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Application of Pectin Coating in the Production of Vitamin Fortified Rice

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ABSTRACT

The quantity of vitamins in rice grain is decreased by milling, washing and cooking process. Therefore, the production of vitamin fortified rice using edible coating was investigated. Three types of low methoxyl pectin (36% degree of methoxyl, 31% degree of methoxyl with 21% degree of amidation and 28% degree of methoxyl with 18% degree of amidation) and control (no pectin coating) were studied. The results showed that L* a* b* values and moisture contents of rice premix were not significantly different ($p > 0.05$). Their values were 71.67-73.00, 13.07-14.32, 78.97-80.92 and 8.01-8.93%, respectively. Rice premix coated with pectin at 36% degree of methoxyl showed the lowest loss of thiamine, riboflavin and niacin during washing. However, pectin coating could not prevent the significant loss of thiamine and riboflavin during cooking in excess water ($p > 0.05$). The suitable ratio of rice premix to milled rice was 1:70. The cooked vitamin fortified rice at this ratio had 0.17 mg/100 g of thiamine and 27.89 mg/100 g of niacin content. The results of consumer acceptance test using Central Location Test (CLT) and Home Use Test (HUT) were similar. It was found that vitamin fortified rice was accepted by consumers at 95% (CLT) and 98% (HUT), respectively.

Key words: low methoxyl pectin, edible coating, vitamin fortified rice

INTRODUCTION

Rice is a staple food of Thai population. Estimated consumption in 2004 was 10.24 million tons (Organization of Agricultural Economics, 2005). Rice is eaten in 2 forms, brown and white rice. But the trend of eating white rice is still upward. Causes of nutrient loss especially soluble vitamins such as thiamine, riboflavin and niacin are milling, washing and cooking process. However, rice can be enriched to restore those lost in milling, washing and cooking by using edible coating. Peil *et al*. (1981) reported that rice coated with combined hydroxypropylmethylcellulose and methylcellulose (3:1 ratio) retained 70, 100, 18, 18 and 21% of vitamin A, iron, niacin, thiamine and riboflavin, respectively. Shrestha *et al*. (2003) reported that rice premix coated with low methoxyl pectin retained 9% and 31% of folic acid during washing and cooking in excess water, respectively.

The objectives of this study were to study the effects of edible coating on qualities of rice premix, to determine the suitable ratio of rice premix to milled rice in order to attain desired enrichment levels in the final product and to determine the consumer acceptance of edible coated vitamin fortified rice.

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MATERIALS AND METHODS

1. Materials

Milled rice (Khao Dauk Mali 105) was purchased from Tesco Lotus. Purple Ribbon Pure pectin (from yellow apple and citrus peel, Degree of methoxyl 36% and pectin content 85-100%) was obtained from Nutrition Partnership Limited. 7210 pectin (from citrus peel, 28% Degree of methoxyl with 21% degree of amidation and 63% pectin content) and 7220 pectin (from citrus peel, 31% Degree of methoxyl with 18% degree of amidation and 63% pectin content) were obtained from The East Asiatic (Thailand) Public Company Limited. Thiamine hydrochloride, riboflavin and niacinamide were obtained from DSM Nutritional Product Co.,Ltd.

2. Effects of edible coating on qualities of rice premix

2.1 Preparation of mixed vitamin solution

Mixed vitamin solution was prepared by dissolving 95 mg of the thiamine hydrochloride, 52.6 mg of the riboflavin and 559 mg of the niacinamide in 8 ml of the distilled water.

2.2 Preparation of low methoxyl pectin solutions

Pectin solutions were prepared followed Rolin *et al*. (1998) by dissolving 1% of Purple Ribbon Pure pectin, 2% of 7220 and 7210 pectins in hot water (60-80°C) in a high-speed mixer. The viscosity of these solutions was 31-36 cP.

2.3 Preparation of rice premix

Rice grain (100 g) was coated with mixed vitamin solution and then with pectin solution followed by calcium chloride solution in a tablet coating pan (model SPKR, MITSUBISHI). The coating of pectin solution followed by calcium chloride solution was repeated and finally, the coated rice was dried in a dryer at 50 degree celcius for 2 hours.

2.4 Washing and cooking of rice premix

Washing test was carried out in a 250 ml erlenmeyer flask by rinsing 20 g rice premix with 60 ml distilled water and gently swirling for exactly 60 s. In cooking test, 5 g of rice was cooked in 125 ml erlenmeyer flask with 100 ml distilled water for 30 min in a water bath (97 ± 3 °C) and cooled immediately. (Shrestha *et al*., 2003).

2.5 Quality measurements

2.5.1 Structure images analysis

Unwashed, washed and cooked rice premixes were viewed on a Laser scanning confocal microscope (model AXIO, ZEISS Laser LSM 5 PASCAL). He/Ne laser at 488 nm was used as a light source to excite the riboflavin (Gue *et al*.,1999). The images acquired with a 5x, 0.15NA., dry objective and 512×512 pixel resolution. They were individual placed in a glass slide without further preparation.

2.5.2 Color measurement

The color characteristics (L* a* and b* values) of rice premixes were quantitatively measured using spectrophotometer (model CM-3500d , MINOLTA). L*, a* and b* values indicate lightness, red to green and yellow to blue, respectively.

2.5.3 Moisture contents of rice premixes were analyzed by using hot air oven (model FD115, WTB binder) at 105 ± 1°C until the weight was constant (A.O.A.C., 2000).

2.5.4 Determination of vitamin loss after washing and cooking

Unwashed, washed and cooked rice premixes were analyzed for thiamine, riboflavin and niacin. Thiamine and riboflavin contents were determined by fluorometric method (A.O.A.C., 2000). Niacin contents was determined by the Food Quality Assurance Service Center, Kasetsart University.

3. The suitable ratio of rice premix to milled rice to attain desired enrichment level in the final product

3.1 Preparation of fortified rice

The rice premix coated with the low methoxyl pectin was obtained from part 2 according to the highest vitamins retained after washing and cooking. The rice premix was blended with milled rice with different ratios (1:100, 1:85 and 1:70) in a cubic mixing tank for 10 min. The milled rice was used as control sample.

3.2 Washing and cooking of fortified rice

Milled and fortified rice were washed the same way as in 2.4 using rice to water ratio 1 : 3. Cooking was done in automatic rice cooker (model SR-D10HN, Panasonic) using rice to water ratio of 1:1.25.

3.3 Quality measurements

3.3.1 Color measurement

The color (L*, a* and b*) values of cooked fortified rice were measured by spectrophotometer.

3.3.2 Determination of vitamin contents

Unwashed, washed and cooked rice were analyzed for thiamine, riboflavin and niacin. Thiamine and riboflavin contents were determined by fluorometric method (A.O.A.C., 2000). Niacin contents was determined by the Food Quality Assurance Service Center, Kasetsart University.

3.3.3 Sensory evaluation

The likina scores of cooked rice were evaluated by 50 untrained panelists using 9-points hedonic scale **(1 = dislike extremely to 9 = like extremely)** for appearance, color, odor, flavor and overall liking.

4. Consumer acceptance test

Consumer acceptance test was carried out using Central Location test (CLT) and Home Use Test (HUT). 100 consumers were used in CLT at two locations (Kasetsart University cafeterias 1 and 2). The samples (before and after cooking fortified rice) and questionnaires were provided for the consumers. For HUT, 100 consumers were provided with samples (fortified rice 142 g for 1 meal) and questionnaires. The 9-points hedonic scale was used to score the consumers' liking. The acceptability of fortified rice was also evaluated by consumers.

RESULTS AND DISCUSSION

1. Effect of edible coating on qualities of rice premix

1.1 Physical properties

The appearances of unwashed, washed and cooked rice premix coated with pectin viewed by confocal laser scanning microscopy were shown in Figure 1. It was found that there were cracks in washed rice and the kernel shape seems to be lost in cooked rice. This may cause a heavy losses of vitamins in rice premix. The color characteristics (L* a* and b* values) of rice premix

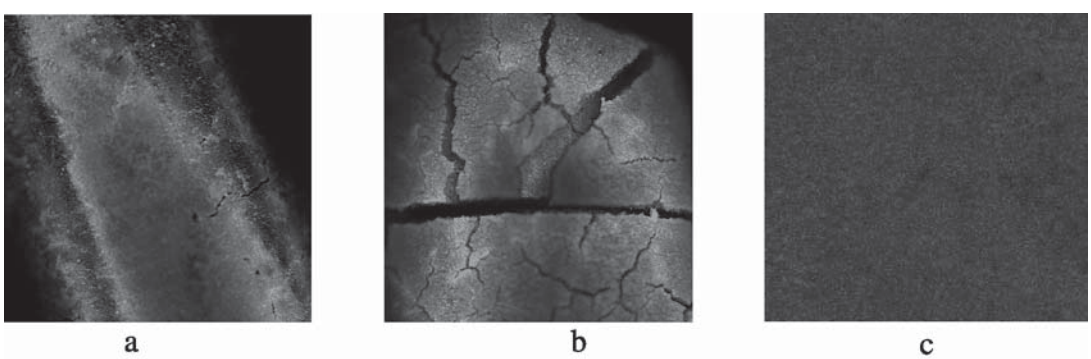

Figure 1 Rice premix as viewed in the CLSM at 5X (a) before cooking (b) after washing (c) after cooking in excess water and draining.

without coating and coated with pectins were not significantly different (p>0.05). Their values were between 71.67-73.00, 13.07-14.32 and 78.97-80.92 for L*, a* and b* values, respectively. The rice premix has yellow color (high b* value) due to addition of riboflavin.

1.2 Chemical properties

Moisture contents of all rice premix samples were not significantly different (p>0.05). Their values were between 8.01-8.93%. Table 1-3 showed the loss of thiamine riboflavin and niacin in washed and cooked rice premix without coating and coated with pectins in excess water and draining. The rice premix coated with pectins showed lower vitamin losses after washing than those without coating. The higher degree of methoxyl pectin showed the lower vitamin losses in washed rice premix than lower degree of

Table 1 Thiamine contents in rice premix, washed and cooked rice in excess water and draining, washing and cooking losses.

Rice premix	Thiamine contents (mg/100 g)			Washing loss (%)	Cooking loss (%) (ns)
	Rice premix	Washed rice premix	Cooked rice premix		
- No pectin coating	23.47 ± 0.13	4.92 ± 0.24	1.68 ± 0.20	79.03 ± 1.14 a	92.84 ± 0.88
- Coated with pectin 36 % degree of methoxyl	25.84 ± 0.12	11.41 ± 0.02	1.37 ± 0.32	55.86 ± 0.29 c	94.69 ± 1.28
- Coated with pectin 31 % degree of methoxyl with 18 % degree of amidation	19.28 ± 4.50	8.19 ± 0.93	1.46 ± 0.05	56.90 ± 5.23 c	92.15 ± 2.09
- Coated with pectin 28 % degree of methoxyl with 21% degree of amidation	24.25 ± 0.27	7.57 ± 0.15	0.84 ± 0.00	68.78 ± 0.99 b	96.67 ± 0.23

Note: alphabets a-c were different within column mean values were significantly different (p≤0.05)
ns means values within column were not significantly different (p>0.05)

Table 2 Riboflavin contents in rice premix, washed and cooked rice in excess water and draining, washing and cooking losses.

Rice premix	Riboflavin contents (mg/100 g)			Washing loss (%)	Cooking loss (%) (ns)
	Rice premix	Washed rice premix	Cooked rice premix		
- No pectin coating	41.98 ± 2.76	8.19 ± 1.41	2.82 ± 0.20	80.54 ± 2.07 a	93.28 ± 0.50
- Coated with pectin 36 % degree of methoxyl	38.68 ± 3.46	12.52 ± 1.46	3.01 ± 0.25	67.66 ± 0.90 c	92.17 ± 1.34
- Coated with pectin 31 % degree of methoxyl with 18 % degree of amidation	45.48 ± 0.30	12.34 ± 0.33	3.32 ± 0.01	72.86 ± 0.55 b	92.69 ± 0.08
- Coated with pectin 28 %degree of methoxyl with 21 % degree of amidation	38.81 ± 1.79	10.91 ± 0.50	2.90 ± 0.02	71.28 ± 2.60 bc	92.53 ± 0.29

Note: alphabets a-c were different within column mean values were significantly different (p≤0.05)
ns means values within column were not significantly different (p>0.05)

methoxyl pectin. This may be due to the fact that the presence of calcium ion was not enough to strengthen gel (Thakur *et al*., 1997).

However, pectin coatings were not good enough to prevent leaching of these vitamins from rice premix when boiled in excess water. The preparation process of rice premix consisted of many steps of coating and drying which had an effect on rice cracking. During boiling, water can easily access into the interior of the cracked grain, this causes increasing of hydration and subsequently leaching of vitamin into the cooking water. (Shrestha *et al*., 2003)

Since, the rice premix coated with pectin (36% degree of methoxyl) had the lowest vitamin loss during washing and cooking, it was selected for the next experiment.

2. The suitable ratio of rice premix to milled rice to attain desired enrichment level in the final product

2.1 Physical and chemical properties

Cooked fortified rice had light yellow in color, due to the leaching out of vitamins from surface of rice premix during washing and cooking. The a* and b* values increased with increasing rice premix to milled rice ratios (Table 4).

The amount of vitamins (thiamine, riboflavin and niacin) in unwashed, washed and cooked milled rice and fortified rice were shown

Table 3 Niacin contents in rice premix, washed and cooked rice in excess water and draining, washing and cooking losses.

Rice premix	Niacin contents (mg/100 g)			Washing loss (%)	Cooking loss (%) (ns)
	Rice premix	Washed rice premix	Cooked rice premix		
- No pectin coating	429.28 ± 11.28	92.46 ± 14.67	22.87 ± 0.83	78.41 ± 3.99 a	94.67 ± 0.06
- Coated with pectin 36 % degree of methoxyl	473.71 ± 0.68	211.14 ± 2.82	25.87 ± 0.37	55.43 ± 0.54 b	94.54 ± 0.08
- Coated with pectin 31 % degree of methoxyl with 18 % degree of amidation	405.07 ± 23.81	182.41 ± 16.54	22.53 ± 0.07	54.77 ± 6.74 b	94.43 ± 0.35
- Coated with pectin 28 % degree of methoxyl with 21 % degree of amidation	478.86 ± 30.57	181.14 ± 2.93	24.88 ± 0.25	62.08 ± 3.03 b	94.79 ± 0.28

Note: value in the same column with different superscripts differ significantly ($p \leq 0.05$)
ns means values within column were not significantly different ($p > 0.05$)

Table 4 L* a* and b* values of cooked vitamin fortified rice.

Rice premix to milled rice	L*	a*	b*
Milled rice	77.49 ± 0.10 a	-2.11 ± 0.06 b	8.94 ± 0.22 d
Fortified rice (rice premix to milled rice)			
1 : 100	77.46 ± 0.12 a	-2.59 ± 0.06 a	9.93 ± 0.17 c
1 : 85	77.47 ± 0.10 a	-2.63 ± 0.06 a	11.43 ± 0.07 b
1 : 70	76.64 ± 0.02 b	-2.57 ± 0.07 a	11.66 ± 0.19 a

Note: value in the same column with different superscripts differ significantly ($p \leq 0.05$)

in Table 5-7. It was found that the amount of vitamins in unwashed, washed and cooked rice increased with increasing ratios of rice premix to milled rice). The ratio of rice premix to milled rice at 1:70 met the requirement for thiamine and niacin fortification of rice, according to Thai Reference Daily Intake (Thai RDI) in which the cooked fortified rice should have thiamine and niacin contents more than 10% of cooked milled rice. But the riboflavin content was less than 10% of cooked milled rice.

2.2 Sensory evaluation

The liking score for each attribute of cooked milled rice and fortified rice were not significantly different ($p>0.05$) (Table 8). This indicates that the fortification of rice with vitamins by mixing rice premix with milled rice had no effects on the panelists preference.

Therefore, the ratio of rice premix to milled rice at 1:70 was selected for study on consumer acceptance.

Table 5 Amount of thiamine in unwashed, washed and cooked rice and fortified rice.

Rice premix to milled rice	Amount of thiamine (mg/100 g)		
	Unwashed	Washed rice	Cooked rice
Milled rice	0.05 ± 0.01 c	0.04 ± 0.01 c	0.01 ± 0.03 c
Fortified rice (rice premix to milled rice)			
1 : 100	0.28 ± 0.01 b	0.17 ± 0.00 b	0.10 ± 0.00 b
1 : 85	0.30 ± 0.01 b	0.19 ± 0.01 b	0.12 ± 0.01 b
1 : 70	0.39 ± 0.21 a	0.25 ± 0.03 a	0.17 ± 0.01 a

Note: value in the same column with different superscripts differ significantly ($p\leq0.05$)

Table 6 Amount of riboflavin in unwashed, washed and cooked rice and fortified rice.

Rice premix to milled rice	Amount of riboflavin (mg/100 g)		
	Unwashed	Washed rice	Cooked rice
Milled rice	0.04 ± 0.00 b	0.03 ± 0.00 c	0.01 ± 0.00 b
Fortified rice (rice premix to milled rice)			
1 : 100	0.43 ± 0.04 a	0.12 ± 0.01 b	0.04 ± 0.01 a
1 : 85	0.52 ± 0.04 a	0.18 ± 0.02 a	0.05 ± 0.01 a
1 : 70	0.55 ± 0.01 a	0.20 ± 0.00 a	0.05 ± 0.00 a

Note: value in the same column with different superscripts differ significantly ($p\leq0.05$)

Table 7 Amount of niacin in unwashed, washed and cooked rice and fortified rice.

Rice premix to milled rice	Amount of niacin (mg/100 g)		
	Unwashed	Washed rice (ns)	Cooked rice
Milled rice	27.86 ± 3.72 b	26.17 ± 1.39	14.70 ± 1.50 b
Fortified rice (rice premix to milled rice)			
1 : 100	49.25 ± 0.12 a	30.10 ± 0.80	12.09 ± 4.23 b
1 : 85	49.77 ± 0.52 a	28.83 ± 0.21	11.34 ± 4.57 b
1 : 70	48.33 ± 0.97 a	32.12 ± 8.07	27.89 ± 0.44 a

Note: value in the same column with different superscripts differ significantly ($p\leq0.05$)
ns means values within column were not significantly different ($p>0.05$).

Table 8 Liking scores of cooked rice and fortified rice.

Attributes	Rice premix to milled rice			
	Milled rice	1 : 100	1 : 85	1 : 70
Appearance (ns)	6.7 ± 1.4	6.7 ± 1.3	6.4 ± 1.4	6.7 ± 1.3
Color (ns)	7.0 ± 1.3	6.7 ± 1.4	6.5 ± 1.3	6.6 ± 1.1
Odor (ns)	5.9 ± 1.1	6.1 ± 1.5	6.1 ± 1.5	6.2 ± 1.7
Flavor (ns)	6.1 ± 1.2	6.3 ± 1.2	6.2 ± 1.3	6.5 ± 1.2
Texture (ns)	6.1 ± 1.5	6.0 ± 1.4	5.9 ± 1.4	6.4 ± 1.4
Overall liking (ns)	6.3 ± 1.5	6.3 ± 1.4	6.1 ± 1.3	6.6 ± 1.3

Notes: ns means values within row were not significantly different (p>0.05).

3. Consumer acceptance test

The results showed that the vitamin fortified rice was significantly accepted by the consumers at 95% (Central Location Test) and 98% (Home Use Test). The overall liking scores of the vitamin fortified rice before and after cooking were 6.9 and 7.5 (CLT) ; 7.4 and 7.8 (HUT), respectively.

CONCLUSION

Rice premix coated with pectin (36% degree of methoxyl) had a minimal loss of vitamins during washing. But pectin coating could not prevent vitamins from cooking loss. The vitamins fortified rice at ratio of 1:70 was suitable. It was significantly accepted by consumers at 95% and 98% with overall liking scores 7.5 and 7.8 for Central Location Test and Home Use Test, respectively.

For further study, we recommend to focus on the protein-based films because they are better in mechanical and barrier properties than polysaccharide based films. Therefore it might protect vitamin loss in washing and cooking process.

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