Quality Improvement of Rice Bread

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Enthusiastic studies have been conducted recently utilizing rice flour, starch and defatted oil seed flour besides wheat flour for bread-making to cope with the increase in bread consumption in countries where wheat is not produced.

Also in Japan, in the past several years the utilization of rice for making bread has become a major interest attributed to surplus rice following excessive rice production over rice consumption.

It was then examined what influence would arise and what effective method would exist in order to improve the quality when rice flour was used for baking bread.

Influence of substitution of rice flour on loaf volume

The result of examination about the influence on the loaf volume of rice bread, when bread is baked, substituting rice flour for a part of wheat flour, by a method almost following the straight-dough AACC method 10–10[1], is shown in Fig. 1.

From this the volume is directly and drastically decreased with the increase in intermixing rate of rice flour substituted although it is indicated as a specific volume in Fig. 1.

Bread made from only rice flour could be at least puffed by annexing 20 per cent of gluten, but the quality of the crumb was very poor. The cause that loaf volume is thus decreased by intermixing rice flour is due to the fact that the gluten in wheat flour, which plays an important role in puffing bread by

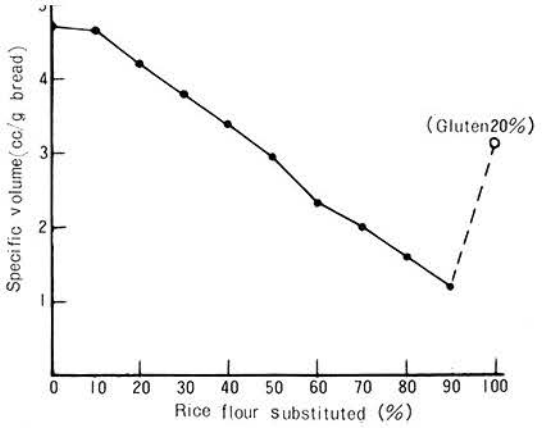


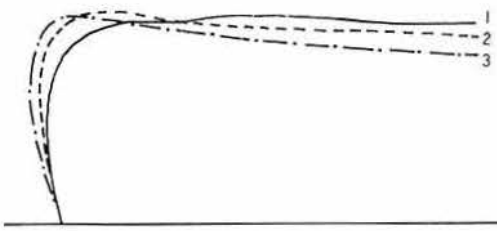
Fig. 1. Influence of the substitution level of rice flour on loaf volume of rice bread

enveloping carbon dioxide generated from fermentation, is diluted by rice flour and this influence will naturally appear also on the properties of dough. What influence the substitution of rice flour has on the physical properties of dough was then examined.

Examination about influence of substitution of rice flour by Brabender's device

The result of examination about the influence of rice flour on the properties of dough by Brabender's Farinograph and Extensograph is shown in Figs. 2 and 3.

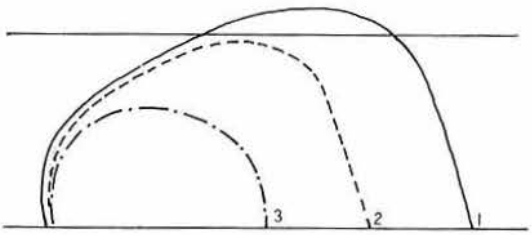
From the outcome of Farinogram, absorption (Abs.), development time and valorimeter value (VV) are apt to decrease with the enhancement in the substituting quantity of rice flour, while from the Extensogram both



	Wheat flour : Rice flour	Abs	DT	VV	Weak
1	100 : 0	62.2%	11.0min	82	5
2	80 : 20	59.5	9.5	78	6
3	60 : 40	57.5	5.5	61	11

Fig. 2. Influence of the substitution of rice flour on the farinogram of wheat flour

Remarks 1) Abs: Absorption, 2) DT: Development time, 3) VV: Valorimeter value, 4) Weak: Weakness



	Wheat flour : Rice flour	Resistance	Extensibility
1	100 : 0	535BU	185mm
2	80 : 20	460	145
3	60 : 40	335	100

Fig. 3. Influence of the substitution of rice flour on the extensogram (90 min.) of wheat flour

extensibility and resistance (R) vastly decreased with the augmentation in the substituting quantity of rice flour.

These tendencies show that the baking quality of dough is low. Thus, it becomes difficult to bake bread, resulting in reducing the quality of bread.

The change in Amylogram is shown in Fig. 4, from which it is clear that the B.U. value suitable for breadmaking (about 500 B.U.) is greatly increased by substituting rice flour.

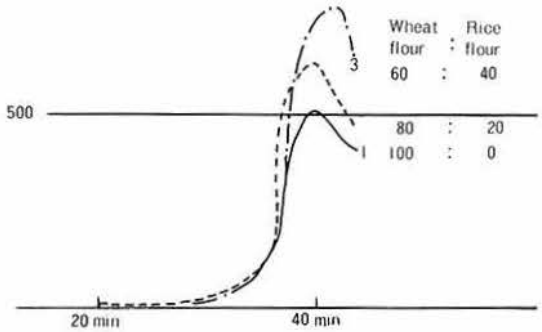


Fig. 4. Influence of the substitution of rice flour on the amylogram of wheat flour

Effect of surfactans

Various tests have been made to bake bread only from starch without using wheat flour[2] where some binder which binds starch granules is necessary to puff bread without the gas escaping. It goes without saying that gluten is the best binder but it has been recognized by Jongh et al.[3] that surfactant is also effective as a binder.

What effect the surfactant has on the change which reduces baking quality due to the substitution of rice flour as mentioned before was subsequently examined. The surfactants used are shown in Table 1.

The result of examination about the effect of using a portion of these surfactants by Brabender's device is shown in Tables 2–4.

On Farinogram, SE was effective to Abs. and MS was most effective to VV. On Extensogram, the surfactant effect was generally recognized and it was effective especially to R where MS was also effective.

In the case of SE, it was noted that it has a tendency to become more effective with the larger HLB. On Amylogram, gelatinization temperature (GT) is increased in the case of the annexed with SE, which is ascribed to the surface of starch granules covered with surfactant and is strengthened as mentioned by McDermott et al[9].

Both maximum viscosity (MV) and viscosity when cooled to 72.5°C (CV) are considerably

Table 1. Surfactants used in the experiment

Glycerin FAE[1]	MS (Stearic, MG[2])	P-100 (Palmitic, MG)	E-100 (Erucic, MG)	B-100 (Behenic, MG)	C_{10}-MG (Capric, MG)	C-100 (Coconut oil, MG)	MH [3]	MT [4]
Sucrose FAE	SE·HLB 15	SE·HLB 11	SE·HLB 7					
Sorbitan FAE	C_{10}-sorE (Capric)	L-300 (Lauric)	P-300 (Palmitic)	S-300 (Stearic)				
Propylen glycol FAE	PL-100 (Lauric)	PO-100 (Oleic)	PP-100 (Palmitic)	PS-100 (Stearic)				
Prepared mixture	MM-A (MG+Casein Na)		FB (MG+CSL[5]+SFAE[6])		SM-300 (MG+SFAE)			

Remarks
1) FAE: Fatty acid ester 2) MG: Monoglyceride 3) Hardened soybeam oil 4) Hardened tallow oil 5) CSL: Calcium stearyl 2-lactylate 6) SFAE: Sorbitan FAE.

Table 2. Effect of surfactants on various farinogram values of wheat flour substituted with rice flour

Wheat flour :	Rice flour	Surfactants*	Abs	DT	VV	Weak
			%	*mm*		*mm*
100:	0	—	63.0	8.0	73	6
80:	20	—	60.0	6.0	66	6
	〃	MS	60.5	9.0	76	8
	〃	P—100	57.7	7.0	70	6
	〃	C_1—MG	59.3	7.5	71	6
	〃	SS·$_{HLB15}$	62.6	7·0	69	8
	〃	〃 $_{11}$	62.7	8.5	74	8
	〃	〃 $_{4}$	63.1	7.5	70	7

* 0.5% (flour basis)

Table 3. Effect of surfactants on various extensogram values of wheat flour substituted with rice flour

	Wheat flour :	Rice flour	Surfactants	Abs	A	R	E
				%	cm^2	BU	*mm*
1)	100:	0	—	59.0	138	535	185
2)	80:	20	—	58.5	90	465	145
3)		〃	MS	59.5	110	525	146
4)		〃	P—100	57.0	110	495	146
5)		〃	C_{10}—MG	55.0	95	490	142
6)		〃	SE·$_{HLB15}$	58.0	104	530	150
7)		〃	〃 $_{11}$	58.5	101	505	148
8)		〃	〃 $_{7}$	58.5	100	505	158

* 0.5% (flour basis)

Remarks
A: Area
R: Resistance
E: Extensibility

Table 4. Effect of surfactants on various amylogram values of wheat flour substituted with rice flour

Wheat flour :	Rice flour	Surfactants	GT	MT	MV	CV
			°C	°C	BU	BU
100:	0	—	61	90.0	495	500
80:	20	—	61	90.0	605	500
	〃	MS	61	95.5	760	980
	〃	P—100	61	92.5	760	950
	〃	C_{10}—MG	60	86.0	840	600
	〃	SE·$_{HLB15}$	63	91.0	800	720
	〃	〃 $_{11}$	61	91.0	770	730
	〃	〃 $_{7}$	63	91.0	740	860

* 0.5% (flour basis)

Remarks
GT: Gelatinization temperature
MT: Maximum viscosity temperature
MV: Maximum viscosity
CV: Viscosity cooled to 72.5°C

increased by annexing surfactant.

In the case of monoglyceride (MG), maximum viscosity temperature is increased, MV is decreased, and CV is enhanced with the longer carbon chain of fatty acid.

The above result showed that the effect of surfactants on viscosity of glue is connected with the hydrophilic properties, MV is increased and CV is not augmented with the higher properties.

The effect of surfactants on rice bread

Table 5. Effect of surfactants on quality of rice bread

Wheat flour	Rice flour	Surfactant	Bread quality			
			Loaf volume	Total score	Taste	Aroma
100 %	0 %	—	700cc	87.3		
80	20	—	610	84.3		
〃		MS	625	85.0		
〃		MT	594	84.9		
〃		MH	600	84.7		
〃		P—100	625	84.6		
〃		B—100	625	83.6	slightly bad	
〃		C—100	688	85.1	bad	bad
〃		E—100	615	85.1	bad	bad
〃		SE • HLB_{15}	652	85.2		
〃		〃 $_{11}$	620	83.2		
〃		〃 $_{7}$	642	84.9		
〃		C_{10}—sorE	653	82.8	bad	bad
〃		S—300	642	82.8		
〃		P—300	637	84.3		
〃		L—300	673	83.3		
〃		PS—100	610	84.8		
〃		PO—100	610	84.3		
〃		PP—100	605	83.9		
〃		PL—100	667	85.4	bad	bad
〃		MM—A	620	85.7		
〃		FB	634	86.2		
〃		SM—300	620	84.1		

quality is shown in Table 5 from which it was found that rice flour substitution greatly decreases the loaf volume of bread; the effect of increasing the volume was especially large in the cases of C-100 and PL-100 while they had a bad effect on the flavor. Besides, the effect was recognized in the case of SE with HLB 15 and 7, C_{10}-sorE, and S-300. C_{10}-MG was not indicated in the table since it completely obstructed yeast fermentation and it was not able to bake bread.

Effect of a-amylase

It was considered that the baking quality would be improved when such measure as strengthening the gluten would be taken since the burden on gluten, which retains gas in the dough becomes larger due to dilution of gluten by substituting rice flour, thus making it difficult to bake bread and decreasing the loaf volume.

The effect of the dough conditioner mainly composed of an oxidizing agent was then compared with that of the one annexed with α-amylase. The result showed the effect is hardly obtained from the conditioner chiefly consisting of an oxidizing agent, which strengthens gluten, but it is unexpectedly procured from the one principally composed of α-amylase.

This shows that bread is not well puffed when rice flour is substituted since sufficient oven spring does not occur on account of the extremely high viscosity of the dough during

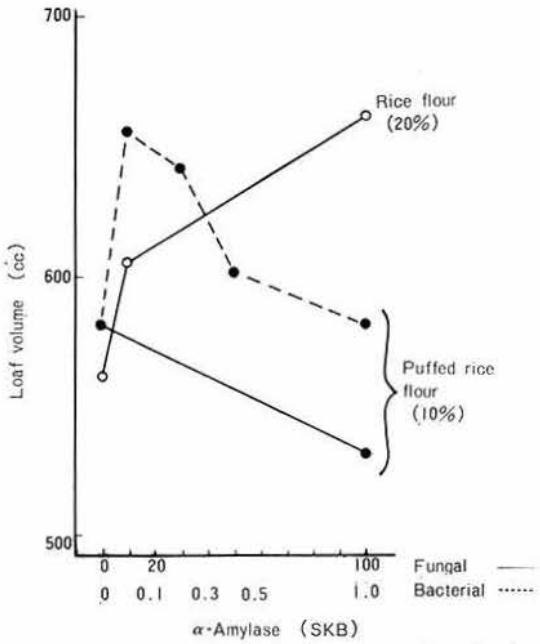


Fig. 5. Effect of α-Amylase on the loaf volume of rice bread

baking in an oven. It could be presumed that by annexing α-amylase bread would be well puffed and the loaf volume would become larger because of the reduction of viscosity. Moreover, the effect of bacterial and fungal α-amylase on loaf volume of rice bread was then examined.

The result is shown in Fig. 5 from which it was found that volume increment could be attained with the increase in annexing quantity of fungal amylase up to 100 SKB when it is annexed to rice flour.

But when puffed rice flour is used for dough, the existence of a large quantity of amylase gives a bad effect since it is decomposed by amylase even at the dough stage.

It was found in conclusion that in such a case, an effective means is to use a little of α-amylase of bacterial with high heat resistance so that sufficient effect may occur only in an oven.

Influence of particle size of rice flour

It is hard to mill rice into similar particle size of wheat flour since it is not so easy to mill rice as wheat. The influence of particle size of rice flour on the quality of rice bread was then examined. As a result, it was found unexpectedly that rice flour with larger particle size does not give a bad effect as shown in Table 6 and may be due to the fact that it does not affect so much the gluten dilution.

Influence of pre-treatment of rice on the baking quality of rice flour

The result of examination on what change appears in the baking quality of the rice flour when rice is milled after it is parched or puffed is shown in Table 7.

It was noted that these pre-treatments were all bad for baking quality of rice flour, resulting in reduction of the loaf volume and lowering of the bread quality.

The absorption especially of puffed rice flour

Table 6. Influence of the particle size of rice flour on quality of rice bread

	Wheat flour	Wheat flour 80% + Rice flour 20%				
Bread	100%	40~60M	60~80M	80~100M	100~150M	150M~
Loaf volume (cc)	680	620	610	590	590	565
Weight (g)	141	139	139	139	140	140
Specific volume	4.8	4.5	4.4	4.2	4.2	4.0
Score of bread quality	87.2	84.2	84.4	84.5	84.5	84.6

M: Mesh

Table 7. Effect of pre-treatment of rice on baking quality of rice flour

	Wheat flour	Wheat flour 80%+Rice flour 20%					
	100%	Not pre-treated		Parched		Puffed	
		B	M	B	M	B	M
Loaf volume (cc)	710	670	660	560	600	560	560
Weight (g)	143	142	142	148	145	149	148
Specific volume	5.0	4.7	4.6	3.8	4.1	3.8	3.8
Score of bread quality	88.1	85.4	85.9	78.3	80.5	78.5	79.9

B: Brown rice M: Milled rice

Table 8. Effect of particle size of puffed rice flour on stickiness of dough and dark spot on crust and dark

Sample No.	Particle-size distribution			Stickiness of dough	Dark spot on crust
	M ~20	M 20~35	M 35~		
(1)	66%	22%	12%	−	##
(2)	11	65	24	−	#
(3)	2	49	49	−	+
	M ~40	M 40~60	M 60~		
(4)	3%	39%	61%	−	−
	M 100%	M 100~200	M 200~		
(5)	17%	16%	67%	##	−

M: Mesh

increased about 10 per cent more than that of wheat flour for which 20 per cent of rice flour without any treatment was substituted, but it was very difficult to bake bread since the dough was too sticky.

The problem of stickiness must be solved in order to put the puffed rice flour, which has a merit of increasing the absorption, into practical application.

As a result of examination about this point, which is shown in Table 8, it was discovered that stickiness could be prevented by enlarging the particle size.

Moreover, desirable result could be obtained by such distribution of particle size as sample No. 4 shown in Table 8, which has no stickiness of dough or dark spot on the crust, since the dark spot appears on the crust when the particle size is too large.

Effect of extension of final proofing time

In the case of bread for which rice flour is substituted, oven spring is very small. The effect of extension of the final proofing time from 55 minutes to 75 minutes was then examined since it was considered that the loaf volume could be increased if the dough would be sufficiently puffed at this stage of bread-making by extending the final proofing time.

Consequently, as shown in Table 9, the loaf volume equivalent to that of 100 per cent of wheat flour could be obtained by extending the final proofing time 20 minutes when the substituting quantity of rice flour is 10 per cent.

Table 9. Effect of final proofing time on loaf volume of rice bread

W. flour	PR. flour	Proof time	Loaf volume
100%	0%	55 min	650 cc
90	10	55	585
〃	〃	60	605
〃	〃	65	645
〃	〃	70	640
〃	〃	75	650

Remarks
W: Wheat, PR: Puffed rice

Summary

The influence of rice flour substitution on the baking quality of wheat flour and the method to improve the rice bread quality were examined. The results are as follows: (1) the baking quality of wheat flour and also the loaf volume are reduced by substituting rice flour to which the use of surfactant is effective, (2) extension of the final proofing time and the use of α-amylase are effective to increase the loaf volume and (3) it was better not to reduce too much the size of rice flour particle.

References

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