Study of various types of rice field management systems on the functional properties of rice

Achmad Ridwan Ariyantoro[1*], *Windi* Atmaka[1], *Belinda* Sonata[1], and *Jauhari* Syamsiyah[2]

[1]Department of Food Science and Technology, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta
[2] Department of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta

Abstract. The purpose of this study was to investigate how various rice field management strategies affected the Mentik Wangi and IR64 white rice (Oryza sativa L.) varieties' physical, chemical, physicochemical, functional, and sensory qualities. With just one factor—the conventional, semi-organic, and organic rice field management systems—the methodology applied a fully randomized design. The One Way ANOVA test and the DMRT test were employed for data analysis, with a 5% significance level. The analysis's findings demonstrated that the rise in white degree value and thousand-grain weight was substantially impacted by the semi-organic rice field management system. Additionally, it improved both kinds' solubility and swelling power. Meanwhile, because it is preferable as far as of color, appearance, and overall quality, the organic rice field management system greatly enhances the sensory experience. Conversely, the conventional rice field management approach on Mentik Wangi and IR64 rice raised the protein content (%db) and amylose content of all kinds.

Keywords: Rice; organic; semi-organic; conventional; characteristics

1 Introduction

Rice (*Oryza sativa* L.) is one of the most important staple foods for the Indonesian population. It is not only a source of carbohydrates but also a staple food in daily life. The Indonesian Central Bureau of Statistics [1] revealed that rice production for food consumption reached 31.36 million tons in 2021, and output reached 32.07 million tons in 2022. This means that there is a surplus of 2.29% compared to the previous year. Increased rice production in quantity goes hand in hand with increased rice consumption in Indonesia; research findings by Sari [2] explain that the amount of national rice production does not meet the needs of national rice consumption; the higher consumption surplus is reflected in higher rice imports, this fact is supported by an increase in population and a continuous increase in consumption.

The increasing population demands increasing rice productivity to meet the national rice demand. Although conventional farming has increased productivity, reliance on chemical fertilizers and pesticides causes adverse impacts on soil and nutrient use efficiency [3]. In

* Corresponding author: achmadridwan@staff.uns.ac.id

addition, awareness of healthy food consumption patterns is also increasing. Awareness of healthy food consumption patterns is also increasing, with consumer preference for more nutritious foods. Therefore, there is a push to steer rice productivity towards organic farming systems as a step towards supporting environmentally friendly and produce food that is equally or more nutritious and contains less (or no) pesticide residues [4].

Organic farming is considered necessary for maintaining a healthy and sustainable environment and as a superior competency to produce superior rice varieties [5]. Although recommendations for developing organic farming have long been introduced, its acceptance in Indonesia still needs to be improved. The majority of marketed rice is produced through conventional methods with the use of chemical pesticides and fertilizers, causing the quality of rice to be less healthy. Rice field management systems are believed to impact rice quality significantly. The different rice cultivation systems will affect the physical-chemical and sensory quality of the rice produced [6]. Various rice cultivation systems, including conventional, semi-organic, and organic, can be applied. "Semi-organic" refers to rice free from pesticides and chemicals and low in chemical fertilizers. This results in stable rice productivity and a significant improvement in soil quality [7].

Various studies have shown that organic cultivation can increase rice protein content by 7.21% compared to conventional 6.28% [8]. Based on SNI 6128:2015 regarding rice, the standard for determining quality rice and ensuring safety and healthy market competition. Rice quality requirements include moisture content, degree of whiteness, shape and length of seeds, and appearance of seeds. Research conducted by Safira [9] with the IR64 rice variety shows that its superior characteristics have a medium amylose content of 23%. Thus, producing a soft and fluffy rice texture due to its good eating quality (medium amylose content), this type of rice has spread in Indonesia, Malaysia, and Burma [10]. Similarly, Mentik Wangi rice (local aromatic) has an amylose content of around 19.32%, so the texture of the rice is fluffy [11]. Amylose levels affect rice's physicochemical properties, which determine the rice's cooking and eating qualities [12].

This research was conducted to see the yield of rice varieties cultivated through different rice field management, conventional, semi-organic, and organic. Gentungan Village was chosen because it has implemented different rice field management systems and varieties, namely conventional, semi-organic, and organic rice fields with the use of Mentik Wangi and IR64 rice varieties. The application of different rice field management systems will result in diverse rice quality characteristics. In addition, until now, research on the physical, chemical, and physicochemical quality characteristics of rice in two rice varieties with different rice field systems has rarely been studied. Therefore, this research very important to investigate the various kind of rice field management system on the characteristic of rice.

2 Material and Methods

2.1 Materials and study design

The primary material used was local white rice (*Oryza sativa* L.) of Mentik Wangi and IR64 varieties obtained from Gentungan Village, Mojogedang, Karanganyar. The materials used for analysis include silica gel, pure amylose, 95% ethanol solution, 1 N NaOH solution, 1 N acetic acid solution, iodine solution (0.2% I_2 + 2% KI), concentrated H_2SO_4, K_2SO_4, $CuSO_4$, Selenium, distilled water, NaOH, 4% boric acid solution, MRMB indicator, HCl, and Kjeldahl tablets and warm water.

The research stage begins with taking dry grain samples and then grinding them manually using a mortar and pestle until rice samples are obtained. Rice was sorted and made into flour using a dry mill blender and sieving with a size 60 mesh. The raw rice was then sensorially

analyzed through the hedonic test using the scoring method with 30 panelists. Furthermore, physical, chemical, and physicochemical analyses included color test, bulk density, thousand-grain weight, moisture content, amylose, protein, water absorption, swelling power, and solubility.

The research was conducted using a completely randomized design (CRD) with three variations divided into rice field management systems: 1) organic, 2) semi-organic, and 3) conventional, and the use of 2 varieties of rice, namely Mentik Wangi and IR64 varieties, with four replications of samples and two replications of analysis. The data obtained were then processed with SPSS software ver. Twenty-five use the oneway Analysis of Variance (ANOVA) method to see the effect of differences in rice field management systems and varieties. If the results differed significantly, they were followed by Duncan's Multiple Range Test (DMRT) at α=0.05.

2.2 1000 Grain Weight, Bulk Density, and Color Test

The method measured thousand-grain weight [13]. Bulk density was measured based on Handayani's research [14]. Measurement of color intensity using Minolta Chromamater CR 400 with Hunter Lab method [15, 16]. The chromameter was calibrated with a white color standard first and then inserted in the cuvette. Next, the values of L, a, and b were measured. The results obtained were calculated through the formula $W = 100 - \{(100\text{-}L)^2 + a^2 + b^2\}^{0,5}$ [17].

2.3 Moisture, Protein Content, and Amylose Content

Moisture content testing used the Thermogravimetric method [18]. Protein content was measured by the Kjeldahl method [18]. The amylose test was measured using the spectrophotometric method through two stages: making a standard curve and determining amylose in the sample [14]. The standard curve starts with preparing 40 mg of pure amylose, which was put into a measuring flask, and 1 ml of ethanol and 9 ml of 1 N NaOH was added. Next, the standard solution was left for 24 hours, and distilled water was added to the mark. Solutions were taken as much as 1, 2, 3, 4, and 5 ml into a measuring flask. After that, 1 N acetic acid was added in each flask: 0.2, 0.4, 0.6, 0.8, 1 ml, and 2 ml of iodine solution. Distilled water solution was added to the mark, shaken, and allowed to stand for 20 minutes. After that, it was measured at a wavelength of 620 nm with a spectrophotometer. Determination of amylose in the sample is done by 100 mg of rice sample that has been finely put into a 100 ml measuring flask and added 1 ml of ethanol and 9 ml of 1 N NaOH. Next, the solution was allowed to stand for 23 hours or heated ± 10 minutes at 100°C and cooled for 1 hour. The solution was then diluted by adding distilled water to the mark, pipetting 5 ml, and putting it into a 100 ml volumetric flask containing 60 ml of water. After that, 1 ml of CH_3COOH 1 N and 2 ml of I_2 2% were added and diluted to a volume of 100 ml. The solution was shaken and allowed to stand for 20 minutes, then measured at a wavelength of 620 nm with a spectrophotometer.

2.4 Swelling Power, Solubility, and Water Absorption

Measurement of swelling power and solubility was carried out according to Kong's method with modifications [19]; as much as 1 gram of sample was dissolved in 40 ml of distilled water and shaken until homogeneous, then heated at 90°C for 30 minutes using a water bath. After that, the precipitate was separated through centrifugation at 2000 rpm for 30 minutes and allowed to stand at room temperature with an ice water bath. Then, the precipitate was weighed. The supernatant was poured into a cup and then baked at 110°C during the solubility

test. Then, it was cooled in a desiccator and considered until constant weight. While testing the Water Absorbency (DSA) based on research [20], the results compared the weight of specific samples soaked in warm water 90°C for ± 10 minutes with the weight of the sample before soaking.

3 Results and Discussion

3.1 Sensory Analysis (Hedonic Test)

3.1.1 Color

Color consistent with what it should be will show its impression in determining the quality of food ingredients [21]. The results of the ANOVA test analysis ($p<0.05$) in **Table 1** show significant differences between organic, semi-organic, and conventional paddy field management systems on the color attributes of the rice produced. Organic rice varieties of mentik wangi (OM) and IR64 (OI) and semi-organic rice varieties IR64 (SI) were most favored by panelists because they had the highest scores compared to other samples. Based on **Figure 1**, the three rice samples have a whiter and less dull color. Meanwhile, the results of the lowest assessment of the color attribute are illustrated by the trend in **Table 1**, where the more the addition of inorganic fertilizer, the lower the assessment score of the color attribute.

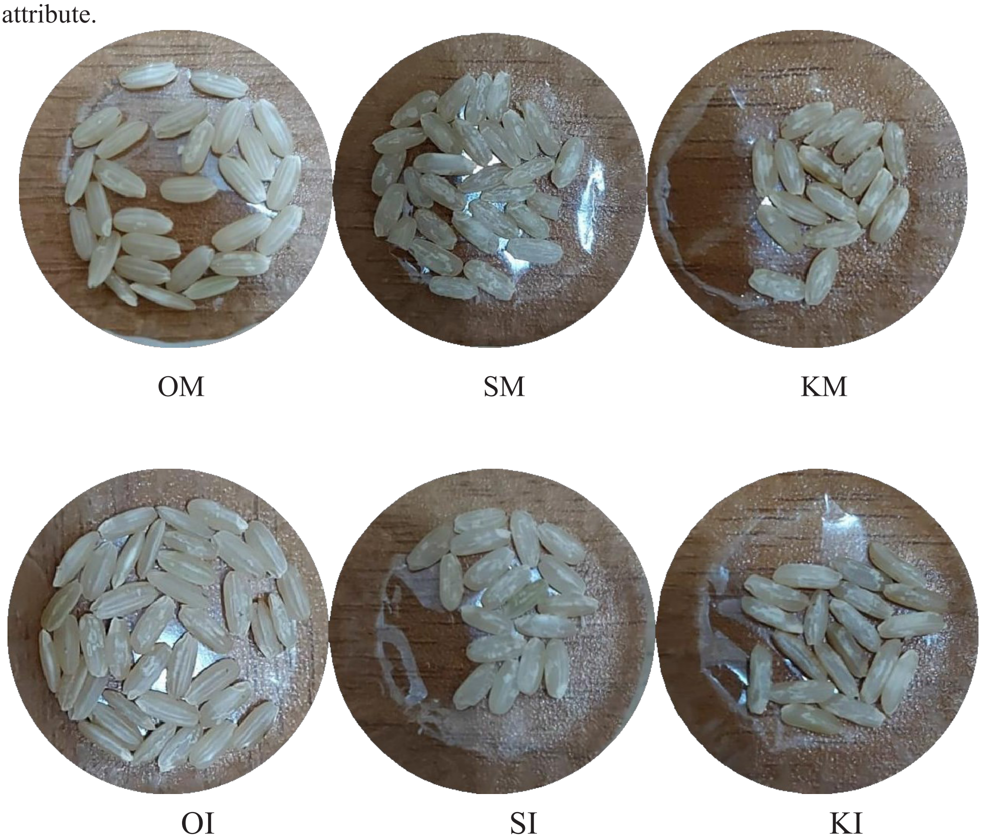

Fig 1. Rice (Oryza sativa L.) of Mentik Wangi and IR64 varieties

3.1.2 Aroma

Assessment of aroma is essential because it determines the deliciousness of food and affects its acceptance. Food aroma forms an important sensory signal, is a component of taste perception, and shapes how people perceive flavor and texture. Aroma acts as a signal for the presence of edible or inedible food before looking at the food [22]. The results through Analysis of Variance (ANOVA) in **Table 1.** showed that the differences in organic, semi-organic, and conventional rice field management systems were not significantly different from the aroma parameters of the rice produced ($p > 0.05$). This can be seen from the panelists who could not distinguish the aroma arising in the six rice treatments. This is because the compound 2-Acetyl-1-pyrolline, the main component of aroma in grains, is only detected after heating processes, such as harvesting [23]. Therefore, further research is needed in the form of sensory testing of rice samples in the form of rice.

3.1.3 Appearance

Appearance is one of the parameters that is important to know in organoleptic tests. The impression of a good and favorable appearance makes panelists interested in seeing other parameters, such as aroma, texture, and taste [24]. Assessment of the appearance of rice is related to the level of diversity and integrity of the rice grains. The results of the ANOVA test analysis ($p<0.05$) in **Table 1** showed that the differences in organic, semi-organic, and conventional rice field management systems in the form of fertilizer composition significantly affected the characteristics of rice appearance. The highest average assessment of appearance attributes was shown by the organic rice variety Mentik Wangi (OM), with a value of 4.43, and the organic rice variety IR64 (OI), with a value of 3.83. Meanwhile, the lowest appearance value is owned by the conventionally managed rice variety IR64 (KI).

3.1.4 Overall

The results of the ANOVA test analysis ($p<0.05$) in **Table 1**. showed that organic, semi-organic, and conventional rice field management significantly differed in the overall parameters of the rice produced. The overall parameter liking test results showed that the panelists' liking value for the rice produced ranged from 2.07–4.23, meaning that the panelists' assessment of the color, aroma, and appearance made in the range of dislike to like. The highest panelists' favorability scores for overall parameters were organic rice varieties of mentik wangi (OM) and IR64 (OI). Panelists least liked rice from conventional rice field management varieties IR64 (KI) because overall, judging from the appearance parameters in the form of rice integrity and color, it was least liked by panelists.

Table 1. Results of Hedonic Test Analysis (Scoring) of Panelists

Samples	Colour	Aroma	Appearance	Overall
KM	$2{,}37 \pm 0{,}89^{d}$	$3{,}00 \pm 0{,}00^{a}$	$2{,}37 \pm 0{,}93^{de}$	$2{,}60 \pm 0{,}72^{d}$
KI	$1{,}93 \pm 0{,}58^{e}$	$3{,}00 \pm 0{,}00^{a}$	$2{,}07 \pm 0{,}87^{e}$	$2{,}07 \pm 0{,}69^{e}$
SM	$2{,}90 \pm 0{,}80^{c}$	$3{,}00 \pm 0{,}00^{a}$	$2{,}53 \pm 0{,}86^{d}$	$2{,}90 \pm 0{,}76^{cd}$
SI	$3{,}50 \pm 0{,}73^{b}$	$3{,}00 \pm 0{,}00^{a}$	$3{,}13 \pm 0{,}90^{c}$	$3{,}17 \pm 0{,}65^{c}$
OM	$4{,}07 \pm 0{,}78^{a}$	$3{,}00 \pm 0{,}00^{a}$	$4{,}43 \pm 0{,}63^{a}$	$4{,}23 \pm 0{,}68^{a}$
OI	$3{,}77 \pm 0{,}82^{ab}$	$3{,}00 \pm 0{,}00^{a}$	$3{,}83 \pm 0{,}70^{b}$	$3{,}73 \pm 0{,}78^{b}$

Notes: Mean ± standard deviation, numbers followed by the same letter in one column indicate not significantly different ($p>0{,}05$).
KM: Mentik Wangi Conventional Rice (Inorganic Fertilizer Urea 200 kg/ha, Phonska 50 kg/ha, and TSP 100 kg/ha

KI: IR64 Conventional Rice (Inorganic Fertilizer Urea 200 kg/ha, Phonska 50 kg/ha, and ZA 100 kg/ha)
SM: Semi-Organic Rice IR64 (Manure 10 ton/ha and Urea 50 kg/ha)
SI: Mentik Wangi Semi-Organic Rice (Manure 10 ton/ha and Urea 50 kg/ha)
OM: Mentik Wangi Organic Rice (10 t/ha manure)
OI: IR64 Organic Rice (10 ton/ha manure)

3.2 Thousand Grain Weight

Thousand-grain weight shows the uniformity of rice size through grain weight. The results of the ANOVA test analysis ($p<0.05$) in **Table 2**. show that the different paddy field management systems did not significantly affect the thousand-grain weight of Mentik Wangi rice varieties but significantly affected IR64 rice. The highest average thousand-grain weight (SI) of 23.88 g was shown in the semi-organic rice field management system, where the application of inorganic fertilizer in the form of urea combined with organic fertilizer (manure) can increase grain weight. Moe et al. [26] stated that the weight of 1000 rice grains is influenced by the levels of chemical and organic fertilizers in manure. CF50PM50 treatment (50% chemical fertilizer and 50% poultry manure) can increase the total N uptake of plants to produce high yields, one of which is the weight of 1000 seeds. At the same time, the lowest 1000-grain weight value in Mentik Wangi and IR64 rice varieties produced in conventional rice fields (KI) was 20.81 g and 22.06 g, respectively [25].

3.3 Bulk Density

Bulk density can show the mass of material particles occupying a specific volume unit. Bulk density is a food-specific physical property of grains and flours that is especially important in shipping and storage [27]. So, the greater the bulk density value, the more accessible or compact the material occupies the same volume size but with greater weight [26]. In rice grains, bulk density is calculated by the ratio between rice grains and their volume and is expressed in g/ml. The ANOVA analysis with a significant level ($p>0.05$) showed that the value of bulk density between treatment samples was not significantly different. The bulk density values were all in the 7.32-7.76 g/ml range (Table 2).

Bulk density can show the mass of material particles occupying a specific volume unit. Bulk density is a food-specific physical property of grains and flours that is especially important in shipping and storage [27]. So, the greater the bulk density value, the more accessible or compact the material occupies the same volume size but with greater weight [28]. In rice grains, bulk density is calculated by the ratio between rice grains and their volume and is expressed in g/ml. The ANOVA analysis with a significant level ($p>0.05$) showed that the value of bulk density between treatment samples was not significantly different. The bulk density values were all in the 7.32–7.76 g/ml range.

3.4 Color Test (Degree of Whiteness)

The results of ANOVA analysis ($p<0.05$) in Table 2. show that different rice field management systems did not significantly affect the L* value of Mentik Wangi and IR64 rice. However, the semi-organic rice field management system significantly affected the L* value of both rice varieties. The highest L-value for both rice varieties was shown by semi-organic rice with an average of 61.33 ± 0.70^a for Mentik Wangi and 59.35 ± 0.91^a for IR64.

The a* value of the three treatments on Mentik Wangi and IR64 rice varieties did not produce a significant effect ($p>0.05$). This means that differences in field management in the form of fertilizer application do not significantly affect the level of variation in the redness

of rice color. [29] also stated that organic and inorganic farming methods produce yellowish-milled rice with a positive b* value. Furthermore, the degree of whiteness was calculated by including all L*, a*, and b* values. It was found that differences in paddy field management systems did not significantly affect the color intensity or whiteness of Mentik Wangi and IR64 rice varieties. However, the semi-organic rice field management system significantly affects both rice varieties.

Table 2. Results of Physics Characteristics Analysis

Parameters	Thousand Grain Weight (g)	Bulk Density (g/ml)	Degrees of Whiteness
KM	20,81±1,12^{a}	7,32±0,07^{a}	56,36±1,08^{ab}
KI	22,06±0,38^{a}	7,52±0,11^{ab}	55,35±1,12^{a}
SM	21,88±1,26^{a}	7,76±0,16^{b}	57,20±0,61^{b}
SI	23,88±1,10^{b}	7,53±0,22^{ab}	55,49±0,78^{a}
OM	22,55±1,25^{a}	7,54±0,38^{ab}	56,24±1,38^{ab}
OI	22,10±0,60^{a}	7,74±0,36^{b}	55,06±0,93^{a}

Notes: Mean ± standard deviation, numbers followed by the same letter in one column indicate not significantly different (p>0,05).

3.5 Moisture Content

The results of ANOVA analysis ($p<0.05$) in Table 3 show that differences in organic, semi-organic, and conventional rice field management significantly affect the moisture content of the rice produced. The overall moisture content value is in the range of 11,91–13,78. This means that all rice treatments are within the safe level of 11–14%, making the shelf life of the rice longer [30]. Among the two varieties studied, the conventional rice variety Mentik Wangi (KM) showed the lowest moisture content, followed by the semi-organic cultivated rice variety IR64 (SI) with sequential values of 11.91%, 12.60%, and 12.54%. Each rice variety has its characteristics. Organic cracked rice of the Mentik Wangi variety yields a moisture content of 13.95% [31], while according to Basito [32], organic cracked rice of the IR64 variety contains a moisture content of ±12%.

3.6 Protein Content

The results of ANOVA analysis ($p<0.05$) in **Table 3** show that differences in organic, semi-organic, and conventional rice field management significantly affect the protein content of the rice produced. Overall protein levels ranged from 7.20-9.68. Conventionally cultivated rice variety IR64 (KI) is functionally superior because it has the highest protein content of 9.68% (%db). Similarly, conventional rice field management produced the most elevated protein in the Mentik Wangi variety.

Swify et al. [33] state that nitrogen N nutrient content dominates urea fertilizer. Urea is the most nitrogen-rich fertilizer (46%). The quality requirements of urea have also been required min. 46%, according to SNI Number 02-2801-2010 [34]. In addition to P and K, element N is essential for plant growth. Proteins are N-containing compounds that play crucial roles in various plant organs, including seeds [45]. The use of Phonska as a mixture of urea fertilizer is also able to supply nitrogen uptake in plants because each granule contains at least 15 nitrogen and other important nutrient components such as 15 phosphate, 15 potassium, and 10 sulfur [35]. In addition, TSP Triple Super Phosphate inorganic fertilizer contains small amounts of N nutrients but has a large amount of Phosphorus P nutrients, around 45-46 P2O5 [36]. Combining the three types of inorganic fertilizers at certain doses can spur rice plants to form amino acids that then turn into proteins.

The protein of rice treated with (SM) is not significantly different or identical to rice treated with (OM), (KM), and (SI). However, the protein content of treated rice (SM) was statistically significantly different from treated rice (OI). The total protein value of the semi-organic rice variety Mentik Wangi (SM) amounted to 6.78, lower than the organic rice variety IR64 (OI) of 8.00. Applying semi-organic rice field management in the form of a combination of 10 t/ha of organic manure fertilizer and 50 kg/ha of inorganic urea fertilizer is not optimal enough to increase the protein content of the rice produced.

3.7 Amylose Content

The higher the amylose content in the rice, the lower the level of rice fluffiness, not sticky, can expand, and become hard after cold [36]. Amylose is a major determinant in the cooking process and eating quality [37]. Based on **Table 3**, the results of ANOVA analysis showed that differences in organic, semi-organic, and conventional rice field management significantly affected the amylose content of the rice produced ($p<0.05$). Overall, the amylose content of the results ranged from 16.21-20.78. The highest amylose levels of 17.72 and 20.78 were shown by the rice variety Mentik Wangi treated with conventional cultivation (KM) and rice variety IR64 treated with conventional cultivation (KI).

Semi-organic treated rice of Mentik Wangi (SM) and IR64 (SI) varieties contained higher amylose at 17.46 and 17.33 compared to organic treated rice of both Mentik Wangi (OM) and IR64 (OI) varieties. These results are in line with the research of Iqbal et al. [3]. They stated that the combined use of 30 PM (manure) and 70 CF (chemical fertilizer) was able to increase amylose content by 10 compared to the control T1 treatment without synthetic N fertilizer [3]. This means that Mentik Wangi and IR64 rice varieties have the potential to be developed through semi-organic rice field management when viewed from amylose levels.

Table 3. Results of Chemical Characteristics Analysis

Parameters	Moisture Content (%)	Total Protein Content (%wb)	Amylose Content (%)
KM	$11,91\pm0,74^{a}$	$7,43\pm0,96^{ab}$	$17,72\pm0,33^{d}$
KI	$12,60\pm0,61^{ab}$	$9,68\pm0,85^{c}$	$20,78\pm0,22^{e}$
SM	$13,23\pm0,23^{bc}$	$6,78\pm0,35^{a}$	$17,46\pm0,29^{cd}$
SI	$12,54\pm0,58^{ab}$	$7,23\pm0,33^{ab}$	$17,33\pm0,10^{c}$
OM	$13,34\pm0,34^{bc}$	$7,20\pm0,47^{ab}$	$16,57\pm0,14^{b}$
OI	$13,78\pm0,55^{c}$	$8,00\pm0,18^{b}$	$16,21\pm0,19^{a}$

Notes: Mean ± standard deviation, numbers followed by the same letter in one column indicate not significantly different ($p>0,05$).

3.8 Water Absorption

Water absorption is the maximum capacity of a material to absorb water within a certain period [38]. The results of ANOVA analysis ($p<0.05$) in **Table 4.** showed that the different rice field management systems applied did not significantly affect the water absorption of Mentik Wangi rice varieties. However, it significantly affected the water absorption of IR64 rice. Overall, the water absorption of the results ranged from 148.08%-176.41%. The semi-organic rice field management system showed the highest water absorption index (SI) of 176.41%. Meanwhile, the conventional IR64 rice treatment (KI) produced the lowest water absorption value at 148.08%.

Low water absorption can be influenced by starch components and the chemical composition of the ingredients, one of which is protein. According to Rachma Oktavianasari et al. [39], the higher the protein and fat content, the more the water absorption level in the

material is reduced. This happens because of the ability of the vegetable protein to form a protective network to hold moisture [40] so it takes work to absorb water. As in **Table 3**, the conventional rice variety Mentik Wangi (KI) has the highest protein content, followed by the organic rice variety IR64 (OI).

3.9 Swelling Power

The results of ANOVA analysis (p<0.05) in **Table 4** show that differences in organic, semi-organic, and conventional rice field management significantly affect the swelling power of the rice produced. Organic rice of the Mentik Wangi variety (OM) and semi-organic cultivated rice of the Mentik Wangi variety (SM) showed significantly higher swelling power than conventional rice of IR64 (KI) and Mentik Wangi (KM) varieties. The swelling power value of the treated rice (OM) and (SM) amounted to 7.61 ± 0.14 and 7.72 ± 0.34, while the treated rice (KI) amounted to 6.41 ± 0.41. These results align with the research of Keawpeng & Meenune [41], which states that the power of organic rice has a significantly higher value than inorganic rice. This is influenced by protein content, which inhibits the swelling of starch in rice grains [42]. The higher the swelling power value of a material, the larger the volume will be. Food with a larger volume gives a more prolonged satiety effect [43].

3.10 Solubility

The results of the ANOVA analysis in **Table 4** show that differences in organic, semi-organic, and conventional rice field management systems significantly affect the solubility of the rice produced (p<0.05). Semi-organic cultivated rice variety IR64 (SI) had the highest solubility compared to the other six rice treatments, followed by organic cultivated rice variety IR64 (OI) with 7.42 ± 0.62 and 6.36 ± 1.54 values. Meanwhile, the lowest solubility value was shown in conventionally managed rice of Mentik Wangi (KM) and IR64 (KI) varieties. These results align with the research of Keawpeng and Meenune [42], which states that the solubility of organic rice has a significantly higher value than inorganic rice. The same trend occurred in swelling power [41].

Table 4. Results of Physicochemical Characteristics Analysis

Parameters	Water Absorption (%)	Swelling Power (g/g)	Solubility (%)
KM	166,34±4,02^{b}	6,86±0,45^{ab}	4,48±0,83^{a}
KI	148,08±3,76^{a}	6,41±0,41^{a}	4,64±0,55^{a}
SM	167,48±2,27^{b}	7,72±0,34^{b}	5,16±0,72^{ab}
SI	176,41±12,03^{b}	7,24±0,74^{ab}	7,42±0,62^{c}
OM	175,23±8,72^{b}	7,61±0,14^{b}	5,49±0,70^{ab}
OI	172,79±5,60^{c}	6,84±0,85^{ab}	6,36±1,54^{bc}

Notes: Mean ± standard deviation, numbers followed by the same letter in one column indicate not significantly different (p>0,05).

4 Conclusion

Applying a semi-organic rice field management system significantly affects color characteristics in the form of the highest L* (Lightness) value, the highest white degree value, and the highest thousand-grain weight of 23.88g. It also produced Mentik Wangi rice with the highest swelling power of 7.72 g/g and the highest solubility in rice variety IR64 at 7.42%. Meanwhile, the organic rice field management system significantly affects rice's sensory characteristics because it is more preferred in terms of color, appearance (wholeness), and

overall. It gave the second-highest growth and solubility results in IR64 rice, which was 7.61 g/g and 6.36%. The highest water absorption result was 176.41% (SI). High water absorption indicates the minimal amount of water required in cooking rice. Meanwhile, the conventional rice field management system on IR64 and Mentik Wangi rice produced the highest total protein content (%db) of 9.68% and 7.43% and the highest amylose content of 20.78% and 17.72%. All rice field management system treatments produced moisture content at a safe level below 14%

The authors are grateful to Gapoktan Desa Gentungan, Mojogedang, Karanganyar Regency, Central Java, for permitting us to conduct this research and the administrators of the assisted farmer groups who have provided facilities and helped collect data in the field. The authors would also like to thank to the LPPM UNS for providing financial support by PUT UNS Funding.

References

[1] The Indonesian Central Bureau of Statistics (BPS), "Berita Resmi Statistik," *Bps.Go.Id*, vol. 19, no. 27, pp. 1–5, (2022).

[2] R. K. Sari, "Analisis Impor Beras Di Indonesia," *Economics Development Analysis Journal*, vol. 3, no. 2, pp. 320–326, (2014).

[3] A. Iqbal,., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., Ullah, S., Munsif, F., Zhao, Q., dan Jiang, L.., "Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency," *Agronomy*, vol. 9, no. 10, doi: 10.3390/agronomy9100651. (2019)

[4] J. P. Reganold and J. M. Wachter, "Organic agriculture in the twenty-first century," *Nat Plants*, vol. 2, no. 2, pp. 1–8, doi: 10.1038/NPLANTS.2015.221. (2016)

[5] U. A. Hamakonda and Maria Clara Mau, "Prospek Pertanian Organik Sebagai Salah Satu Konsep," *Jurnal Pertanian Unggul*, vol. 2, no. 1, pp. 28–39, (2023).

[6] E. T. Champagne, K. L. Bett-Garber, C. C. Grimm, and A. M. McClung, "Effects of organic fertility management on physicochemical properties and sensory quality of diverse rice cultivars," *Cereal Chem*, vol. 84, no. 4, pp. 320–327, doi: 10.1094/CCHEM-84-4-0320. (2007)

[7] K. Surekha, "Evaluation of Organic and Conventional Rice Production Systems for their Productivity, Profitability, Grain Quality and Soil Health," *Agrotechnology*, vol. 01, no. S11, doi: 10.4172/2168-9881.s11-006. (2013).

[8] A.F. Aziez, , Indradewa, D., Yudono, P. and Hanudin, E, "Uji Komparasi Kualitas Beras Varietas Padi Sawah Yang Dibudidayakan Secara Organik Dan Konvensional," *Agrineca*, vol. 16, no. 2, pp. 24–37, (2016).

[9] Safira, D. C. Pengaruh Waktu Pemasakan dan Konsentrasi Santan Kelapa Terhadap Karakteristik Nasi Kuning Instan Varietas IR 64 (Doctoral dissertation, Fakultas Teknik, (2019).

[10] D. J. Mackill and G. S. Khush, "IR64: a high-quality and high-yielding mega variety," *Rice*, vol. 11, no. 1, doi: 10.1186/s12284-018-0208-3. (2018)

[11] D. D. Handoko and S. D. Ardhiyanti, "Teknologi Pascapanen Padi dalam Meningkatkan Mutu Beras Nasional (Rice Postharvest Technology in Improving the National Rice Quality)," *MEWUJUDKAN PERTANIAN BERKELANJUTAN: Agenda Inovasi Teknologi dan Kebijakan*, no. November, pp. 323–345, (2018).

[12] A. R. Sari, Y. Martono, and F. S. Rondonuwu, "Identifikasi Kualitas Beras Putih (Oryza sativa L.) Berdasarkan Kandungan Amilosa dan Amilopektin di Pasar Tradisional dan 'Selepan' Kota Salatiga," *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, vol. 12, no. 1, pp. 24–30, Jan., doi: 10.30599/jti.v12i1.599. (2020)

[13] A.R. Shahwani, , Baloch, S.U., Baloch, S.K., Mengal, B., Bashir, W., Baloch, H.N., Baloch, R.A., Sial, A.H., Sabiel, S.A., Razzaq, K. and Shahwani, A.A., "INFLUENCE OF SEED SIZE ON GERMINABILITY AND GRAIN YIELD OF WHEAT (Triticum Aestivum L .) VARIETIES," *Journal of natural sciences research*, vol. 4, no. 23, pp. 1–11, (2014).

[14] N.A. Handayani, Cahyono H, Arum W, Sumantri I, Purwanto P, Soetrisnanto D, "Kajian Karakteristik Beras Analog Berbahan Dasar Tepung Dan Pati Ubi Ungu (Ipomea Batatas)," *Jurnal Aplikasi Teknologi Pangan*, vol. 6, no. 1, pp. 23–30, , doi: 10.17728/jatp.210. (2017)

[15] S. W. Chung, D. J. Yu, and H. J. Lee, "Changes in anthocyanidin and anthocyanin pigments in highbush blueberry (Vaccinium corymbosum cv. Bluecrop) fruits during ripening," *Hortic Environ Biotechnol*, vol. 57, no. 5, pp. 424–430, , doi: 10.1007/s13580-016-0107-8. (2016)

[16] N. Aryanti, A. Nafiunisa, D. H. Wardhani, and A. C. Kumoro, "EXTRACTION CHARACTERISTIC AND MICROENCAPSULATION OF ANTOCYANIN AS NATURAL FOOD COLOURING FROM ROSELLE CALYCES BY ULTRASOUND-ASSISTED EXTRACTION," *Jurnal Bahan Alam Terbarukan*, vol. 6, no. 2, pp. 87–96, doi: 10.15294/jbat.v6i2.9547. (2017).

[17] R. T. Mawarni and S. B. Widjanarko, "Grinding By Ball Mill With Chemical Purification on Reducing Oxalate in Porang Flour," *Jurnal Pangan dan Agroindustri*, vol. 3, no. 2, pp. 571–581, (2015).

[18] S. Sudarmadji,. Haryono, B., and Suhardi.. Prosedur analisa untuk bahan makanan dan pertanian, pp.67-72. (1997).

[19] C. Mota, , Santos, M., Mauro, R., Samman, N., Matos, A.S., Torres, D. and Castanheira, I., "Protein content and amino acids profile of pseudocereals," *Food Chem*, vol. 193, pp. 55–61, , doi: 10.1016/j.foodchem.2014.11.043. (2016).

[20] X. Kong, , Qiu, D., Ye, X., Bao, J., Sui, Z., Fan, J. and Xiang, W.,., "Physicochemical and crystalline properties of heat-moisture-treated rice starch: Combined effects of moisture and duration of heating," *J Sci Food Agric*, vol. 95, no. 14, pp. 2874–2879, , doi: 10.1002/jsfa.7028. (2015).

[21] S.K Dewi. Pembuatan Produk Nasi Singkong Instan Berbasis Fermented Cassava Flour sebagai Bahan Pangan Pokok Alternatif. Skripsi. Fakultas Teknologi Pertanian. Institut Pertanian Bogor. (2008)

[22] J.K. Negara, Sio, A.K., Rifkhan, R., Arifin, M., Oktaviana, A.Y., Wihansah, R.R.S. and Yusuf, M., "Aspek mikrobiologis, serta Sensori (Rasa, Warna,Tekstur, Aroma) Pada Dua Bentuk Penyajian Keju yang Berbeda," *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*, vol. 4, no. 2, pp. 286–290, doi: 10.29244/jipthp.4.2.286-290. (2016).

[23] W. J. Maina, "Analysis of the factors that determine food acceptability," *~ 253 ~ The Pharma Innovation Journal*, vol. 7, no. 5, pp. 253–257, (2018).

[24] X. Wei, D. D. Handoko, L. Pather, L. Methven, and J. S. Elmore, "Evaluation of 2-acetyl-1-pyrroline in foods, with an emphasis on rice flavour," *Food Chem*, vol. 232, pp. 531–544, doi: 10.1016/j.foodchem.2017.04.005. (2017)

[25] Y. Ashila, R. I. Pratama, Y. Mulyani, and I. Rostini, "Fortification of Red Tilapia Bone Flour as a Source of Calcium on Doughnut Preference Level," *Asian Journal of Fisheries and Aquatic Research*, vol. 18, no. 4, pp. 17–26, doi: 10.9734/ajfar/2022/v18i430448. (2022)

[26] K. Moe, A. Z. Htwe, T. T. P. Thu, Y. Kajihara, and T. Yamakawa, "Effects on NPK status, growth, dry matter and yield of rice (Oryza sativa) by organic fertilizers applied in field condition," *Agriculture (Switzerland)*, vol. 9, no. 5, doi: 10.3390/agriculture9050109. (2019)

[27] T. Rahman,. "Formulasi dan evaluasi sensori tepung bumbu ayam goreng berbasis tepung singkong termodifikasi." Jurnal Pangan 26, no. 2: 153-166. (2017)

[28] M. Astawan, T. Wresdiyati, and M. Ichsan, "Karakteristik Fisikokimia Tepung Tempe Kecambah Kedelai (Physichochemical Characteristics of Germinated Soybean Tempe Flour)," *Jurnal Pangan dan Gizi*, vol. 11, no. 1, pp. 35–42, (2016).

[29] M. Kaur, N. Kaur, M. Kaur, and K. S. Sandhu, "Some properties of rice grains, flour and starches: A comparison of organic and conventional modes of farming," *Lwt*, vol. 61, no. 1, pp. 152–157, doi: 10.1016/j.lwt.2014.11.007. (2015).

[30] Mohd Ramli, N.A., Fazalul Rahiman, M.H., Kamarudin, L.M., Mohamed, L., Zakaria, A., Ahmad, A. and Rahim, R.A., "A New Method of Rice Moisture Content Determination Using Voxel Weighting-Based from Radio Tomography Images," *Sensors (Basel)*, vol. 21, no. 11, doi: 10.3390/s21113686. (2021)

[31] E. B. Tarigan and B. Kusbiantoro, "Pengaruh Derajat Sosoh dan Pengemas terhadap Mutu Beras Aromatik selama Penyimpanan," *Penelitian Pertanian Tanaman Pangan*, vol. 30, no. 1, pp. 30–37, 2011.

[32] Basito, "Kajian Karakteristik Fisikokimia dan Sensori Beras Organik Mentik Susu dan IR64; Pecah Kulit dan Giling Selama Penyimpanan," *Jurnal Teknologi Hasil Pertanian*, vol. 3, no. 2, pp. 95–101, (2010).

[33] S. Swify, R. Mažeika, J. Baltrusaitis, D. Drapanauskaitė, and K. Barčauskaitė, "Review: Modified Urea Fertilizers and Their Effects on Improving Nitrogen Use Efficiency (NUE)," *Sustainability*, vol. 16, no. 1, p. 188, doi: 10.3390/su16010188. (2023).

[34] D. Amalia and R. Fajri, "Analisis Kadar Nitrogen Dalam Pupuk Urea Prill Dan Granule Menggunakan Metode Kjeldahl Di Pt Pupuk Iskandar Muda," *QUIMICA: Jurnal Kimia Sains dan Terapan*, vol. 2, no. 1, pp. 28–32, , doi: 10.33059/jq.v2i1.2639. (2020)

[35] R. NAFERY, B. ASNAWI, and G. S. FATIMAH, "RESPON TANAMAN KEDELAI (Glycine max (L.) Merrill VARIETAS RAJABASA AKIBAT PEMBERIAN PUPUK ORGANIK DAN NPK PHONSKA TERHADAP PERTUMBUHAN DAN HASIL," *Jurnal TriAgro*, vol. 2, no. 2, doi: 10.36767/triagro.v2i2.425. (2017).

[36] A. Menna and Haile, J. Influence of Incidental Application of Sulfur Impurity in Triple-Super Phosphate Fertilizer on Wheat Yield. (2021).

[37] R. Lestari, S. Kartini, L. Berti, and M. Romita, "Penetapan Kadar Amilosa Dan Protein Pada Beras Solok Jenis Anak Daro Dan Sokan Yang Ditanam Dengan Sistem Pertanian Organik Dan Sistem Pertanian Konvensional," *JOPS (Journal Of Pharmacy and Science)*, vol. 1, no. 2, pp. 28–32, doi: 10.36341/jops.v1i2.491. (2018)

[38] L. Zhou, , Chen, S., Yang, G., Zha, W., Cai, H., Li, S., Chen, Z., Liu, K., Xu, H. and You, A., "A perfect functional marker for the gene of intermediate amylose content Wx-in in rice (Oryza sativa L.)," *Crop Breeding and Applied Biotechnology*, vol. 18, no. 1, pp. 103–109, doi: 10.1590/1984-70332018v18n1a14. (2018)

[39] M. Astuti and M. Mora, "Pengaruh Persentase Komposisi Serbuk Kulit Kakao dengan Bahan Pengisi Lidah Mertua Terhadap Sifat Fisis Dan Mekanik Papan Partikel," *Jurnal Fisika Unand*, vol. 9, no. 2, pp. 169–175, doi: 10.25077/jfu.9.2.169-175. (2020).

[40] R. Rachma Oktavianasari, D. Damat, and H. A. Manshur, "Kajian Karakteristik Fisikokimia dan Organoleptik Beras Analog Berbahan Dasar Tepung Gembili (Dioscorea aculleata. L), Tepung Jagung (Zea mays, L) dan Pati Sagu (Metroxylon sp)," *Food Technology and Halal Science Journal*, vol. 5, no. 2, pp. 125–136, doi: 10.22219/fths.v5i2.21911. (2023)

[41] D. Webb, Y. Li, and S. Alavi, "Chemical and physicochemical features of common plant proteins and their extrudates for use in plant-based meat," *Trends Food Sci Technol*, vol. 131, no. November 2022, pp. 129–138, doi: 10.1016/j.tifs.2022.11.006. (2023)

[42] I. Keawpeng and M. Meenune, "Physicochemical properties of organic and inorganic Phatthalung Sungyod rice," *Int Food Res J*, vol. 19, no. 3, pp. 857–861, (2012).

[43] E.T Champagne, Bett-Garber, K.L., Fitzgerald, M.A., Grimm, C.C., Lea, J., Ohtsubo, K.I., Jongdee, S., Xie, L., Bassinello, P.Z., Resurreccion, A. and Ahmad, R., "Important sensory properties differentiating premium rice varieties," *Rice*, vol. 3, no. 4, pp. 270–281, doi: 10.1007/s12284-010-9057-4. (2010)

[44] H. Santosa, Handayani, N. A., Fauzi, A. D., & Trisanto, A.. Pembuatan beras analog berbahan dasar tepung sukun termodifikasi heat moisture treatment. Jurnal Inovasi Teknik Kimia, 3(1). (2018)

[45] Quilichini, T. D., Gao, P., Yu, B., Bing, D., Datla, R., Fobert, P., & Xiang, D. . The Seed Coat's Impact on Crop Performance in Pea (Pisum sativum L.). Plants, 11(15), 2056. https://doi.org/10.3390/plants11152056. (2022)