Characterization of rice physicochemical properties local rice germplasm from Tana Toraja regency of South Sulawesi

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Abstract. The research about the characterization of physicochemical properties from local rice germplasm of Tana Toraja’s Regency, South Sulawesi aims to determine the physicochemical properties of rice as a parameter to indicate the quality of cooking. Local varieties categorized as germplasm that needs to be protected for future varietal improvement. In this research, the researchers used seven varieties of local rice. The parameters analyzed including physicochemical properties of amylose content, protein content, gel consistency, and gelatinization temperature. Percentage of amylose content ranged from 2 to 18 %. Pare Bumbungan and Pare Lalodo are categorized as waxy rice and Pare Ambo, Pare Bau, Pare Kobo, Pare Rogon and Pare Tallang are categorized as low amylose content. The percentage of protein content ranged from 7.3 to 9.5 %. Gelatinization temperature of rice showed high gelatinization temperature. Pare Bumbungan, Pare Kobo, Pare Lalodo, and Pare Rogon are categorized as soft gel consistency (>50 mm). Pare Ambo, Pare Bau and Pare Tallang are categorized as medium gel consistency (36-50 mm). Pare Rogon and Pare Kobo are two kinds of rice varieties according to the quality of cooking criteria for consumers in Indonesia.

1. Introduction
Rice (Oryza sativa L.) is the carbohydrate sources consumed by humans. Increased productivity of rice plants is needed to fulfill these needs. Agricultural productivity is related to the potential of genetic varieties. Assembling of new varieties requires the availability of germplasm with a wide genetic diversity to be used as a crossing parent. Local varieties, in this case, local rice is categorized as germplasm that needs to be protected for future varietal improvement. The disappearance of existing local rice varieties is considered to threaten its genetic diversity. In fact, localized seed erosion local varieties of local rice varieties will disappear. Identification and description of the existence of local rice are necessary to prevent the extinction of local rice varieties [1].

In rice breeding, the identification of local rice quality is one of the indicators to assemble the new varieties. The good quality of local rice can be determined by the characteristic of cooking quality. It is divided into three kinds including sticky, medium, and fluffy rice. The cooking quality is determined by genetic factors than post-harvest treatment. [2].

Based on the explanation above, the researchers conducted the research of characterization of rice physicochemical properties from local rice germplasm in Tana Toraja, South Sulawesi. In this research, physicochemical properties are used as parameters in identifying the cooking quality of rice. It is
analyzed by testing amylose content, gelatinization temperature, gel consistency, and protein content of seven local rice germplasms.

2. Materials and Methods

2.1. Materials

This research was conducted at the Chemical Laboratory, Center of Health Laboratory, Makassar, and Chemical Laboratory, Cereals Plant Research Institute, Maros. The materials in this research were 7 local rice germplasms (Pare Ambo, Pare Bau, Pare Bumbungan, Pare Lalodo, Pare Kobo, Pare Rogon, Pare Tallang) accession from Tana Toraja, South Sulawesi.

2.2. Methods

2.2.1. Analysis of Amylose Level. Measurement of amylose level was conducted according to the Rice Systems Evaluation Standard [3]. At the Standard Curve preparation stage, 40 mg pure amylose was fed into a 100 ml volumetric flask and added 1 ml of 95% ethanol and 9 ml of NaOH 1 N. The standard solution were sterilized for 24 hours and added aquatic until the mark on volumetric flask. Furthermore, the solution was dropped as much as 1, 2, 3, 4, and 5 ml and then put into a 100 ml volumetric flask. 2 ml Iodine solution was added in each volumetric flask. The solution also added of 0.5 N acetic acid each amount of 0.2; 0.4; 0.6; 0.8; and 1 ml. Add aquatic until the mark on volumetric flask. The solution was shaken and stand for 20 minutes. The solution was measured by the intensity of the color formed by the spectrophotometer at a wavelength of 620 nm. The standard curve describes the link between amylose concentration and absorbance.

At the measurement of the sample stage, a total of 200 mg of non-fat samples was introduced into the test tube and 1 ml of ethanol and 9 ml of NaOH 1 N were added. The sample solution was heated for 10 minutes then cool and transferred to a 100 ml 100ml flask, then adjusted until the mark with aquades. The solution was dropped as much as 5 ml, then put into 100 ml volumetric flask and added 2 ml of iodine solution and 1 ml of 0.5 N acetic acids. The subsequent solution and aquades were added until the mark, then the solution shaken, stuck for 20 min, and measured the color intensity which is formed by a spectrophotometer at a wavelength of 620 nm. Amylose content was calculated by equation 1:

\[
\text{Amylose Content (\%)} = \frac{A}{S} \times \frac{FP}{W} \times 100\%
\]

\(A\) : Sample absorbance at a wavelength of 620 nm
\(S\) : slope on the standard curve
\(FP\) : dilution factor, 20
\(W\) : sample weight (gram)

Based on amylose content levels, rice is grouped into five groups[4], glutinous rice (0-2 %), very low amylose content (2-9%), low amylose content (10-19%), medium amylose content (20 – 25 %), high amylose content (>25%).

2.2.2. Analysis of Protein Levels, Micro Kjeldahl Method. The protein measurements based on the Micro-Kjeldahl Method were performed in 3 stages: destruction, distillation, and titration. A sample of 150 mg was fed into a volumetric flask and added 1.94 g of selenium reagent mixture catalyst, and 10 ml of concentrated H2SO4. Samples were boiled for 20 minutes until the liquid clear. The samples were boiled slowly, then cool again. Aquades was added until the mark and 3 drops of PP indicator. Then additional NaOH until the color of liquid changed into purple while cool using water the samples were distilled. Erlenmeyer contains 20 ml of H3BO3 solution placed under the condenser. The condenser tube shall be submerged under the H3BO3 solution. The distilled solution was added 3 drops of BCG
indicator. Then it was titrated with standardized HCl 0.02N. Titration was stopped until the colour change to the purple. The blanking was done using the same method as the sample. The protein content was calculated by using the following equation:

\[ N \text{ Content} (\%) = \frac{(v_s - v_b) \times c \times 14.007}{W} \times 100\% \]  \hspace{1cm} (2)

\[ \text{Protein Content} (\% \text{ wet basis}) = \%N \times \text{Rice conversion factor} \]  \hspace{1cm} (3)

N : Nitrogen
\[ v_s \] : HCL volume of titration sample (ml)
\[ v_b \] : volume of blanko titration (ml)
C : HCL concentration (N)
W : sample weight (mg)
Rice Converion Factor: 5.95

2.2.3. Gelatinization Temperature (GT). The gelatinization temperature was indicated by alkali spreading to test. The samples were evaluated by the degree of spreading of individual milled rice kernel in a weak alkali solution (1.7% KOH) at room temperature (30°C). 6 intact milled grains were placed in a petri dish to which 15 ml of 1.7% KOH was added. The grains were carefully separated from each other and incubated at ambient temperature for 23 hrs to allow spreading of the grains.

2.2.4. Gel Consistency Gel Consistency was determined by 100 mg rice flour. The flour was put into the tubes. 0.2 ml alcohol 95% (contain 0.025% thymol blue) and 2 ml KOH 0.2 N was added and then shaken tubes by a vortex mixer. The tubes were heated using a water bath to a temperature of 90°C for 15 minutes, lifted and then stand for 5 minutes, then cooled using ice water for 20 minutes. Tubes were laid horizontally for 1 hrs on a table lined with millimeter graph paper and the total length of the gel measured in millimeters.

Category of gel consistency [5], high gel consistency <36 mm, medium gel consistency 36-50 mm, low gel consistency >50 mm.

3. Result and discussion
The measurement of amylose content based on International Rice Research Institute (IRRI) method [3]. The amylose content of samples was showed around 2.517- 18.295 %. The categories based on Dela and Khush (2000)[4], rice with an amylose content of 0-2% can be categorized as sticky rice. Rice with amylose content of 10 - 19% can be categorized as rice with low amylose content. The local rice from Tana Toraja categorized as glutinous rice were Pare Bumbungan (2.676 %) and Pare Lalodo (2.517%). Another local rices categorized as rice with low amylose content were Pare Ambo (18.295%), Pare Bau (17.507%), Pare Kobo (15.916%), Pare Rogon (17.797%), Pare Tallang (17.797%).

Table 1. Categorized local rice based on amylose content

| Local Rice     | Amylose Content (%) | Category               |
|----------------|---------------------|------------------------|
| Pare Ambo      | 18.295              | Low- Amylose Content   |
| Pare Bau       | 17.540              | Low- Amylose Content   |
| Pare Bumbungan | 2.676               | Glutinous Rice         |
| Pare Kobo      | 15.916              | Low- Amylose Content   |
| Pare Lalodo    | 2.517               | Glutinous Rice         |
| Pare Rogon     | 17.797              | Low- Amylose Content   |
| Pare Tallang   | 17.797              | Low- Amylose Content   |
Pare Bumbungan and Pare Lalodo are categorized as glutinous rice. It contains no amylose (whole starch consisting of amylpectin), when it is cooked, the rice condition is very sticky, soft, moist, solid, less water-absorbing, and less expanding. While Pare Ambo, Pare Bau, Pare Kobo, Pare Rogon, dan Pare Tallang are categorized as rice with low amylose content. The low-amylose content of rice has a sticky rice characteristic, not too wet or dry. There is no high amylose rice in this study. Rice with the high amylose content has a fluffy rice characteristic, hard, and dry.

Differences in amylose content of rice are influenced by varieties, air temperatures of planting sites, and N levels in the soil. The study by Juliano [6] showed that the rice with the same variety but planted in the regions which have different nitrogen content in the soil and the air temperature of different planting locations will produce the rice with different amylose content. In line with this, the research by Rusmiati [7] also showed the glutinous rice and low-amylose content rice in Enrekang, South Sulawesi. Pare Pallan (2.033%), Pare Pulu Lotong (2.122%) and Pare Pinjan (2.033%) were categorized as glutinous rice, while Pare Solo (18.595%), Pare Salle (16.193 %) dan Pare Lambau (15.538 %) were categorized as low-amylose content rice. Enrekang and Toraja have the same natural form. Most of the rice was grown in the highlands.

Indonesia has many varieties of rice with various levels of amylose. Bengawan Solo, Tukad Petanu, Sentani, Membrano, Cilosari, and Cisadane are rice local varieties that categorized as low-amylose content. Bondoyudo, Pandan wangi, Rojolele, IR-64, Cibodas, Maros, and Way Opo Buru are categorized as medium-amylose content. IR-68, Batang Anai, Digul Indrasari Ratih, and IR-36 are categorized as high-amylose content [8].

Micro Kjeldahl Method was used to analyze the protein levels. The results of protein contents in 7 samples local rice from Tana Toraja showed amount of 7.3-8.5 %. The highest protein level was Pare Ambo (8.5%), and the lowest protein level was Pare Bumbungan (7.3%).

Table 2. Protein levels of local rice by micro kjeldahl method.

| Local Rice  | Protein Levels (%) |
|-------------|--------------------|
| Pare Ambo   | 8.5                |
| Pare Bau    | 8.2                |
| Pare Bumbungan | 7.3            |
| Pare Kobo   | 8.4                |
| Pare Lalodo | 7.4                |
| Pare Rogon  | 7.6                |
| Pare Tallang| 8                 |

According to Juliano [6], the protein content of rice was in the range of 7%. The protein content of milled rice was strongly influenced by rice milling degree and the soil conditions in which the rice was grown. Rice grown on soils rich in N elements tends to have high levels of protein.

Overall, the local rice from Tana Toraja has a protein content less than or equal to 8.5%. This shows the tendency of sticky rice texture [9]. Proteins have the dominant fraction of water-insoluble glutelin. The lower protein content can form a sticky rice texture. Sticky rice texture in accordance with amylose content analysis that indicates that local rice has a sticky rice texture.

Based on gelatinization temperature, rice can be classified into three types: low gelatinization (55-69 °C), medium temperature gelatinization (70-74 °C) and high gelatinization temperature (> 74 °C) [4].

All samples of local rice from Tana Toraja classified as high gelatinization temperature. For Pare Ambo, Pare Kobo, and Pare Lalodo were black rice, the color fades but did not affect rice texture changes. Pare Bau, Pare Bumbungan, Pare Rogon, and Pare Tallang did not change the texture of rice. Overall, it indicates a low spread of alkali in rice that can lead to low corrosion of the granules.
### Table 3. Categorized local rice based on gelatinization temperature.

| Local Rice     | Rice Condition | Alkali Test | Gelatinization Temperature |
|----------------|----------------|-------------|---------------------------|
| Pare Ambo      | Not affected, whiten | Low         | High                      |
| Pare Bau       | Not affected     | Low         | High                      |
| Pare Bumbungan | Not affected     | Low         | High                      |
| Pare Kobo      | Not affected, whiten | Low       | High                      |
| Pare Lalodo    | Not affected, whiten | Low       | High                      |
| Pare Rogon     | Not affected     | Low         | High                      |
| Pare Tallang   | Not affected     | Low         | High                      |

According to Aryunis [9] gelatinization temperature associated with the time of cooking rice showed the increase of gelatinization temperatures will lengthen the cooking time of rice. Rice with low gelatinization temperature will absorb water and expands at a lower temperature than rice that has high gelatinization temperature [9]. Gelatinization temperature influenced by granule characteristic and that presence protein, fat, and sugar components. Rice that has high protein content will require more water and more time to cook. This is related to the structure of the seed. Starch granules that wrapped by proteins and granular protein fill the spaces between starch granules in the endosperm.

The gel consistency value can be used as the index of the softness of the rice. The consistency of rice gel consistency from local rice from Tana Toraja which ranges from 36-50 mm is Pare Ambo, Pare Bau, and Pare Tallang which shows the index of moderate softness. While Pare Kobo, Pare Rogon, Bumbungan and Pare Lalodo exceed 50 mm including low gel consistency category which shows the index of high softness.

### Table 4. Categorized Local Rice based on Gel Consistency.

| Local Rice     | Scale (mm) | Type of Gel Consistency |
|----------------|------------|-------------------------|
| Pare Ambo      | 43         | Medium                  |
| Pare Bau       | 48         | Medium                  |
| Pare Bumbungan | 108        | Low                     |
| Pare Kobo      | 58         | Low                     |
| Pare Lalodo    | 122        | Low                     |
| Pare Rogon     | 59         | Low                     |
| Pare Tallang   | 45         | Medium                  |

According to Aryunis [9] in his research, the consistency of gel associated with the texture of rice, the higher the consistency of the gel the more texture produced. The rice with the hardest consistency gel is Pare Bau, while the rice with the softest consistency gel is Pare Lalodo.

Pare Ambo is the rice with the lowest consistency of the gel scale (43 mm) which shows the gel consistency is harder than the others. This is in accordance with amylose content analysis, Pare Ambo is the highest amylose content compared to the others. While Pare Bumbungan and Pare Lalodo showed the consistency of the gel above 100 mm. Both rice is categorized as very low amylose content. Amylose levels affect gel consistency.

In the research conducted by Damardjati and Purwani [2], it showed that several rice varieties in Indonesia have a variety of gel consistency. Rice varieties of japonica (Padi Bulu from Central Java) include Rojolele (79.3 mm), Cendrawati (66.5 mm), and Hawarabatu (74.0 mm) categorized in low gel consistency (> 50 mm) with a high softness index. Indica rice varieties (Padi Cere from West Java) such as Angkong (63.0 mm), Jambe (70 mm), Ciamis (50 mm) are also included in low gel consistency category (> 50 mm) with high soft index.
4. Conclusion

Based on this research, it can be concluded that the local rice from Tana Toraja which categorized as sticky rice are Pare Bumbungan (2.676%) and Pare Lalodo (2.517%), while rice with low amylose content includes Pare Ambo (18.295 %), Pare Bau (17.570%), Pare Kobo (15.916%), Pare Rogon (17.797%), Pare Tallang (17.797%). The whole local rice contains protein content ranging from 7.3-8.5%. Overall, rice has a high gelatinization temperature. The consistency of rice gel from local rice from Tana Toraja regency ranging from 36-50 mm are Pare Ambo, Pare Bau and Pare Tallang, while Pare Kobo, Pare Rogon, Pare Bumbungan and Pare Lalodo are more than 50 mm including low gel consistency category.

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