Study the Characteristics of Rice Supplements Made by Formulating the Composition of Skim Milk, Ferrous Fumarate, and Thiamine

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Abstract: Rice is a staple food ingredient as a source of carbohydrates, but low in micronutrients such as iron and calcium, as well as relatively low thiamine (vitamin B_1) and riboflavin (vitamin B_2) due to the rice milling process. This study aims to explore the manufacture of rice supplements by formulating the composition of skim milk, ferrous fumarate and thiamine. The experimental research design used a factorial pattern, the first factor was the concentration of skim milk with a variation of 20%; 30%; and 40%, the second factor is the concentration of ferrous fumarate with a variation of 200 ppm; 300 ppm; and 400 ppm, and the third factor is thiamine concentration with a variation of 300 ppm; 400 ppm; and 500 ppm. The rice supplements were tested for micronutrient stability and organoleptic tests by adding them to rice when cooked. The results showed that rice supplements which were added or fortified at the time of cooking, the test results showed that the protein, calcium, and iron content were stable, while thiamine showed an average decrease in response of 9-10%. Based on the results of the organoleptic test on the color parameters, the response was not significantly different, while the organoleptic test for the taste and aroma parameters showed a significantly different response.

1 INTRODUCTION

Rice (*Oryza sativa*) is a high source of energy from carbohydrates and contributes to the largest percentage of calorie fulfillment, however rice contains relatively low protein, vitamins and minerals. Grains and their yields are relatively low in protein, also protein in grains is incomplete, with one of the amino acids being lysine. The lysine content in rice is approximately 4%. Skim milk is a good source of protein, skim milk protein contains essential amino acids (Hardinsyah and Martianto, 1989), to increase the nutritional value of protein in rice can be done by adding skim milk. According to the International Rice Research Institute in the Philippines, the nutritional value of rice needs to be improved. So far, rice is known as a food source of energy, not a source of vitamins and minerals that are important for health. As nutrients, vitamins and minerals are needed by the body in small amounts, but in fact they have a very important function for the body's metabolism so that efforts are needed to increase the iron and thiamine content in rice. In this case, to increase the iron content, ferrous fumarate compounds are used, because these compounds are organoleptically acceptable and have good absorption in the body, while to increase vitamins, thiamine is used which is not easily oxidized and functions as an important coenzyme in the body's metabolic system.

Based on the nutritional adequacy ratio (RDA), the protein requirement in adults is 62-65 g per day, 13-26 mg iron per day and 1.4 mg thiamine per day. To meet the needs of daily nutritional intake (daily intake) a food-based approach can be carried out, namely by improving food or food and food fortification.

Fortification is a deliberate effort to add important micronutrients, namely vitamins and minerals to food so that it can improve the nutritional quality of the food supply and benefit public health with minimal risk to health.

Rice was chosen as food for fortification because it is a staple food consumed by the population, especially in Asia. In addition, rice is generally cooked singly, without the addition of other ingredients and seasonings. Therefore, rice has a great opportunity to be fortified. The Indonesian government also launched mandatory fortification for

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rice products that must contain thiamine, folic acid, iron, zinc and others.

The purpose of this study was to study the characteristics of rice supplements containing sources of protein, calcium, iron, and thiamine (vitamin B_1) by testing cooked rice. The results of this study are expected to contribute to the fulfillment of community nutrition through rice, which is a staple food source, especially in the Asian region.

2 METHODOLOGY

2.1 Materials

The materials used in this study include the main raw materials, namely maltodextrin, skim milk, ferro fumarate, and thiamine, and IR-64 rice supporting materials and chemicals for testing protein, calcium, iron, and thiamine. The tools used consisted of a set of rice supplement powder making tools, including a tunnel dryer, mixer / blender, grinder. A set of rice cookers and a set of analyzers / test kits for protein, calcium, iron and thiamine.

2.2 Method

The research was conducted in three stages, namely the first, second and third stages of research.

2.2.1 First Stage Research

The first phase of research was to conduct nutritional analysis of protein, calcium, iron, and thiamine on IR 64 rice and analysis of skim milk on protein and calcium content.

2.2.2 Second Stage Research

The second stage of research was the manufacture of rice supplements with the amount (weight) according to the research needs, namely by mixing maltodextrin and skim milk with a composition variation of 4: 1 (s1); 7: 3 (s2); and 3: 2 (s3), the mixture of these ingredients is then mixed with 30% (w / w) water, stirring until homogeneous. Then in each of these mixtures were added Ferrous Fumarate to reach a concentration of 200 ppm (f1), 300 ppm (f2), and 400 ppm (f3), and thiamine was added to each mixture until it reached a concentration of 300 ppm (t1), 400 ppm (t2) and 500 ppm (t3), while continuing to stir until homogeneous. Furthermore, each drying process was carried out at a temperature of 45 °C. For 4 hours using a tunnel dryer, after the dry conditions have been reached, it is milled and sieved with an 80 mesh sieve so that rice supplements are obtained in the form of powder with varying nutritional compositions, then testing the nutritional stability of rice cooking. In this second phase of research, analysis of rice supplements on protein, calcium, iron and thiamine was also carried out. The second stage experimental formulation can be described in the following table:

Table 1: Formulations for making rice supplements.

D: M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		(t_1)300	(t_2)400	(t_3)500
(s_1) 4 : 1	(f_1) 200	$s_1f_1t_1$	$s_1f_1t_2$	$s_1f_1t_3$
	(f_2) 300	$s_1f_2t_1$	$s_1f_2t_2$	$s_1f_2t_3$
	(f_3) 400	$s_1f_3t_1$	$s_1f_3t_2$	$s_1f_3t_3$
(s_2) 7 : 3	(f_1) 200	$s_2f_1t_1$	$s_2f_1t_2$	$s_2f_1t_3$
	(f_2) 300	$s_2f_2t_1$	$s_2f_2t_2$	$s_2f_2t_3$
	(f_3) 400	$s_2f_3t_1$	$s_2f_3t_2$	$s_2f_3t_3$
(s_3) 3 : 2	(f_1) 200	$s_3f_1t_1$	$s_3f_1t_2$	$s_3f_1t_3$
	(f_2) 300	$s_3f_2t_1$	$s_3f_2t_2$	$s_3f_2t_3$
	(f_3) 400	$s_3f_3t_1$	$s_3f_3t_2$	$s_3f_3t_3$

D: M = Maltodextrin: Skim Milk

2.2.3 Third Stage Research

This third phase of research is a test of the nutritional stability of the rice supplements. Rice cooking is carried out with 500 g of IR 64 rice, after washing were added 300 g of water and 25 g of rice supplement. Each time the rice is cooked, the rice is previously added / mixed with each rice supplement whose nutritional composition varies. After cooking, the rice produced is then tested for nutritional content of protein, calcium, iron and thiamine. So that it can be seen the nutritional stability before and after cooking rice. At the same time, organoleptic or sensory testing is also carried out on the parameters of color, taste, and aroma.

3 RESULTS AND DISCUSSION

The first stage of research is the analysis of IR 64 rice raw materials. The analysis carried out in this first stage research was to determine the nutritional composition of rice before the fortification experiment and testing of the nutritional stability of cooked rice were carried out, namely testing the levels of protein, calcium, iron and thiamine.

The results of the analysis can be produced as follows:

Table 2: Results of Analysis of IR 64 Rice and Skim Milk.

Nutritional Components	IR 64 White Rice	Skim Milk
Protein	5.82%	32.45 %
Calcium	51.60 ppm	113.40 ppm
Fe	8.55 ppm	6.42 ppm
Thiamine	1.24 ppm	3.50 ppm

According to the World Food Program (2015), the iron content in rice to be enriched with iron should not be less than 40 mg / kg and no more than 48 mg/kg. According to the nutritional label reference for processed food (2016), the daily nutritional adequacy figure required for thiamine intake is 1.4 mg/day. Based on the nutritional adequacy ratio (RDA), the protein requirement in adults is 62-65 g per day, 13-26 mg iron per day and 1.4 mg thiamine per day. To meet the needs of daily nutritional intake (daily intake) a food-based approach can be carried out, namely by improving food or food fortification.

Based on the results of the analysis of IR 64 rice on protein, calcium, iron, and thiamine, it can be concluded that the rice consumed by the public shows a deficiency in the micronutrients of calcium, iron, and thiamine. So that fortification efforts are needed, one of which is by adding rice supplements that have been enriched with iron sources from Fero Fumarate, calcium from skim milk, and thiamine from pure thiamine. Meanwhile, the body's need for protein can be supplied from animal protein food sources.

The results of the second stage of research with the formulations in table 1, the nutritional concentrations (protein, calcium, iron, and thiamine) are as follows:

Protein and calcium content for every 100 g of rice supplements,

- for comparison of maltodextrin : Skim milk (4:1) contains protein = 6.49 % and calcium 22.68 ppm.
- for comparison of maltodextrin : Skim milk (7:3) contains protein = 9.735 % and calcium 34.02 ppm.
- for comparison of maltodextrin : Skim milk (3:2) contains protein = 12.98 % and calcium 45.02 ppm.

Iron content for every 100 g of rice supplement,

- for comparison of maltodextrin : Skimmed milk (4 : 1), mixed with 200 ppm ferrous fumarate, contains iron = 671,284 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 1006.28 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 1341.28 ppm.
- for comparison of maltodextrin : Skimmed milk (7 : 3), mixed with 200 ppm ferrous fumarate, contains iron = 671.293 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 1006.93 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 1341.93 ppm.
- for comparison of maltodextrin: Skimmed milk (3 : 2), mixed with 200 ppm ferrous fumarate, contains iron = 672.568 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 1007.568 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 1342.567 ppm.

The protein, calcium, and iron content in the process of making rice supplements did not change, while the thiamine content changed as follows.

The changes that occur from thiamine before and after the process of making rice supplements are due to the heat process, namely during drying and milling, resulting in a decrease in the thiamine content in powdered rice supplements.

Table 3: Thiamine content (ppm) for every 100 g of rice supplement.

D: M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	216	332	420
	300	234	328	444
	400	230	323	432
7 : 3	200	224	329	425
	300	210	320	432
	400	239	330	425
3 : 2	200	222	324	419
	300	218	328	438
	400	230	331	430

D : M = Maltodextrin : Skim Milk

This third stage of research is the application of rice supplements that are added when the rice cooking process is about to be carried out using a rice cooker.

The results of the third stage research can be shown as follows:

Protein and calcium content for every 500 g of rice,

- for comparison of maltodextrin : Skim milk (4 : 1) contains protein = 30.7225 g (4.76 %) and calcium 26.367 mg (40.879 ppm).
- for comparison of maltodextrin : Skim milk (7 : 3) contains protein = 31.5338 g (4.89 %) and calcium 26.651 mg (41.319 ppm),
- for comparison of maltodextrin : Skim milk (3 : 2) contains protein = 32.345 g (5.015 %) and calcium 26.934 g (41.785 ppm).

Iron content for every 500 g of rice,

- for comparison of maltodextrin : Skimmed milk (4 : 1), mixed with 200 ppm ferrous fumarate, contains iron = 32.646 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 45.62 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 58.615 ppm

- for comparison of maltodextrin: Skimmed milk (7 : 3), mixed with 200 ppm ferrous fumarate, contains iron = 32.647 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 45.63 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 58.64 ppm
- for comparison of maltodextrin: Skimmed milk (3 : 2), mixed with 200 ppm ferrous fumarate, contains iron = 32.651 ppm; mixed with 300 ppm ferrous fumarate, contains iron = 45.66 ppm; mixed with 400 ppm ferrous fumarate, contains iron = 58.71 ppm.

Protein, calcium, and iron in the process of processing rice supplements in the second stage of the study showed that they did not change or decrease significantly, this may be because there are no factors that cause protein destruction. While for calcium and iron are relatively stable to the effects of oxidation or reduction, so they are relatively stable or do not experience change / decrease. Meanwhile, there was a relatively slight decrease in thiamine, but in this second stage the decrease was not significant.

Based on the results of the third stage research, it shows that the amount of protein, calcium, and iron is not significantly different or does not change/decrease the weight content of protein, calcium and iron before cooking and after cooking, so the content (weight) is relatively the same. The protein, calcium and iron content in this third stage experiment showed the same stability as in the second stage experiment for the same reasons. However, the concentration of the three has increased. This happens because the process of cooking rice into rice does not have any activities that separate or degrade the components of protein, calcium and iron.

The results of this study can be identified that the protein, calcium, and iron content increased compared to cooked rice without the addition of rice supplements made in the second stage.

Based on the results of the third stage research, it showed that there was a change or decrease in thiamine either in quantity or concentration significantly, but there was an increase in thiamine content when compared to rice cooked with the addition of rice supplements (made in the second stage) and rice cooked without the addition of rice supplements.

Table 4: Thiamine content (mg) for every 500 g of rice.

D : M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	4.65	6.54	8.70
	300	4.44	5.91	7.90
	400	4.56	5.70	8.40
7 : 3	200	4.82	6.77	8.90
	300	5.00	6.20	8.20
	400	4.64	5.90	8.80
3 : 2	200	5.00	7.10	9.20
	300	5.60	6.43	9.10
	400	5.20	6.20	9.30

D : M = Maltodextrin : Skim Milk

The decrease in the amount or concentration of thiamine in cooked rice may be due to the effect of heating, resulting in some thiamine degradation. So it can be assumed that the temperature and duration of cooking can affect the reduction in thiamine content, so with the rice supplements that are added before starting cooking, it can be used as an effort to maintain the thiamine content according to the established standard of normal human needs, namely 1.4 mg/day.

Table 5: Thiamine content (ppm) for every 500 g of rice.

D: M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	9.30	13.10	17.40
	300	8.88	11.80	15.80
	400	9.20	11.40	16.80
7 : 3	200	9.60	13.20	17.80
	300	10.00	12.40	16.40
	400	9.20	11.80	17.60
3 : 2	200	10.00	14.20	18.40
	300	11.20	12.80	18.20
	400	9.90	12.40	18.60

D : M = Maltodextrin : Skim Milk

Thiamine decreased, this is because thiamine is relatively unstable by heat, which is in accordance with the chemical properties of thiamine, is stable at acidic pH, but is not stable in alkaline solutions, and is not stable to heat, but is stable during storage in frozen conditions. In addition, thiamine is also unstable when exposed to ultraviolet rays and gamma ray irradiation. The lack of stability in thiamine may also be the result of a strong reaction to the Maillard reaction.

The organoleptic/sensory test results with the rice color attribute showed no significant difference for each addition of rice supplements, which appeared to be slightly yellowish in color. The yellowish color of the cooked rice is due to the presence of Fero Fumarat which is reddish orange in color, which has an effect on the color of the rice Therefore, the more Fero Fumarat content in the rice supplement, the more it affects the color of the rice. So the use of rice supplements based on this research is recommended to supplement rice with the addition of 200 ppm and this can meet the iron needs in rice for consumption by normal humans.

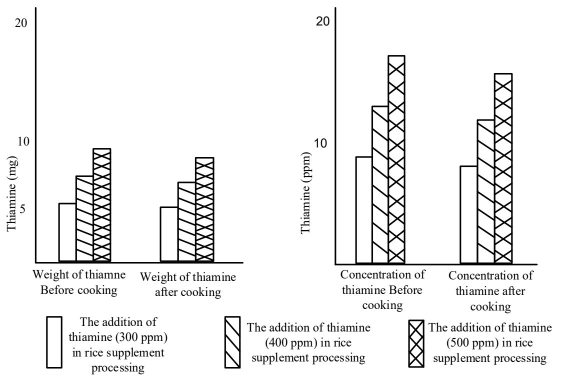

Figure 1: Comparison of the quantity and concentration of Thiamine in rice before and after cooking to which rice supplements are added.

Table 6: Organoleptic test results with color attributes for every 500 g of rice.

D : M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	2.4	2.6	2.6
	300	2.7	2.7	2.6
	400	2.8	2.8	2.7
7 : 3	200	2.5	2.5	2.4
	300	2.6	2.6	2.5
	400	2.7	2.7	2.8
3 : 2	200	2.4	2.6	2.5
	300	2.6	2.7	2.6
	400	2.7	2.7	2.6

D : M = Maltodextrin : Skim Milk

The organoleptic/sensory test results with the rice aroma attribute showed a significant difference for each addition of rice supplements, namely rice added with rice supplements with 200 ppm Fero fumarate content was relatively preferred, and the more ferrous fumarate content the less preferred.

The organoleptic/sensory test results with the rice taste attribute showed a significant difference for each addition of rice supplements, namely rice added with rice supplements with 200 ppm Ferrous fumarate content was relatively preferred and the more ferrous fumarate content the less preferred. so with the addition of thiamine in this amount can be recommended, so that it can be considered minimally and efficiently.

Table 7: Organoleptic test results with aroma attributes for every 500 g of rice.

D : M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	4.3	4.4	4.3
	300	3.7	3.7	3.6
	400	3.1	3.0	3.1
7 : 3	200	4.4	4.5	4.4
	300	3.6	3.6	3.7
	400	2.7	3.1	2.8
3 : 2	200	4.3	4.1	4.6
	300	3.5	3.7	3.6
	400	2.7	2.7	2.6

D : M = Maltodextrin : Skim Milk

Table 8: Organoleptic test results with taste attributes for every 500 g of rice.

D : M (S)	Fe-fumarate (F), (ppm)	Thiamine (T),(ppm)		
		300	400	500
4 : 1	200	4.8	4.8	4.6
	300	3.4	3.5	3.3
	400	3.1	3.2	3.2
7 : 3	200	4.6	4.5	4.5
	300	3.6	3.6	3.4
	400	2.8	3.1	2.9
3 : 2	200	4.5	4.5	4.5
	300	3.5	3.4	3.3
	400	2.6	2.6	2.6

D: M = Maltodextrin : Skim Milk

4 CONCLUSION

Based on this research, three-stage experiments have been carried out, namely nutritional analysis of IR 64 rice and skim milk, rice supplement processing, and application trials in rice cooking, it can be concluded that the protein, calcium, and iron content did not significantly decrease in rice cooking process. While the thiamine content decreased in the rice cooking process, it could still contribute to rice fortification and was acceptable to consumers.

Experiments of this research can recommend that optimal rice supplement is the mixing formulation of Maltodextrin : Skim milk (4 : 1); Ferrous fumarate 200 ppm; and thiamine 300 ppm. The reason for the formula recommendation is that it can meet the nutritional standard requirements, is acceptable to consumers, and is relatively efficient from the rice it produces.

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