The Volatile Components and Rice Quality of Three Indonesian Aromatics Local Paddy

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Abstract. The purpose of this research was to study the post-harvest analysis of local aromatic rice variety of AnakDaro, CicihMerah, and Mandoti covering the volatile component, physical and milling quality, and the physicochemical properties of rice. The research materials were obtained from local farmer in West Sumatera, South Sulawesi, and Bali. The analysis was conducted at the Rice Quality Laboratory at Indonesian Center for Rice Research (ICRR), Sukamandi, West Java. The results indicated that AnakDaro was extracted with Likens Nickerson had a 2-acetyl-1-pyrroline amount (13.79 ppb) higher than that of Mandoti and CicihMerah. The extraction technique with Likens Nickerson has the best recovery compared to SPME (Solid Phase Microextraction) and maceration. In general there are differences in physical quality of grain and rice, milled quality and rice protein content of AnakDaro, Mandoti and CicihMerah. AnakDaro had high amylose content and hard cooked rice texture in cold conditions. CicihMerah had high amylose content with soft cooked rice texture in cold conditions. Mandoti had a very low amylose content with a very soft cooked rice texture in cold conditions. The characteristic of gelatinization temperature of AnakDaro and CicihMerah were high (> 74°C) while Mandoti was moderate (70-74°C).

1. Introduction
Local rice has been cultivated for generations so that the genotype of the variety has well adapted to land conditions and specific climates in its development area. Naturally, local rice has resistance to pests and diseases, tolerant of abiotic stresses, and has good quality of rice that is favored by many consumers in each location. Every season farmers choose rice varieties with delicious rice taste, so that local varieties generally have high quality. Local varieties with superior characteristics need to be preserved as assets of national genetic resources and utilized in breeding programs. By utilizing local varieties in rice breeding with it specific advantages possessed could be expected to increase the superiority of rice varieties cultivated in specific localities [1].

Aromatic rice is increasingly in demand by consumers because it has a more fragrant aroma than ordinary rice. Aromatic rice is fragrant rice when cooked. Aromatic rice is composed of a mixture of complex active fragrance components, including 2-acetyl-1-pyrroline (2-AP) components which are described as pandan-like scents by Asians [2].

AnakDaro is one of local aromatic rice which is favored by people in Sumatera Barat, Indonesia. The aroma from the Rojolele and Mandoti samples had similarities characterized by the aroma of pandanus, cereals, buttery, and green. CicihMerah samples are characterized by sweet and creamy aroma. Samples of Mentikwangi, Bengawan Solo, and AnakDaro have similar characteristics but are not characterized by a distinctive aroma. The taste of the CicihMerah and Bengawan Solo samples is in
one group characterized by sweet and savory flavors. Mandoti is in a different group characterized by salty and bitter taste. Mentikwangi and Si Buyung, as well as AnakDaro and Rojolele even though they are in one group but not characterized by one characteristic taste attribute [3].

Consumer preference in term of rice shape and the taste of rice greatly determines the level of adoption of rice varieties. Local varieties generally have a rice shape and delicious taste of cooked rice so that the selling price is higher and preferred by consumers in each of their growing and developing agroecosystems. Some local varieties have good rice quality such as Pandanwangi, Mentikwangi, and Rojolele varieties that come from West Java and Central Java.

AnakDaro is local varieties that has been purified and released by the government from the city of Solok, West Sumatra with the Decree of the Minister of Agriculture No. 73 / Kpts / SR.120 / 2/2007 [1]. CicihMerah is red rice from Bali, while Mandoti is red glutinous rice from South Sulawesi. The objectives this study was to analyse the volatile component, physical and milling quality, and the physicochemical properties of local aromatic rice such as AnakDaro, CicihMerah and Mandoti. This information was needed if these varieties was used as one of the elders in the breeding program to develop new superior varieties.

2. Materials and Methods
The research materials consisted of three local rice samples namely AnakDaro, Mandoti, and CicihMerah obtained from farmers in West Sumatera, South Sulawesi and Bali. Each sample consisted of + 1 kg of dry milled grain was sampled from each rice variety to be analysed. The research material was taken to the Rice Quality Laboratory, Indonesian Center for Rice Research at Sukamandi for quality analysis. Clean dried grain was peeled into brown rice using rice husker (Satake THU 35A). Then the brown rice was polished with rice polisher (Satake TM-05) into milled rice. Characterization of milled rice included volatile component, physical quality of grain, physical quality and quality of milled rice and physicochemical properties of local aromatic rice.

Identification of volatile components was carried out using three extraction techniques, namely Likens-Nickerson with modification [4], maceration [5] and SPME/Head space. Identification of physical quality of grain includes moisture content, grain density, empty grain, immature grain + chalky grain, yellow grain + damaged grain, and 1000 grain weight. Identification of the physical character of rice included the whiteness degree, translucency, milling degree (Satake Milling Meter scale), and the shape of rice. Rice milling quality analysis included the yield of brown rice, yield of milled rice, percentage of head rice, percentage of broken rice, and percentage of groats [6]. Analysis of the physicochemical properties of rice included protein (Kjeldahl), amylose [7], gel consistency [8], gelatinization temperature [9], water absorption ratio (WAR) and volume expansion ratio (VER) [10] and amylographic properties [11]. The data were analysed using Anova and followed by DMRT test if there was a difference using SPSS 14.0 software. The data were presented in average value.

3. Results and Discussion

3.1. Volatile Compounds
In this study the AnakDaro extracted with Likens-Nickerson has a number of 2-Acetyl-1-pyrroline (13.79 ppb) higher than that of Mandoti and CicihMerah (Table 1). The highest amount of 2-Acetyl-1-pyrroline extracted with Nickerson Likens and the lowest extracted by maceration. The 2-Acetyl-1-pyrroline was identified as a key aroma component in rice from aromatic rice [12]. The component is described by the panelist as “popcorn-like” or the aroma of pandanus, and the component is thermally produced, because the component is only identified in cooked rice, not in raw rice. The 2-Acetyl-1-pyrroline content is influenced by the degree of milling, packaging, and temperature, where a low degree of milling can increase the amount of 2-Acetyl-1-pyrroline, while a high storage temperature will reduce the content of 2-Acetyl-1-pyrroline. The content of 2-Acetyl-1-pyrroline compounds in aromatic rice is 15 times higher than in non-aromatic rice [13].
Hexanal is a major component in both rice from aromatic and non-aromatic rice [14]. The difference between the two is that in aromatic rice contains less hexanal. Hexanal in rice from aromatic rice contributes to the smell of "musty". The longer the shelf life of rice the higher the number of hexanal. Hexanal can be formed from the process of fat oxidation in rice [15]. In this study, extraction using Likerson Nickerson hexanal amount on Mandoti variety rice (2.82 ppb) was higher than AnakDaro Children (1.76 ppb) and CicihMerah (0.10%) (Table 1).

**Table 1.** The main volatile compounds that contribute to the three local aromatic rice with three extraction methods

| No | Variety   | Compounds                  | Likens-Nickerson | SPME | Maceration | Aroma Description |
|----|-----------|----------------------------|------------------|------|------------|-------------------|
| 1  | AnakDaro  | Heksanal                   | 1.76             | 0.02 | 0.02       | Green/grass        |
| 2  |           | Benzaldehida               | 0.11             | 0.024| 0.011      | Nutty, bitter      |
| 3  |           | (E,E)-2,4-nonadienal       | 0.03             | 0.004| nd*        | Fatty/waxy         |
| 4  |           | 2-acetyl-1-pyrroline       | 13.79            | 0.04 | nd*        | Pandan leaves      |
| 5  |           | 2-pentyl-furan              | nd*              | nd*  | nd*        | Nutty, bean        |
| 2  | Mandoti   | Heksanal                   | 2.82             | 1.22 | 0.03       | Green/grass        |
| 2  |           | Benzaldehida               | 0.04             | 0.02 | nd*        | Nutty, bitter      |
| 3  |           | (E,E)-2,4-nonadienal       | 0.95             | 0.02 | nd*        | Fatty/waxy         |
| 4  |           | 2-acetyl-1-pyrroline       | 0.11             | 0.004| nd*        | Pandan leaves      |
| 5  |           | 2-pentyl-furan              | nd*              | nd*  | nd*        | Nutty, bean        |
| 3  | CicihMerah| Heksanal                   | 0.10             | 2.71 | 0.03       | Green/grass        |
| 2  |           | Benzaldehida               | 0.05             | 0.04 | nd*        | Nutty, bitter      |
| 3  |           | (E,E)-2,4-nonadienal       | 0.77             | 0.11 | nd*        | Fatty/waxy         |
| 4  |           | 2-acetyl-1-pyrroline       | 0.13             | 0.15 | nd*        | Pandan leaves      |
| 5  |           | 2-pentyl-furan              | nd*              | nd*  | nd*        | Nutty, bean        |

*nd : not detected

The 2-Pentyl-furan and benzaldehyde in cooked rice from aromatic rice is described by the aroma of nutty [14]. 2-Pentyl-furan was not detected in all three varieties analyzed, both with Likens Nickerson extraction, SPME, and maceration. The AnakDaro variety has a higher amount of benzaldehyde than that of Mandoti and CicihMerah. While the aroma (E, E) -2,4-Nonadienal rice from aromatic rice is described with the aroma of fatty [16]. Mandoti variety has higher content of (E, E) -2,4-Nonadienal than CicihMerah and AnakDaro (Table 1).

Based on the results of the above analysis, the extraction technique with Nickerson Likens has a higher recovery than SPME, because the results of the analysis of the above compound components have a higher value than using SPME. While the extraction technique with maceration has the lowest recovery compared to two other extraction techniques. This shows that the maceration technique is not suitable for extracting volatile compounds of rice.

**3.2. Physical and Milling Quality**

The appearance of milled rice is important to consumers. Preferences for grain size and shape vary from one group of consumers to another. Some ethnic groups prefer short bold grains, some prefer medium-long grains, and others highly price long slender. Generally consumers in Indian subcontinent prefer long grains, but, in Southeast Asia, the demand is for medium to medium-long rice. In temperate areas,
short grain varieties are prevalent. On the international market there is strong demand for long-grain rice [17].

Table 2. Physical characteristics of three local aromatic rice

| Variety        | Moisture content (%) | Length (L) | Width (W) | Shape (L/W) | Whiteness Degree (%) | Translucency (%) | Milling Degree (%) |
|----------------|----------------------|------------|-----------|-------------|----------------------|------------------|-------------------|
| AnakDaro       | 12.1<sup>c</sup>     | 5.57<sup>a</sup> | 2.21<sup>a</sup> | 2.51<sup>b</sup> | 43.3<sup>b</sup>       | 1.76<sup>c</sup> | 103.3<sup>b</sup> |
| Mandoti       | 11.7<sup>b</sup>     | 6.66<sup>b</sup> | 2.66<sup>b</sup> | 2.50<sup>b</sup> | 41.2<sup>a</sup>       | 0.91<sup>a</sup> | 94.7<sup>a</sup>  |
| CicihMerah     | 11.5<sup>c</sup>     | 6.41<sup>c</sup> | 2.83<sup>c</sup> | 2.26<sup>c</sup> | 41.3<sup>a</sup>       | 1.72<sup>b</sup> | 95.0<sup>a</sup>  |

The number in one column followed by the same letter is not significantly different.

The International Rice Research Institute (IRRI) classifies the length of rice as follows: very long (> 7.5 mm), long (6.61-7.5 mm), medium (5.51-6.60 mm), and short (<5.50 mm) [18]. Table 2 shows that AnakDaro (5.57 mm) and CicihMerah (6.41 mm) include as medium rice, while Mandoti include as long rice (6.66 mm). The results of statistical analysis showed differences in the physical quality of rice, namely moisture content, length, shape of rice, whiteness degree, translucency and milling degree (Table 2). The length of Pandanwangi Cianjur and Garut (5.76 and 5.51 mm) include as medium rice [19]. The length of Rojolele and Mentikwangi an aromatic varieties from Java were 6.9 mm and 6.1 mm which categorised as length rice [20]. The length of non pigmented (Keteki Joha) and pigmented (Poreiton Chakhao) aromatic paddy varieties from India were 5.82±0.03 mm (medium) and 6.51±0.03 mm (long)[21] respectively determined as per [22].

Based on Table 2 it is known that the ratio of length and width (shape) of AnakDaro, Mandoti and CicihMerah were 2.51, 2.50, and 2.26 respectively. The ratio of length and width of the rice determines the classification of the grain shape. The International Rice Research Institute classifies rice into 4 types: slender (> 3.0), medium (2.1-3.0), bold (1.1-2.0), and round (≤ 1) [18]. Based on the classification, the rice shape of AnakDaro, Mandoti and CicihMerah were medium. Based on the statistical analyses AnakDaro dan Mandoti have the same rice shape but is different from CicihMerah (Table 2). The rice shape of both Pandanwangi Garut and Cianjur (2.06 and 2.00) are bold [19]. The rice shape of both Rojolele and Mentikwangi are medium (2.5 and 2.3) [20]. The rice shape non pigmented (Keteki Joha) and pigmented (Poreiton Chakhao) aromatic paddy varieties from India were 2.91±0.01 (quasislender) 3.25±0.06 (slender)[21] respectively determined as per [22].

In general, consumers prefer rice with long grain and slender shape. Shape, size, weight and seed uniformity are important factors in the rice industry. The rice dimension determines in the international market because long rice has a high demand [23]. In addition, information on the ratio of length and width is required in determining drying and processing equipment.

Besides the shape and color of rice, the physical characteristics of rice that directly affect the level of consumer preference for milled rice offered are the translucency of rice grains. Consumers generally like white and clear milled rice, except glutinous rice. Rice translucency is determined by genetic traits and milling methods. The use of friction method is that the friction between the grains of rice will produce rice with a higher value of translucency than the abrasive method, namely grinding stone grinding. AnakDaro has whiteness degree and translucency of 43.4% and 1.76% respectively (Table 2). The whiteness degree and translucency of Pandanwangi Cianjur and Garut consecutively are (54.1, 47.8 and 2.3, 2.7) [19]. While the whiteness degree, transparency and milling degree of Rojolele and Mentikwangi respectively were 51.9%, 2.9%, 150 and 45.2%, 2.3%, 115 [20].

Milling degree is a combined criterion between whiteness degree and translucency of rice grains. The milling level of brown rice produced milled rice with higher milling degree. Measurement of the milling degree of rice is carried out relatively by using the Satake Milling Meter. As a comparison, white crystals of BaSO4 are used with a milling degree value of 199. AnakDaro Child milling degree is 104 based on Satake Milling Meter. The whiteness degree e and the milling degree of Mandoti and CicihMerah are the same, but different from AnakDaro. Whereas the rice translucency of the three
varieties are different (Table 3). The milling degree of Pandanwangi Cianjur and Pandanwangi Garut respectively were 155 and 130 based on Satake Milling Meter [18]. The milling degree of Rojolele and Mentikwangi respectively were 150 and 115 [20].

Table 3. Milling quality of three local aromatic rice

| Variety        | Yield of Brown Rice (%) | Yield of Milled Rice (%) | Head Rice (%) | Broken Rice (%) | Groat (%) | Green/Chalky Grain (%) | Yellow/Damaged Grain (%) |
|----------------|-------------------------|--------------------------|---------------|-----------------|-----------|------------------------|--------------------------|
| AnakDaro       | 77.67<sup>a</sup>       | 70.03<sup>b</sup>       | 93.20<sup>b</sup> | 5.90<sup>b</sup> | 0.90<sup>c</sup> | 0.28<sup>b</sup> | 1.88<sup>c</sup> |
| Mandoti        | 78.30<sup>b</sup>       | 67.50<sup>a</sup>       | 96.38<sup>c</sup> | 3.53<sup>a</sup> | 0.20<sup>a</sup> | 0<sup>a</sup>     | 0.60<sup>b</sup> |
| CicihMerah     | 81.20<sup>c</sup>       | 70.9<sup>c</sup>        | 85.30<sup>a</sup> | 14.30<sup>c</sup> | 0.50<sup>b</sup> | 0.33<sup>b</sup> | 0.40<sup>c</sup> |

The number in one column followed by the same letter is not significantly different.

The yield of AnakDaro brown rice and milled rice are 77.77 % and 70.03 % consecutively. The yield of Pandanwangi Cianjur milled rice is 68.7% lower than that of Pandanwangi Garut 70.1%[19]. Head rice is a component of physical quality of rice that directly affects the level of acceptance by consumers. In general, consumers do not like milled rice with low head rice percentage. Standards of quality of milled rice based on SNI No. 01-6128-2015 [24], only Mandoti (96.38%) met the requirement of Premium class (95%), while AnakDaro (93.20%) and CicihMerah (85.30%) met the Medium 1 class of the requirement (Table 3). The yield of milled rice is affected by grain density and weight of 1000 grains. The greater the density and weight of 1000 grains will result in a higher yield of milled rice.

Conversely with the head rice, high percentage of broken rice cause declining of consumer acceptance. According to quality standards of INS No. 01-6128-2015 for broken rice, Mandoti met the requirement of Premium class, while AnakDaro and CicihMerah met the requirement of Medium 1 class (Table 3). One of factors that determine the high broken rice in milled rice is moisture. When grain was milling with low moisture content cause high broken grain. Conversely, if too wet will produce a high grain groats.

The percentage of groat grain of AnakDaro (0.91%), Mandoti (0.17%) and CicihMerah (0.53%) fulfilled the requirement of Medium 1 class (maximum 2%). The chalky grain of AnakDaro (0.28%) and CicihMerah (0.30%) met the standard requirement for quality Medium 1 (maximum 2%), while Mandoti (0%) met the requirement of Premium class (maximum 0%). The yellow+ damaged grain of AnakDaro (0.28%), Mandoti (0.59%) and CicihMerah (0.42%) met the standard requirement for quality Medium 1 class (maximum 2%)(Table 3). The chalky grain is caused by physiological factors, genetic factors, young seeds (harvest age is not optimum, seed growth is less than perfect), easily damaged by pest attacks and low storage capacity and the yellow+damaged grain is caused by fermentation process, the growth of the fungus due to imperfect grain drying process after. Chalky grain, yellow+damaged grain are the components that consumers consider in choosing the rice they buy.

3.3. Nutrition Quality, Physicochemical Properties, and Amilographic Profile

3.3.1. Nutrition Quality

The protein content of samples of AnakDaro, Mandoti and CicihMerah analysed consecutively were 7.21, 7.68 % and 9.72 % (dry weight) (Table 4). Pandanwangi Cianjur and Pandanwangi Garut have the same protein content of 8.3 % [19]. The protein content of Rojolele and Mentikwangi were 8.31% and 8.27% consecutively [25]. In the Indonesian Food Composition Table, the average protein content of milled rice in Indonesia is 8.4% [26]. The character of rice protein is inhibiting water absorption and swelling of starch granules when rice is cooked, and greatly affects the texture of cooked rice. Rice with high protein content usually produces less soft cooked rice (tends to be hard) [27]. Genetic factors, cultivation technology, fertilization and agro-ecosystem of rice growing areas are known to influence the character and quantity of rice protein (Table 4).
3.3.2. Physicochemical Properties

Amylose content is an important component in determining the physicochemical properties of rice. The physicochemical properties of rice affect the quality of the rice and the quality of the cooked rice produced. The amylose content of starches in milled rice usually ranges from 15 to 35%. Based on amylose content, milled rice is classified as: waxy (1-2% amylose), non-waxy (>2% amylose), very low (2-19%), intermediate (20-25% amylose), and high (25-33% amylose) [18]. AnakDaro and CicihMerah have high amylose content, so they have hard texture of cooked rice. Mandoti has very low amylose content with very soft cooked rice texture.

The level of cooked rice texture is negatively correlated with the content of rice amylose. The higher the amylose content of rice, the lower the cooked rice texture (the harder the rice texture). Amylose content is also positively correlated to other quality crops, namely the water absorption ratio (WAR) and volume expansion ratio (VER) of rice during cooking. The results of other studies also stated that the higher the amylose content, the more rice produced with hard texture and the rice is more expanded because it absorbs more water [28]. The dominant influence that determines the amylose content of rice varieties is the genetic factor of the parent crosses. Water absorption ratio (WAR) and volume expansion ratio (VER) for AnakDaro, Mandoti and CicihMerah are 4.3, 4.0, 3.9 and 3.4, 3.2, 2.8 consecutively (Table 4).

The gel consistency properties was also one of the characters that determines the quality of rice texture. The results of the study indicate that if the gel consistency is hard, then the texture of rice after cooking tends to become less sticky. The harder the consistency of the gel, the harder the texture of the rice is. These conditions indicate that between consistency gel and amylose content has a positive relationship [29]. The soft consistency of the gel is shown by the length of the gel paste that is formed. The opposite is for the texture of the hard gel consistency. The physicochemical properties such as the gel consistency of cooked rice is derived more from the genetic nature of rice. Most local rice has a soft gel consistency character.

| Variety      | Protein (%) | Amylosa (%) | Gel Consistency (mm) | Explanaltion | Alkali (Score) | Gelatination Temperature (°C) | WAR *) | VER **) |
|--------------|-------------|-------------|----------------------|--------------|---------------|-------------------------------|--------|--------|
| AnakDaro     | 7.21        | 26.79       | 30                   | Hard         | 1.00          | >74                           | 4.3    | 3.4    |
| Mandoti      | 7.68        | 5.25        | 100                  | Soft         | 5.00          | 70–74                         | 4.0    | 3.2    |
| CicihMerah   | 9.72        | 26.22       | 65                   | Soft         | 3.00          | >74                           | 3.9    | 2.8    |

*) Water Absorption Ratio
**) Volume Expansion Ratio

Rice is grouped into 3 groups based on the gel consistency, i.e., consistency of hard gel (very flaky rices) with gel length ≤ 40 mm, flaky rices with gel length 41-60 mm, and low gel consistency (soft rices) with gel length ≥ 61 mm [30]. Harder gel consistency gel is associated with harder cooked rice and this feature is particularly evident in high-amylose rice. Hard cooked rice also tend to be less sticky. The gel consistency of AnakDaro is hard (30 mm), while Mandoti (100 mm) and CicihMerah (65 mm) are soft (Table 4).

Gelatinization temperature is the time required for cooking the milled rice. It is estimated by the extent of alkali spreading. The degree of spreading is measured using a seven-point scale. The corresponds of alkali spreading value to gelatinization temperature as follows: 1-2, high (74.5 – 80°C), 3 high intermediate, 4-5, intermediate (70-74°C), and 6-7, low (<70°C). In Asia there is a normally a preference for rice with intermediate gelatinization temperature.

The characteristics of the gelatination temperature of the sample AnakDaro and the CicihMerah are high (> 74°C) while Mandoti is moderate (70-74°C) (Table 4). The measurement of the gelatinization temperature of rice is one of the cooking quality tests related to cooking temperature, where water is
absorbed and starch granules expand permanently in hot water. Rice with a high gelatinization temperature becomes very soft and tends to be sticky after cooking. Rice that has a high gelatinization temperature requires more water and cooking time than those with moderate or low gelatinization temperatures. Thus the gelatinization temperature has a positive correlation with the time of rice cooking [31].

3.3.3. Amilographic Profile
The quality of processed products and utilities for basic ingredients containing starch can be identified in various ways. One of them is by identifying the amilographic properties of pasta which can describe the character of the processed products. The specific characteristics of rice as a characteristic of "processing behavior" are carried out by identifying the amilographic characteristics or viscosity properties of rice starch. Rice that contains starch can be determined the character of the paste viscosity to see the characters that are suitable for the use of certain processed products.

The paste viscosity measured includes peak viscosity and set back viscosity. The peak viscosity value is smaller than the viscosity value of 50°C. The difference in viscosity value of 50°C with peak viscosity is obtained by the return viscosity value which can give a hint of the retrograde character of starch granules [32]. These properties are important to know whether the product at room temperature or after cooling will become more hardened, texture stable or softer. All values of reverse viscosity of aromatic rice analyzed showed a positive value. However, the product character associated with the amylography of this paste is also determined by the size of the setted back viscosity value. The higher the value of the set back viscosity of the local aromatic rice flour the more suitable for making the product which is hardened or expanded. For paste with low or moderate viscosity values, it is more suitable for products with medium to soft texture. Measurement of gelatinization temperature, peak viscosity and setback viscosity of pasta from AnakDaro, Mandoti and CicihMerah rice fields each has a value range of 48.1-65.6°C, 1139.2-3436.8 cp, and 339.2-1932.8 cp (Table 5).

Table 5. Amilographic profile of local aromatic rice

| Variety      | Initial gelatinization | Granular starch breaks | Viscosity |
|--------------|------------------------|------------------------|-----------|
|              | Time (minute) | Temp. (°C) | Time (minute) | Temp. (°C) | Visco (cp) | 50°C (cp) | Set back (cp) |
| Anak Daro    | 10          | 65.6       | 18          | 92.6       | 3436.8     | 5369.6    | 1932.8       |
| Ketan Merah  | 6           | 48.1       | 12          | 72.1       | 1139.2     | 1478.4    | 339.2        |
| Mandoti      | 10          | 64.8       | 18          | 92.7       | 3206.4     | 4556.8    | 1350.4       |
| Cicih Merah  | 10          | 64.8       | 18          | 92.7       | 3206.4     | 4556.8    | 1350.4       |

4. Conclusion
Anak Daro variety that was extracted with Likens-Nickerson has a 2-acetyl-1-pyrroline amount (13.79 ppb) higher than that of Mandoti and Cicih Merah. The extraction technique with Likens Nickerson had the best recovery compared to SPME and maceration. In general there were differences in physical quality of grain and rice, milled quality and rice protein content of Anak Daro, Mandoti and Cicih Merah. AnakDaro had high amylose content and hard cooked rice texture in cold conditions. CicihMerah had high amylose content with soft texture cooked rice in cold conditions. Mandoti had very low amylose content with a very soft cooked rice texture in cold conditions. The characteristic of gelatinization temperature of AnakDaro and CicihMerah were high (> 74°C) while Mandoti was moderate (70-74°C).

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