensory test, rice received by the panelists, namely O-39e (12.88) and O-57d (12.89) strains, while rice received by the panelists is O-57e (12.89) strain.

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