World Applied Sciences Journal 32 (6): 1140-1146, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.32.06.708

Physichocemical Properties of Analog Rice from Composite Flour: Cassava, Green Bean and Hanjeli

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Abstract: Dependence on rice as a staple food of Indonesia is not matched by domestic rice production. An alternative food that resembles Indonesian staple food is a necessary requirement to meet the needs of domestic rice and food diversification, therefore a research on non- paddy rice is to be done. Analysis of the results of this study is expected to provide a review of the influence of the raw material type and feedstock composition on the physicochemical properties of analog rice, as well as the composition of which produces the best analog rice. The ingredient used in this study are cassava starch, green beans and hanjeli flour (*Coix lacryma-jobi* L.). From the results, the best analog rice composition is 80% fermented cassava starch, 10% green beans and 10% hanjeli. The best analog rice formula has bright color with 80.43 brightness degrees, which is higher than Rojolele rice with 72.57 brightness degree. The best analog rice has 128.41% of water absorption. A chemical analysis shows that the best analog rice in this study contained 12.51% water, 71.94 % carbohydrate, 4.86% protein and 1.1% fat. Amylose content in this rice, which is classified as low amylose content, is 14.09%.

Key words: Analog rice · Cassava starch · Hanjeli · Green beans

INTRODUCTION

Rice is one of the most important crops and a primary food source for more than half of the world's population [1]. Rice supplying as much as half of calories of the world population [2]. Over 90 percent of the world's rice is produced and consumed in the Asian Region by 6 countries (China, India, Indonesia, Bangladesh, Vietnam and Japan) comprising 80% of the world's production and consumption [3].

Southeast Asia's consumers eat large quantities of rice, 9 out of 10 countries with the largest rice consumption per person are in the region. Most rice is consumed as fully milled white rice (or table rice) that is steamed or cooked in water and served in a bowl at a meal in the home or away from home at a restaurant or cafeteria [4]. However, the population ofrice consuming countries continue to grow and it is estimated that we will have to produce 40% more rice in 2030 [5].

Dependence on rice as a staple food of Indonesia is not matched by domestic rice production. From Indonesia statistic data in 2010, rice consumption achieves 34 million tones per year. In 2011, Indonesia imported 2.75 million tones or $1513,6 millions [6]. In 2019-2021 Indonesia will defisit 3,009 mt rices [3]. It proves that Indonesia does not have national food endurance. An effort is needed to supply food needs, thus reaching a solution which is food diversification. But the culture of Indonesian people who consume rice three times a day can be difficult to be changed. So an alternative food that resembeles rice as the main food is needed and contain almost the same or higher nutrition amount as paddyrice. Analog rice is artificial rice that is produced from non-paddy carbohydrate with varied methods.

Analog rice is a product imitation of rice made from non paddy carbohydrate source, which contains approaching or exceeding carbohydrate content of rice. Rice analog can be made from materials such as cassava, sago, daluga tubers, sorghum, etc. The quality of analog rice is expected to resemble or exceed the rice in general. Rice is the staple food consumed by the majority of the Indonesian population. The quality of rice can be grouped into four, namely (1) the milling quality, (2) the taste and cooking quality, (3) the nutritional quality, (4) the quality based on the seed visibility and purity.

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Milling quality of rice can be seen from the water content in the rice. High water content leads to damage rice due to chemical, biochemical and microbiological processes. The taste and cooking quality can be seen through the amylose content of rice and water absorption. Nutritional quality in rice is affected by the chemical composition of the rice. Visibility is a quality of the rice physical characteristics that play a role in determining the level of acceptance by rice color. Rice color criteria can be measured using tools and indicated by the value of brightness. In addition to the white color, the translucent rice also directly influence the level of consumer preferences. Consumers like white and translucent milled rice.

Based on research by Kurachi, artificial enriched rice is made from 50-98% (db) starch or derivatives, 2-45% additives and 0.1-10% hydrocolloid gelling. Artificial rice is made by mixing materials according to the composition, adding 25-55% water to the mixture to form clumps, granulating mixture into rice using a roll-granulator, evaporating granules for 3-40 minutes at temperature of 70-105°C and drying until the moisture content reaches below 20%. Artificial rice product can be cooked using a minimal amount of water with twice the volume of rice [7].

Indonesia has produced a large amount of cassava. Cassava contains hihg cabohydrate, but less protein. To increasing consumer acceptance, in this research cassava is fermented by lactic acid bacteria. Lactic acid bacteria are found to be useful in flavouring foods, in inhibiting spoilage bacteria and pathogens, in intestinal health and other health benefits related to blood cholesterol levels [8]. Green bean and hanjeli have high protein content to supply nutritional in analog rice.

The objectives of this study were compare kinds of raw materials and to examine the effects of compositions of raw materials to quality and physicochemical properties of analog rice and determine composition raw material that produce best analog rice.

MATERIALS AND METHODS

The raw material uses in this research are, cassava starch branded “Gunung Agung”, green beans, lactic acid bacteria, hanjeli, aquadest and analysis materials else. Lactic acid bacteria diversified Lactobacilus bulgaricus, Lactobacilus casei, acidophilis, plantarum and Streptococus sp. Lactic acid bacteria is gotten from cassava industry in Pati, Central Java. Cassava starch, green beans and hanjeli areobtained from traditional market in Indonesia. The main eqiumpment is electrical stove, cold extruder, oven, mixer and others analysis tools.

Fermenteation of Cassava Starch: Cassava starch which is gotten from market, is fermented with lactic acid bacteria. 15 ml of lactic acid bacteri is diluted with 10 L water. Cassava is soaked with diluted lactic acid bacteria in closed containers. Fermentation is happened for 7 days. After 7 days, cassava is filtered from liquid. After that, fermented cassava flous is dried with sun until dry.

Production of Analog Rice: Table 1 presents comparison of raw materials's compositions: cassava starch, fermented cassava starch, green beans and hanjeli. Process production of begins with drying of raw materials: green beans and hanjeli. After that, dried raw materials is mashed to become flour. To make composite flour, all material’s flour is mixed with certain composition using mixer. Water 55% of total weight is heated until 60°C. Composite flour and water are mixed while heated.

Table 1: Design of research to determine effect of best raw materials’ composition consist of cassava starch, green beans and hanjeli

Formula	Cassava (%w)	Fermented starch (%w)	Green Beans (%w)	Hanjeli (%w)
1	70	-	15	15
2	70	-	20	10
3	70	-	10	20
4	80	-	10	10
5	80	-	5	15
6	80	-	15	5
7	-	70	15	15
8	-	70	20	10
9	-	70	10	20
10	-	80	10	10
11	-	80	5	15
12	-	80	15	5

Cooking is done with stiring by mixer for 20 minutes. Cooking dough extrude in cold extrusion and cut using knife thus produced similar grain rice. Drying is done in oven with temperature 60°C for 3 hours.

Methods of Analysis: Analog rice is analyzed that consist of brightness colour, water content, carbohydrate content, protein content, fat, water absorption, amylose content and hedonic analysis. Hedonic analysis uses consumer acceptance test method. Brightness colour analysis uses Minolta Chromameter CR-300. Water content uses oven. Protein analysis uses Kjedahl method. Fat content uses extraction method. Amylose content uses iodo-iodi calorimetry method. Carbohydrate content uses by difference method [9].

RESULT AND DISCUSSION

Proximate Analysis: Proximate analysis is done to know nutrition content in food product. Table 2 shows the results of proximate analysis of analog rice in various compositions. The results is compared with "Rojolele" rice. Analysis of analog rice moisture content ranges from 10.23% to 13.44%. The water content has approached the water content of Rojolele rice. The water content in various compositions of analog rice has met Indonesian Standard requirement, a maximum of 14%. This number is a safe moisture content for rice storage and would prevent the growth of mold that often live in cereal/ grains. Rice with water content more than 14% can be easier to spoil. Moisture content affect mechanical and physical properties in rice [10]. The axial dimensions of rice increased with moisture content.

The results of protein content analysis in various compositions of analog rice range from 4.77% to 7.75% (db). The resulting protein levels have been able to approach the levels of protein in Rojolele rice of 8.4%. Table rice in Indonesia has protein content approximately 6%. This analog rice can supply nutrition for daily consumption.Protein content in rice effects absorption water. Rice with high protein needs more water and more time when is cooked. It is related with seed structure, strach granule is veiled protein layer and it prevents water to enter starch.Proteins affect the amount of water the rice absorbs early in cooking and the availability of water early in cooking will determine the hydration of the protein and the concentration of the dispersed and viscous phases of the starch, which will determine the texture of the cooked rice [11].

Results of fat content analysis of analog rice in various compositions ranges from 0.7% to 2.05. have a larger fat content than Rojolele rice. Rice with less fat content prevents rice from rotten and rice has a long save time. The results of carbohydrate content analysis in various compositions of analog rice range from 65% to 80%. When compared with 77.11% of Rojolele rice, carbohydrate content of analog rice already resembles rice in the market. The highest carbohydrate content is possessed by formula 4 and 10 of analog rice.

Amylose Analysis: Table 3 shows the amylose content of analog rice in various compositions. Amylose content is one of the chemical properties that determines the physical properties of rice.Amylose content has a fairly high correlation with glycemic index. The higher the amylose content of rice, hence the lower the glycemic index. This is due to the unbranched polymer compound of amylose that makes the bond becomes very strong and difficult to digest. In other words, the lower the levels of amylose, the fluffier rice produced and vice versa.

Great variations in the amylose and amylopectin ratio in rice grains of different varieties that allow their classification as waxy (1-2% amylose), very low amylose content (2-12%), low amylose content (12-20%), intermediate amylose content (20-25%) and high amylose content (25-33%) [12]. Increasing amylose content in rise make rice more hard and be sticky. High amylose starch showed higher moduli,low loss tangentvalues,and higher retrogradation rate [13].

Based on the analysis, the analog rice has 13.88% to 17.56% amylose content range. Therefore, the analog rice is classified as low amylose rice. Low amylose rice when cooked yields sticky, shiny and unexpanded rice, then remain clotted after cooled down. rice with high amylose content provides dry and fluffy textures while low amylose rice gives moist, chewy and clingy textures after cooking [14]. However, amylose content cannot determine the favorite level of rice because public taste is vary. One example is the people of Sumatra tend to like unsticky rice, while people of West Java tend to like fluffier rice.

Brightness Analysis: Brightness is one of factor which effect consumer acceptance. This analysis is done to know brightness degree of analog rice from value of L (Lightness), a and b what is coordinate in cromatis diagram. This analysis uses Minolta Chromameter CR 300. Table 4 shows the results of color brightness analysis of the analog rice in various compositions.

Table 2: Result of analog rice proximate analysis with different compositions, consist of: carbohydrate analysis, fat analysis, protein analysis and water content with control rice "Rojolele".

FORMULA	Carbohydrate (%w)	Fat (%w)	Protein (%w)	Water (%)
1	74,59	1,64	7,08	11,22
2	74,74	1,24	7,70	10,08
3	73,74	2,05	6,45	13,16
4	72,98	1,11	4,80	13,44
5	73,93	1,51	4,17	13,24
6	74,38	0,71	5,42	10,83
7	69,68	1,63	7,13	11,85
8	68,42	1,23	7,75	12,45
9	70,52	2,04	6,50	11,79
10	71,94	1,10	4,86	12,51
11	69,65	1,51	4,23	12,43
12	69,78	0,70	5,48	10,23
Rojolele	77,11	1,70	8,4	13,00

Table 3: Result of amylose analysis analog rice with differences in compositition

FORMULA	Amylose Content (%)
1	17,56
2	15,9
3	14,63
4	15,3
5	14,33
6	16,45
7	13,88
8	15,4
9	14,35
10	14,09
11	17,04
12	16,4

Table 4: Result of color brightness analysis analog rice with differences in composition and the control rice is Rojolele.

Formula	L	a	b	°Hue	Color
1	75,34	-0,73	15,83	87,37	Yellow
2	73,42	-1,28	12,16	83,99	Yellow
3	67,77	-0,75	15,12	87,17	Yellow
4	80,21	0,00	12,54	89,98	Yellow
5	63,29	-1,83	15,29	83,18	Yellow
6	76,66	0,13	11,57	89,36	Yellow
7	73,94	-0,22	14,83	89,15	Yellow
8	73,12	-0,41	15,25	88,45	Yellow
9	75,45	-0,30	13,38	88,72	Yellow
10	80,43	-0,06	12,61	89,71	Yellow
11	75,16	0,17	10,22	89,07	Yellow
12	75,80	-0,22	13,99	89,09	Yellow
Rojolele	72,57	-0,93	8,64	83,83	Yellow

The results of the color analysis show that all analog rice has a degree of hue in yellow range and brightness from 63.29 to 80.45. When compared with Rojolele rice, some of the analog rice has degrees of hue and brightness close to Rojolele rice. With a brightness level almost similar to rice, consumer acceptance of analog rice is expected to be increased. The pattern of increased lightness parameter with consequent reduction in both redness and yellowness parameters [15]. Analog rice from fermented cassava starch has higher brightness than ordinary cassava. It is because fermentation can increase brightness of starch. Beside that, brightness is affected by compositions of raw materials. Analog rice with a lot of amount hanjeli has higher brightness.

Water Absorption: Water absorptin one of factors affects qualitiy of rice. Absorption water indicates volume of rice after cooking. Table 5 shows the results of water absorption analysis in various compositions. Water absorption power of rice analog ranges from 0.8 to 1.84 times. Average water absorption of rice in Indonesia is 2.5 times.

The greater the power of water absorption, the greater the water needed for cooking rice. Analog rice has water absorption power less than ordinary rice. It indicates the volume of analog rice is smaller than ordinary rice. Absorption water is affected by amylose content. Table 5 shows that formula 5 has smallest water absorption it is caused by low amylose content in formula 7. The lower the amylose content, the absorption rate is also low, so volume expansion of rice is also low.

Consumer Acceptance Test: Figure 2 shows the average results of the hedonic tests of analog rice in various compositions with color as parameter. The best analog rice composition obtained is in formula 4 (8.5), 10 (9), 11 (9.5) and 12 (9.4). The best analog rice formula produced has a high brightness level with a fond and towards-fond acceptance. In this formula, the rice analog produced has a bright yellow color, while the other formulas tend to

Table 5: Result of absorption water analog rice with difference in composition

FORMULA	Water Absorption (%)
1	141
2	184
3	117
4	128
5	157
6	100
7	80
8	150
9	116
10	128
11	103
12	106

Fig. 1: Result of preliminary research shows analog rice from tapiova (left) and analog rice from cassava starch (right)

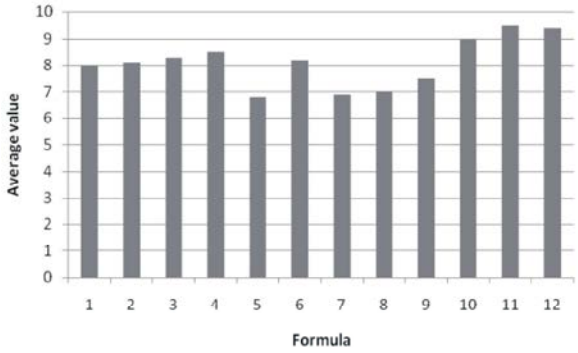

Fig. 2: Hedonic analysis' rating of analog rice with parameter color

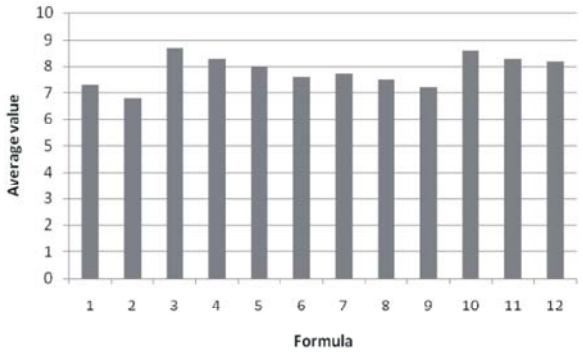

Fig. 3: Hedonic analysis' rating of analog rice with parameter flavor

produce brownish yellow colored rice. In general, consumers prefer lighter colored rice than the the darker one. These results are consistent with the brightness analysis of rice by using a Minolta CR-300 Chromameter where formula 4, 10, 11 and 12 have the brightness brightness level (L*) between 75.16 to 60.43.

Figure 3 shows the average results of the hedonic tests of analog rice in various compositions with flavor as parameter. Analog rice with the highest value is obtained in formula 3 (8.7), 4 (8.3), 10 (8.6) and 11 (8.3). Panelists' assessment on these four formulas with the highest level of fond and very fond acceptance is caused by the bland taste that is closer to rice in general. The main ingredients of rice that determine taste are protein, starch, lipid and moisture.Analog rice foemula 4, 10 and 11 has lower protein than others. However, in terms of taste, a lower protein appeared to be more desirable [16].

The amylose content in the starch, which also affected the taste of rice, determined the viscosity of cooked rice. When the moisture content of rice dropped to below 15%, the taste value decreased as well [16]. All of the analog rice in this experiments has moisture content below 14%.

Figure 4 shows the average results of the hedonic tests of analog rice in various compositions with texture as parameter. Analog rice with the highest value is obtained in formula 3 (9.4), 4 (8.5), 10 (8.9) and 12 (9.3). Panelists' assessment on theses formulas has a level of acceptance of fond and very fond. In general, consumers tend to like unsticky rice, but not too fluffier either. Based on the results of all hedonic tests, the best analog rice with the highest value of color, flavor and texture parameters is obtained in formula 4 and 10. Figure 5 shows the analog rice of formula 4 and 10.Hardness is an important textural characteristic that influences palatability of cooked rice [15].

Figure 5 shows analog rice formula 4 (left) and formula 10 (right). Further analysis of overall hedonic tests will be done to determine the best formula. Determination of the best formula is based on which formula gets the highest mean value from the panelists. The highest mean value of the panelists in overalls can be seen in Figure 6.

In overall hedonic tests, the highest value acceptance of analog rice is obtained in formula 10 (9.2). Overall assessment is done based on color, texture and flavor of analog rice. Analog rice formula 10 has a bright color with a degree of brightness of 80.43, higher than the Rojolele rice at 72.57. This analog rice carbohydrate content is 71.94%, lower than Rojolele rice, but the protein content

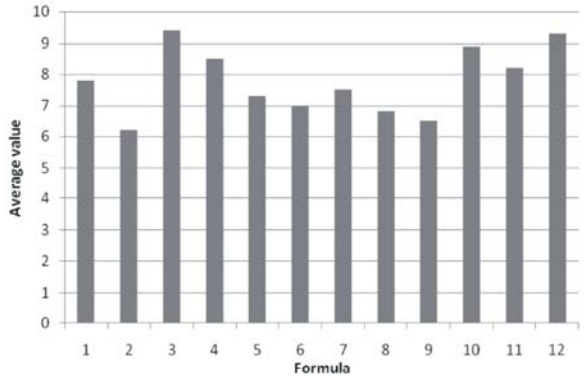

Fig. 4: Hedonic analysis' rating of analog rice with parameter textur

Fig. 5: Best analog rice base on hedonic analysis: Formula 4(left) and formula 10 (right)

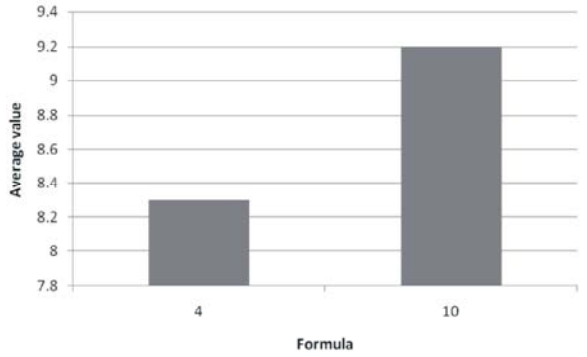

Fig. 6: Overall hedonic analysis' rating of analog rice

is 4.86%, lower than Rojolele rice at 8.4%. The amylose content of this formula is 14.09%, thus the rice is unsticky and not fluffy. Formula 10 is made from fermented cassava starch. Fermented cassava starch can increase consumer acceptance. With capability to convert complex substance to simple substance, giving taste and aroma in foods, so lactic acid bacteria can increase consumer acceptance in fermented products.

CONCLUSIONS

Fermented starch can increase consumer acceptance in analog rice. Composition of raw material affects physical and chemical characteristic in analog rice. The best formula of analog rice is obtained from 80% fermented starch, 10% green beans and 10% cereal grains. The best analog rice has a bright with 80.43 degree of brightness, higher than Rojolele rice as the control rice at 72.57 and water absorption power of 128.41%. The results of chemical analysis show that the best analog rice in this study contained 12.51% water, 71.94% carbohydrate, 4.86% protein and 1.1% fat. The amylose content of this analog rice is 14.09%, therefore classified as low amylose rice.

ACKNOWLEDGEMENTS

The authors wish to thank for the financial support provided from PKM-P 2013 grant by Directorat General of Higher Education (DITJEN DIKTI) Indonesia.

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