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Research Article

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Combination of Rice Malt and Barley Malt for Wort Production

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ABSTRACT

The production of rice malt can be used as an ingredient in gluten-free foodstuffs especially for brewing purpose. Rice used as adjunct is limited because the relative lower soluble nitrogen compare with that of barely will dilute total nitrogenous substances in wort and beer. In this research, we focus on investigation the rice varieties for rice malt production; the appropriate ratio of barley malt and rice malt during wort production; ratio of malt/water, temperature, pH, time during wort production. Our results show that rice variety OM 4884, 50% barley malt: 50% rice malt; malt/water 1:4. Proteinazation is optimized at temperature 47-50 ^{o}C, pH 5.2-5.5 in 30 minutes. During saccharization, β – amylase is optimized at 63 – 65 ^{o}C, pH 5.4 – 5.5 in 30 minutes. And α – amylase is operated at 69 – 73 ^{o}C, pH 5.3 – 5.7 in 30 minutes.

***Keywords**: Rice malt, wort production, proteinazation, saccharization*

INTRODUCTION

The basic ingredients in beer are water, malt, hop and yeast. Barley is the most common cereal used to produce malt[6]. Raw materials are the main contributor to operating cost, particularly for the brewery that imports malt and adjuncts from abroad. Rice (*Oryza sativa*) is preferred by some brewers because of its lower haze protein and lipids contents compared with those of corn grit. Rice adjunct in brewing cause neutral aroma, yields a light, clean-tasting beer. However rice malt has never been successfully used in brewing because of its low free α-amino nitrogen content.

There are many reports of rice malt production[3,4,7] characterized different rice varieties through morphological description and chemical−physical analyses. Artit Kongkaew *et al.*[1] designed to optimise rice malt replacement for barley malt in wort production and to improve FAN by adding α-amylase and protease. E. Asante *et al.*[2] investigated the production and purification of α-amylase from malted rice extract. Heidi Mayer *et al.*[5] conducted to produce rice malt suitable for beer brewing.

The main purpose of this research is to investigate the rice varieties for rice malt production; the appropriate ratio of barley malt and rice malt during wort production; ratio of malt/water, temperature, pH, time during wort production.

MATERIAL AND METHOD

Material

Barley malt is supplied from Australia. Rice is originated from Mekong River Delta, Vietnam.

Research method

In this research, we examine rice varieties for rice malt production; the appropriate ratio of barley malt and rice malt during wort production; ratio of malt/water, temperature, pH, time during wort production.

Experiment #1: Rice varieties for rice malt production. The experiment is randomly designed with one factor A, three replications. We examine 19 varieties of rice coded from A1 to A19. Total roots are 171.

Table 1. Rice varieties for rice malt production

Sample	Rice varieties		Sample	Rice varieties		Sample	Rice varieties
A1	AS996		A8	OM 4218		A14	OM 5629
A2	IR 50404		A9	OM 4274		A15	OM 5976
A3	OM 2395		A10	OM 4884		A16	OM 6076
A4	OM 2517		A11	OM 4900		A17	OM 6162
A5	OM 2818		A12	OM 5472		A18	OM 6377
A6	OM 4092		A13	OM 5494		A19	OM 6521
A7	OM 4103						

Experiment #2: Effect of barley malt: rice malt during wort production. Experiment is randomly designed with one factor C (ratio of barley malt: rice malt, %), three replications. Total roots are 18.

Table 2. Effect of barley malt: rice malt during wort production

Factor	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Barley malt (%)	100	90	80	70	60	50	40	30	20	10	0
Rice malt (%)	0	10	20	30	40	50	60	70	80	90	100

Experiment #3: Parameters in wort production

- Ratio of malt: water. Experiment is randomly designed with one factor D (ratio of malt: water, %), three replications. Total roots are 12.

Table 3. Ratio of malt: water

D	D1	D2	D3	D4
Malt (g)	1	1	1	1
Water (ml)	3	4	5	6

- Effect of pH and temperature during proteinazation: Experiment is randomly designed with two factors, 3 replications. Factor E (temperature 40, 45, 50, 55 oC); Factor F (pH 4.5, 5.0, 5.5, 6.0). Total roots are 48.

Table 4. Effect of pH and temperature during proteinazation

Temperature (^oC) / pH	40	45	50	55
4.5	E1F1	E2F1	E3F1	E4F1
5.0	E1F2	E2F2	E3F2	E4F2
5.5	E1F3	E2F3	E3F3	E4F3
6.0	E1F4	E2F4	E3F4	E4F4

- Effect of time during proteinazation. Experiment is randomly designed with one factor, 3 replications. Factor I (time of proteinazation; 20, 30, 40, 50, 60 minutes). Total roots are 15.
- Effect of pH and temperature during saccharization. Experiment is randomly designed with two factors, 3 replications. Factor G (temperature; 60, 65, 70, 75^{o}C). Factor H (pH; 4.5, 5.0, 5.5, 6.0, 6.5). Total roots are 60.

Table 5. Effect of pH and temperature during saccharization

Temperature / pH	60	65	70	75
4.5	G1H1	G2H1	G3H1	G4H1
5.0	G1H2	G2H2	G3H2	G4H2
5.5	G1H3	G2H3	G3H3	G4H3
6.0	G1H4	G2H4	G3H4	G4H4
6.5	G1H6	G1H6	G3H6	G4H6

- Effect of time for β-amylase during saccharization. Experiment is randomly designed with one factor, 3 replications. Factor J (time of proteinazation; 15, 30, 60, 90, 120 minutes). Total roots are 15.
- Effect of time for α-amylase during saccharization Experiment is randomly designed with one factor, 3 replications. Factor K (time of proteinazation; 30, 60, 90, 120 minutes). Total roots are 12.
- Summary of parameters for wort production: determine the effectiveness of temperature, pH and time during proteinazation and saccharization in wort production by checking the reduced sugar and nitrogen amine in wort.

Statistical analysis

All data are processeed by ANOVA, Statgraphics.

RESULT AND DISCUSSION

Chemical composition of rice varieties

Table 6. Chemical composition of rice varieties

No	Sample	Code	Moisture (%)	Dry matter (%)	Protein (%)	Glucid (%)
1	A1	AS 996	12.88	87.12	7.63	72.53
2	A2	IR 50404	13.82	86.18	8.46	69.17
3	A3	OM 2395	12.26	87.74	8.77	68.88
4	A4	OM 2517	12.66	87.34	7.22	67.83
5	A5	OM 2818	11.93	88.07	6.74	72.87
6	A6	OM 4092	12.73	87.27	7.26	67.49
7	A7	OM 4103	12.54	87.46	8.65	68.16
8	A8	OM 4218	12.04	87.96	7.67	72.20
9	A9	OM 4274	12.21	87.79	6.82	71.86
10	**A10**	**OM 4884**	**12.56**	**87.44**	**8.99**	**73.21**
11	A11	OM 4900	12.31	87.69	6.77	68.19
12	A12	OM 5472	12.34	87.66	7.76	69.51
13	A13	OM 5494	12.4	87.60	6.78	72.59
14	A14	OM 5629	11.46	88.54	6.80	69.19
15	A15	OM 5976	12.33	87.67	7.10	68.50
16	A16	OM 6076	12.01	87.99	6.71	69.27
17	A17	OM 6162	13.30	86.70	7.04	68.84
18	A18	OM 6377	12.59	87.41	6.88	69.55
19	A19	OM 6521	12.30	87.70	7.82	69.84

Fig. 1: Protein and glucid in different rice varieties

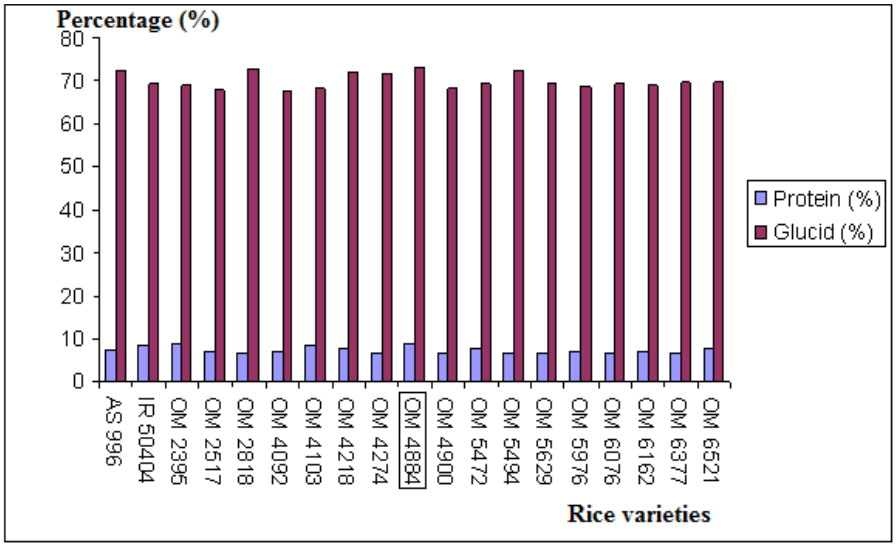
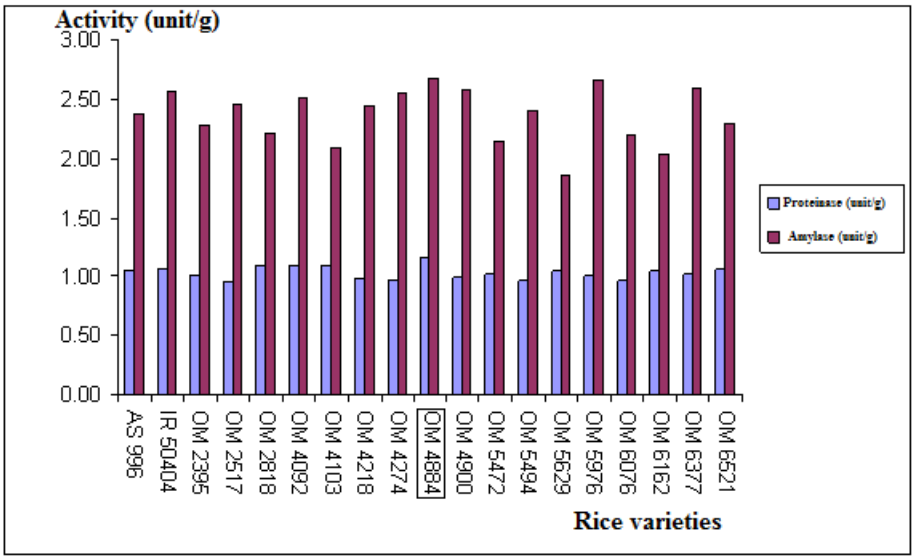


Fig. 2: Proteinase and amylase in rice varieties



OM 4884 has the highest content of protein and glucid; proteinase and amylase. So we choose this rice for further research.

Effect of combination rice malt and barley in wort production

Table 7. Compositon of wort by combination of rice malt and barley malt

No	Sample	Ratio (%)		Composition of wort					
		Barley malt	Rice malt	Reduced sugar		Nitrogen amine		Soluble dry matter	
				(g/l)	(%)	(mg/l)	(%)	(^{o}Brix)	(%)
1	C1	100	0	242.57	100	981.02	100	17.8	100.0
2	C2	90	10	208.62	86.0	938.31	95.6	17.0	95.5
3	C3	80	20	208.12	85.8	884.67	90.2	15.2	85.4
4	C4	70	30	180.39	74.4	877.38	89.4	14.0	78.7
5	C5	60	40	146.11	60.2	750.29	76.5	13.0	73.0
6	**C6**	**50**	**50**	**142.58**	**58.8**	**710.19**	**72.4**	**11.2**	**62.9**
7	C7	40	60	136.53	56.3	572.17	58.3	10.5	59.0
8	C8	30	70	92.16	38.0	545.08	55.6	9.5	53.4
9	C9	20	80	89.14	36.7	509.15	51.9	9.0	50.6
10	C10	10	90	50.58	20.9	396.13	40.4	7.0	39.3
11	C11	0	100	41.75	17.2	374.77	38.2	5.0	28.1

Fig. 3: Nitrogen amin (mg/l) in wort by barley malt/ rice malt

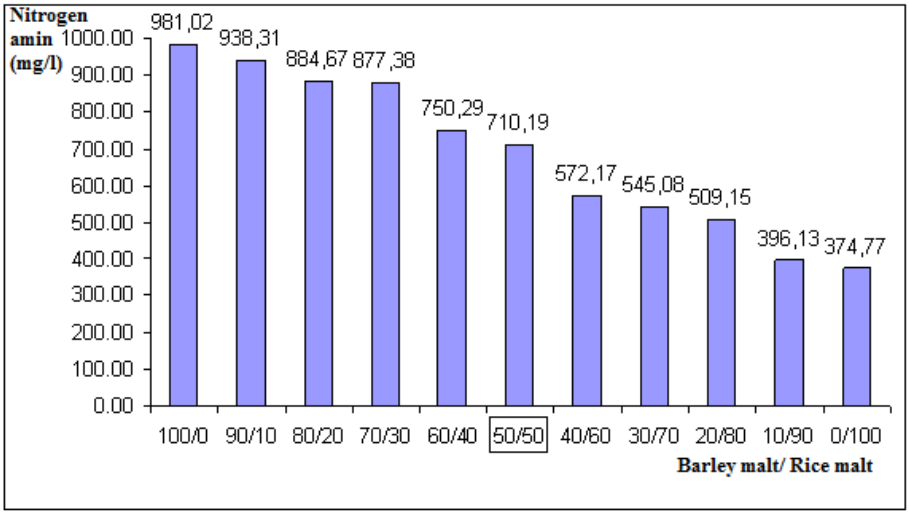
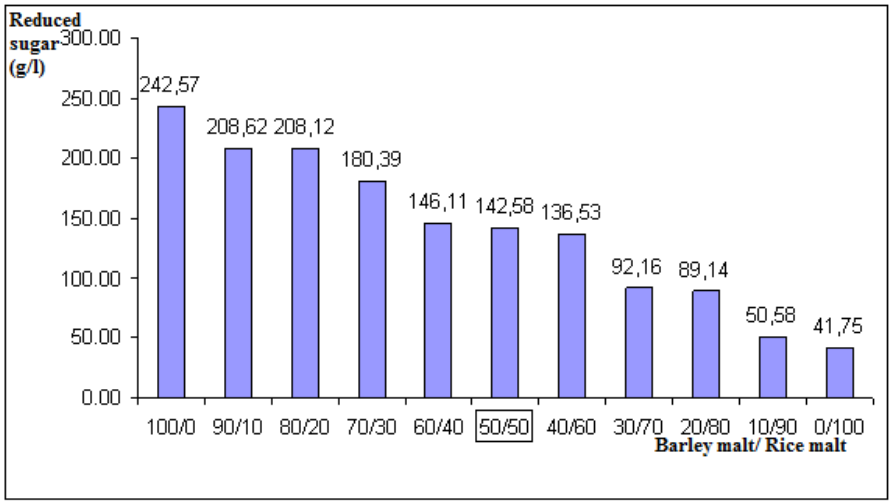


Fig. 4: Reduced sugar (g/l) in wort by barley malt/ rice malt



From above result, we choose ratio barley malt/ rice malt (50%:50%) for further experiments.

Technical factors during wort production

Effect of malt/ water

Table 8. Wort composition by malt/water

No.	Sample	Malt / water	Soluble dry matter (^{o}Brix)	Nitrogen amin (mg/l)	Reduced sugar (g/l)
1	D1	1/3	11.8	909.06	165.25
2	**D2**	**¼**	**11.2**	**709.06**	**141.81**
3	D3	1/5	8.6	382.16	109.8
4	D4	1/6	7.8	245.61	92.15

We choose malt/water (1/4) for further experiments.

Effect of pH and temperature for proteinazation

Table 9. Effect of pH and temperature for proteinazation

No	Code		Temperature (^{o}C)	pH	Nitrogen amin (mg/l)
1	E1F1		40	4.5	639.6
2	E1F2		40	5.0	595.3
3	E1F3		40	5.5	618.2
4	E1F4		40	6.0	598.4
5	E2F1		45	4.5	596.4
6	E2F2		45	5.0	664.1
7	E2F3		45	5.5	679.2
8	E2F4		45	6.0	629.7
9	E3F1		50	4.5	603.1
10	E3F2		50	5.0	692.2
11	**E3F3**		**50**	**5.5**	**712.0**
12	E3F4		50	6.0	659.4
13	E4F1		55	4.5	658.3
14	E4F2		55	5.0	608.9
15	E4F3		55	5.5	617.2
16	E4F4		55	6.0	647.9

At temperature 50 ^{o}C and pH 5.5, the wort has the highest nitrogen amine 712 mg/l

Effect of time for proteinazation

Table 10. Effect of time for proteinazation

No.	Sample	Temperature (°C)	pH	T (minute)	Malt/Water	Nitrogen amin (mg/l)
1	I1	49	5.4	20	1/4	631.25
2	**I2**	**49**	**5.4**	**30**	**1/4**	**716.88**
3	I3	49	5.4	40	1/4	751.56
4	I4	49	5.4	50	1/4	765.63
5	I5	49	5.4	60	1/4	771.35

The wort has the nitrogen amine optimized at 30 minutes 646.88 mg/l. So we choose this value for further research. So during proteinazation, we use 50% barley malt and 50% rice malt, malt/ water ¼, temperature 49 – 50 °C; pH 5.2 – 5.5 in 30 minutes.

Effect of pH and temperature during saccharization

Table 11. Effect of pH and temperature to reduced sugar in wort during saccharization

No	Sample	Temperature (°C)	pH	Reduced sugar (g/l)
1	G1H1	60	4.50	61.41
2	G1H2	60	5.00	71.49
3	G1H3	60	5.50	76.03
4	G1H4	60	6.00	69.00
5	G1H6	60	6.50	68.97
6	G2H1	65	4.50	72.00
7	G2H2	65	5.00	73.68
8	**G2H3**	**65**	**5.50**	**94.50**
9	G2H4	65	6.00	72.63
10	G1H6	65	6.50	75.53
11	G3H1	70	4.50	74.10
12	G3H2	70	5.00	76.50
13	**G3H3**	**70**	**5.50**	**82.50**
14	G3H4	70	6.00	61.17
15	G3H6	70	6.50	79.50
16	G4H1	75	4.50	70.99
17	G4H2	75	5.00	74.52
18	G4H3	75	5.50	79.06
19	G4H4	75	6.00	76.03
20	G4H6	75	6.50	75.02

From table above, we see that there are two regimes we can choose at temperature 65°C, pH 5.5 or 70°C, pH 5.5 to get the best reduced sugar content in wort.

Effect of time for β-amylase activation during saccharization

Table 12. Effect of time to reduced sugar in wort during saccharization by β-amylase

No	Code	Barley malt/ Rice malt	Malt/ Water	Temperature (°C)	pH	Time (minutes)	Reduced sugar (g/l)
1	J1	50/50	1/4	63	5.4	15	76.70
2	**J2**	**50/50**	**1/4**	**63**	**5.4**	**30**	**97.04**
3	J3	50/50	1/4	63	5.4	45	107.30
4	J4	50/50	1/4	63	5.4	60	113.17

From above result, we choose 30 minutes for saccharization by β-amylase.

Effect of time for α-amylase activation during saccharization

Table 13. Effect of time to reduced sugar in wort during saccharization by α-amylase

No	Sample	Barley malt/ Rice malt	Malt/ Water	Temperature (^oC)	pH	Time (minutes)	Reduced sugar (g/l)
1	**K1**	**50/50**	**1/4**	**72**	**5.4**	**30**	**85.78**
2	K2	50/50	1/4	72	5.4	60	88.45
3	K3	50/50	1/4	72	5.4	90	90.65
4	K4	50/50	1/4	72	5.4	120	97.94

From above result, we choose 30 minutes for saccharization by α-amylase.

Optimal conditions for wort production

Table 14. Optimal conditions for wort production

Parameter			Optimal result
Barley malt/ Rice malt			50/50
Malt/ water			1/4
Proteinazation	Temperature (^oC)		47 – 50 ^oC, 30 minutes
	pH		5.4
Saccharization	β-amylase	Temperature (^oC)	63 – 65 ^oC, 30 minutes
		pH	5.4
	α-amylase	Temperature (^oC)	69 – 73 ^oC, 30 minutes
		pH	5.4

The analysed results show that the wort has nitrogen amin 790 mg/l and reduced sugar 154 (g/l) which is adaptable for brewing.

CONCLUSION

This study was conducted to produce rice malt suitable for beer brewing. Rice malt could also contribute to new beer flavors and brands. A screening of 19 rice varieties was conducted. Malting of cereal grains other than barley has attracted a lot of attention in recent years. The reason has been the need to find suitable alternative to imported barley. Improving the malting qualities of rice malt will thus enhance its potential and usage in brewing.

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