An Insight into On-Trend Applications of Whole-Grain: Frozen Dough Bread and Noodles

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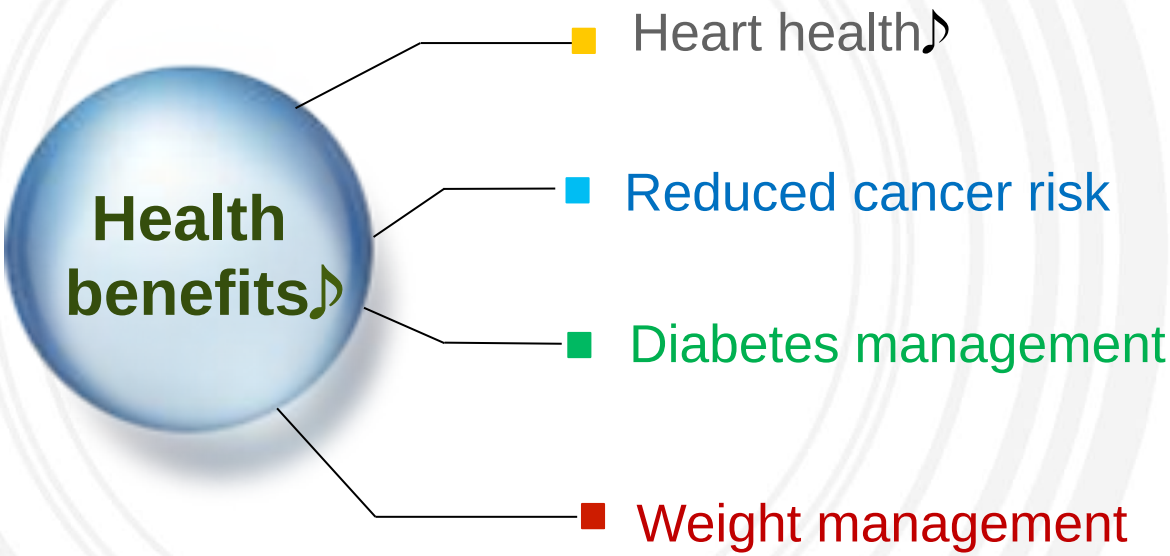
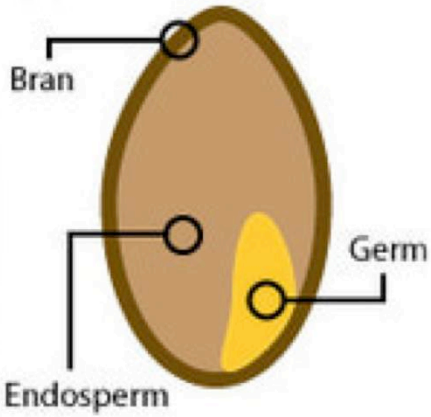
Whole grain

- ✓ Whole grains are cereal grains which are composed of the intact, ground, cracked or flaked caryopsis.
- ✓ They contain cereal germ, endosperm, and bran, in contrast to refined grains which retain only endosperm.
- ✓ US-FDA approved a whole-grain health claim for the foods containing 51 percent or more whole grains by weight.





<Grain anatomy>

Processing performance of whole-grain flour

- ✓ There is a lack of fundamental processing knowledge on whole-grain flour. → The application of whole-grain flour is still limited.
- ✓ Whole-grain foods has a tendency to have undesirable quality attributes, compared to refined flour products.

Compared to refined wheat flour

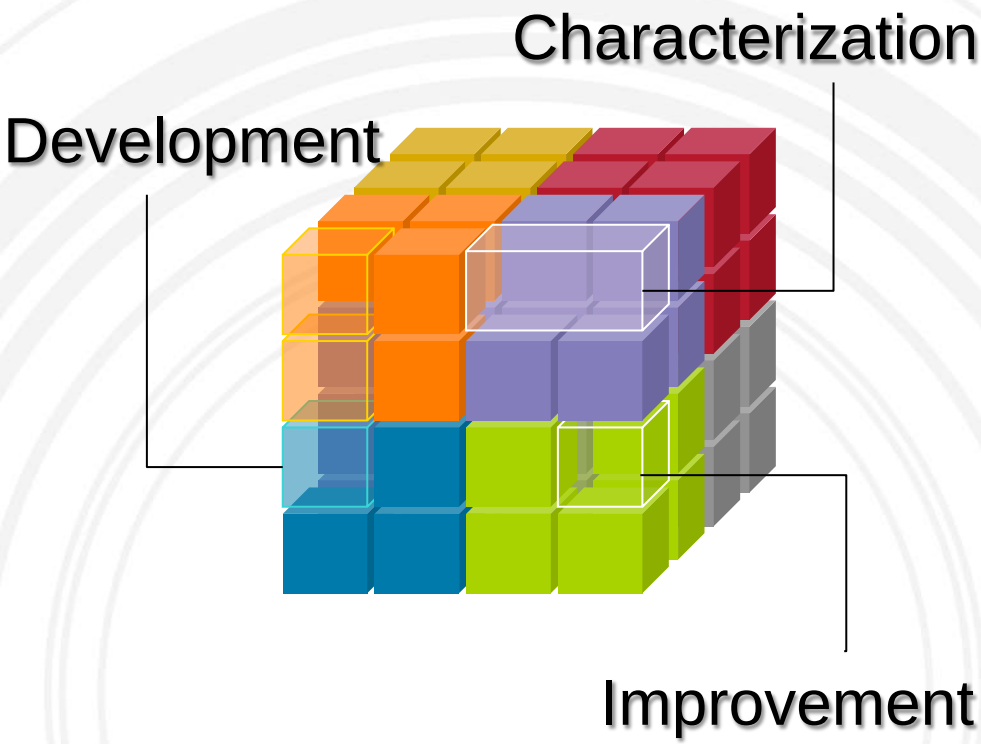
Why?

1. Less gluten and more fibers (dough stability, extensibility etc.)

2. worse sensory qualities (odor, color, texture, etc.)

⇒ Therefore, there is a need to effectively improve the processing performance of whole-grain flour.

Research objectives



→ Physicochemical characterization of refined white and whole-grain flours

→ Application of whole-grain flour to frozen dough bread

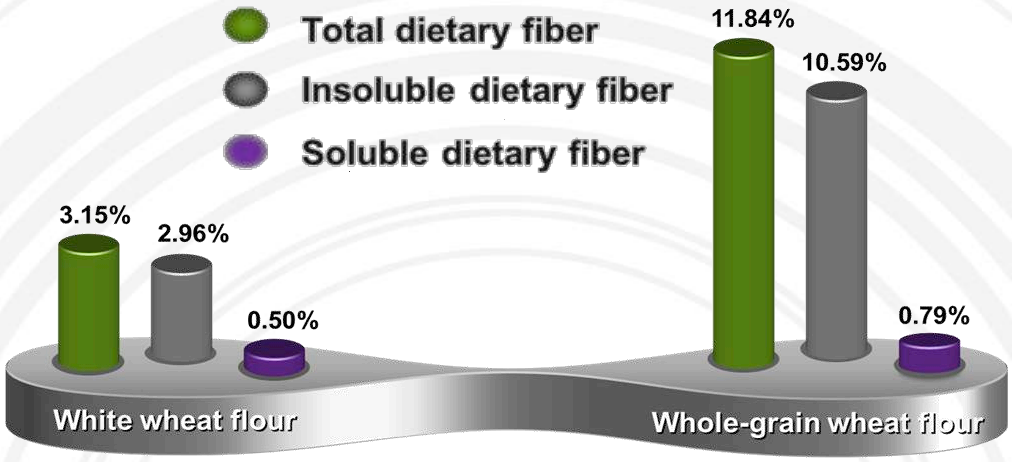
→ Development of whole-grain noodles (extruded and instant fried noodles)

→ Establishment of experimental procedures to improve the quality attributes of whole-grain products

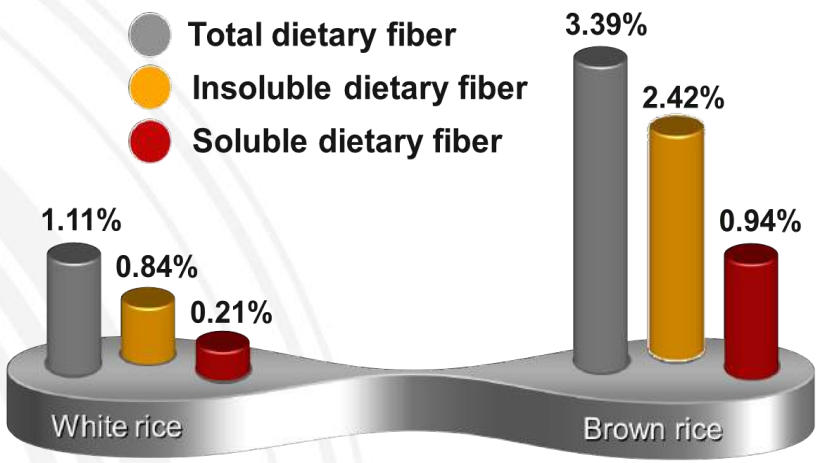
Evaluation of whole-grain flour as a functional ingredient in a processed food system

Chemical composition of whole-grain flour

< Whole wheat>

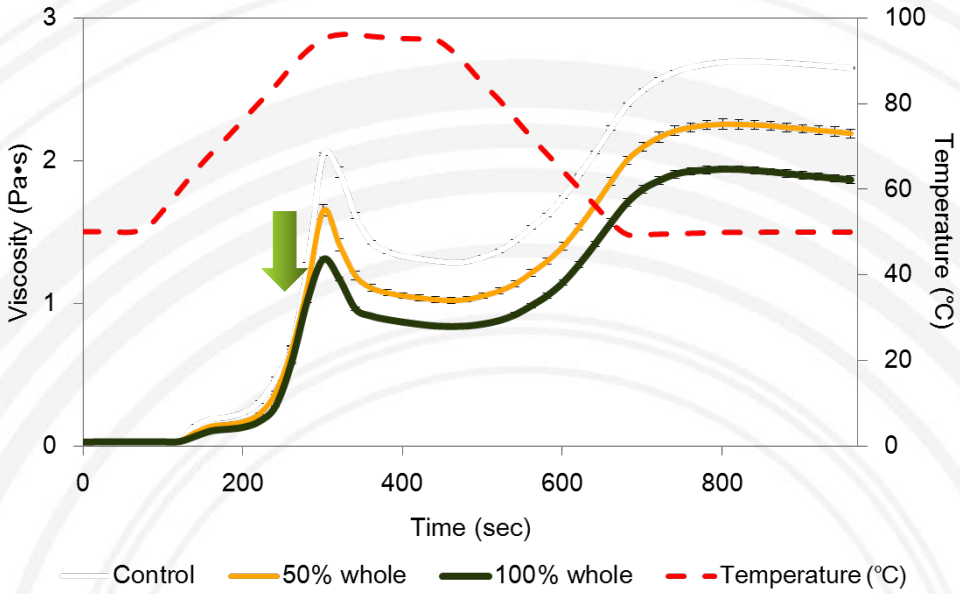


< Brown rice>



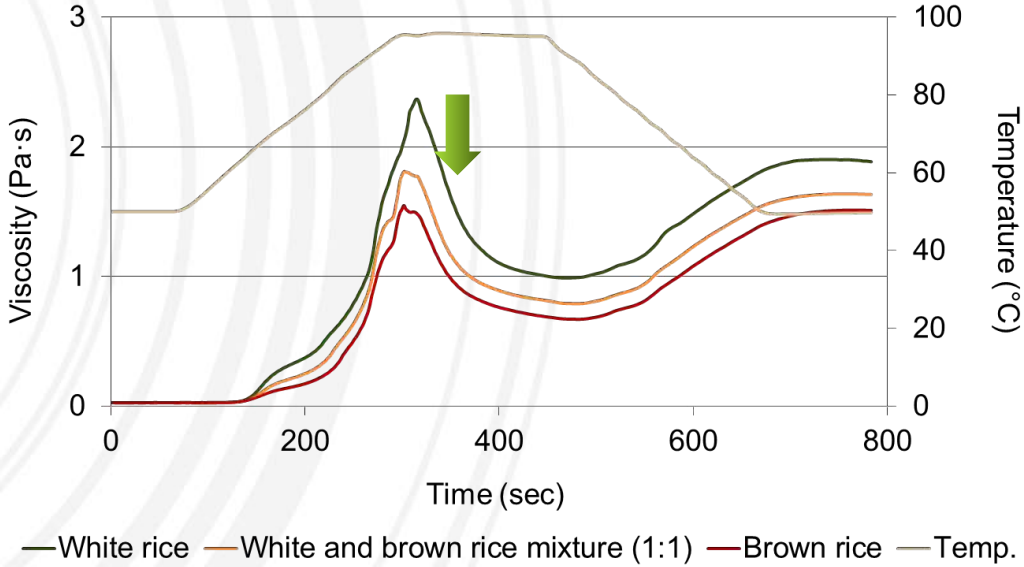
(%)	Moisture	Ash	Protein	Fat	CHO
White wheat flour	13.05[a]	0.56[b]	13.13[b]	1.03[b]	85.36[a]
Whole grain wheat flour	11.55	0.97[a]	15.89[a]	1.83[a]	85.65[b]
White rice flour	8.3[a]	0.3[b]	6.1[b]	0.2[b]	85.1[a]
Brown rice flour	8.2[a]	1.1[a]	6.4[a]	2.2[a]	82.1[b]

Pasting profile of whole-grain flour



<Whole wheat>

<Brown rice>



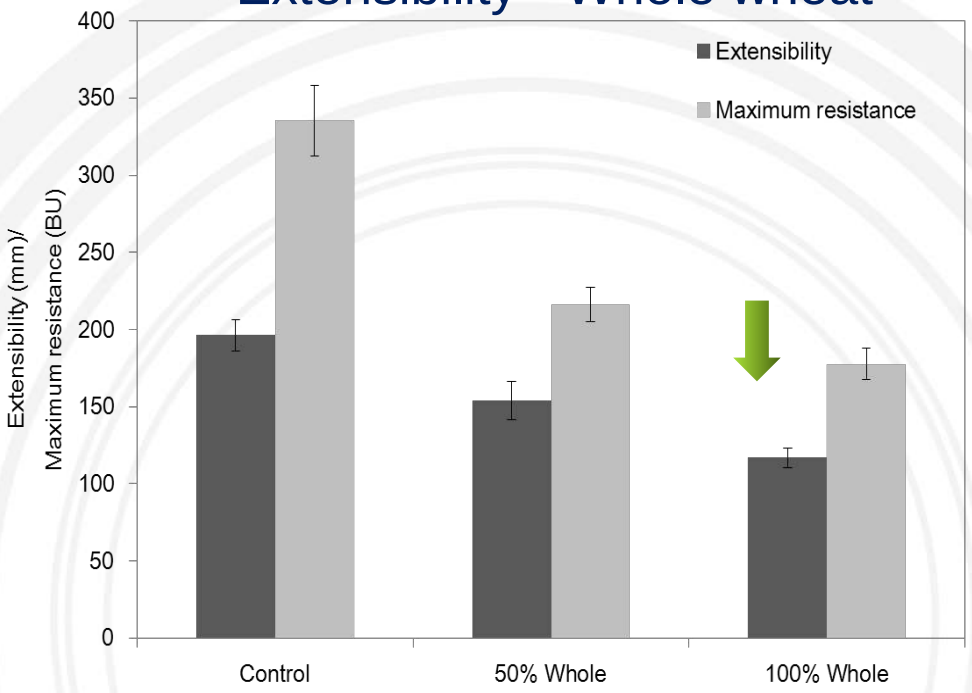
✓ Whole-grain flours exhibited lower pasting profiles.

Mixing properties of whole-grain dough

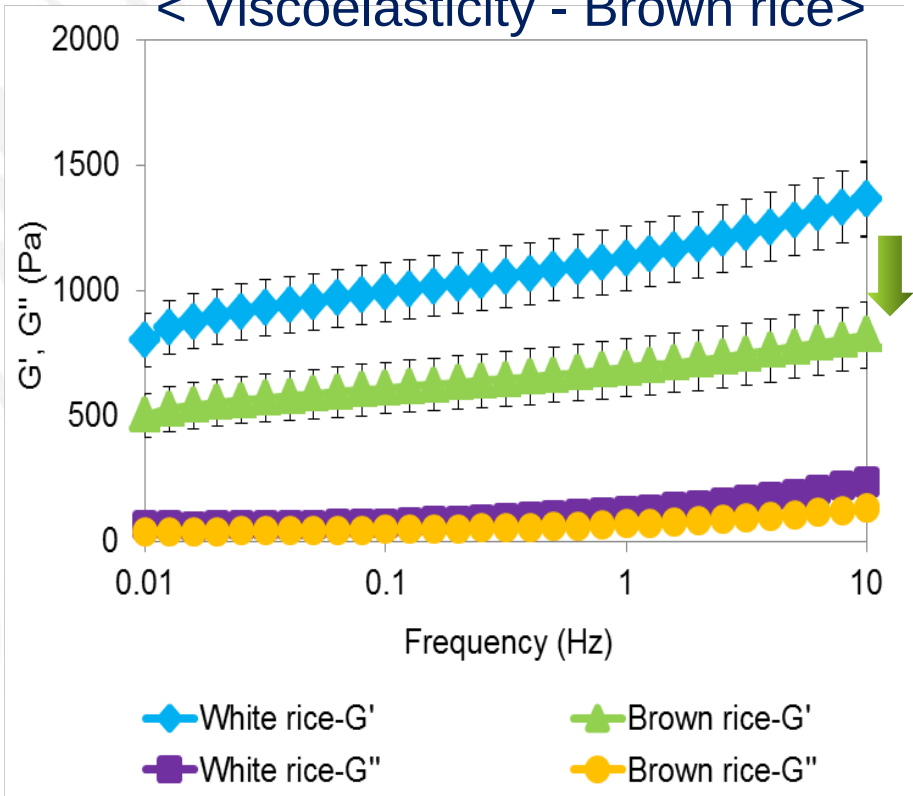
		Control	50% Whole	100% Whole
Torque (Nm)	C1	1.09±0.01a	1.10±0.03a	1.10±0.00a
	C2	0.51±0.01a	0.46±0.01b	0.44±0.00b
	C3	1.84±0.01a	1.78±0.01b	1.74±0.01c
	C4	1.97±0.00a	1.89±0.03b	1.88±0.03b
	C5	3.10±0.10a	3.08±0.03a	3.07±0.05a
Water absorption (%)		51.40±0.17c	52.30±0.17b	52.90±0.00a
Dough stability (min)		9.84 ±0.03a	9.20±0.18b	8.74±0.09c
Development time (min)		7.94±0.91a	5.84±0.78b	5.69±0.43b

Rheological property of whole-grain dough

< Extensibility - Whole wheat>



< Viscoelasticity - Brown rice>



√ Whole-grain flour reduced the elastic property of dough (extensibility ↓, G'↓)♪

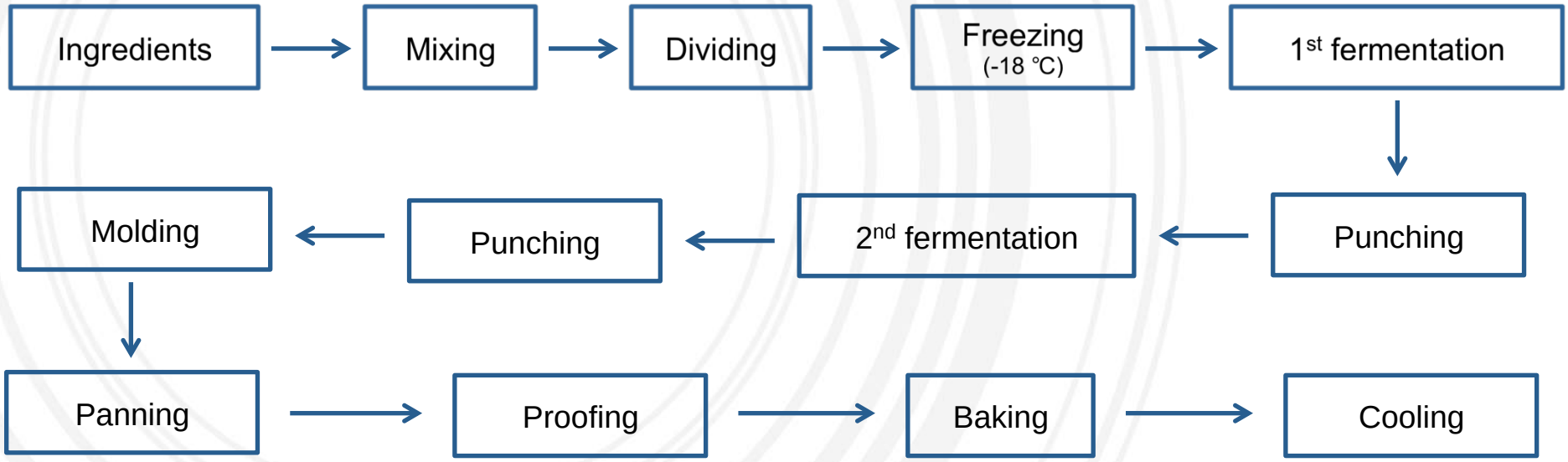
Frozen dough bread

The segment of ‘Bake off’ products that use frozen dough is one of the fastest growing areas at the industrial level.

<Straight-dough method (AACC 10-10)>

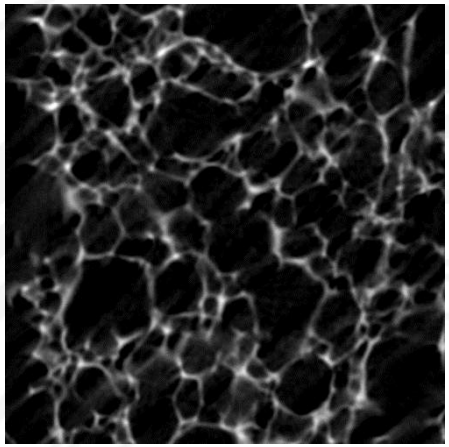
	Flour	Shortening	Salt	Sugar	Yeast	Water	Ascorbic acid
Flour basis (%)	300.0	9.0	4.5	18.0	3.0	182.47	200ppm

<Procedure>

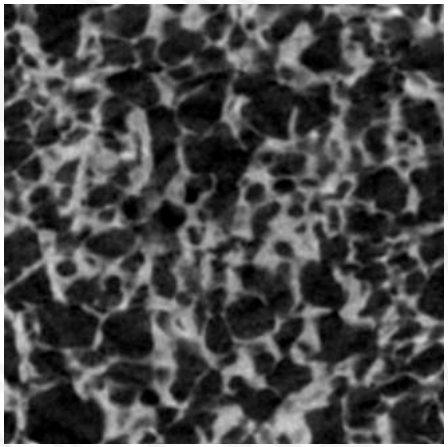


Computed Tomography

✓ 2D cross-sectional images of white and whole-grain bread



<Wheat bread>

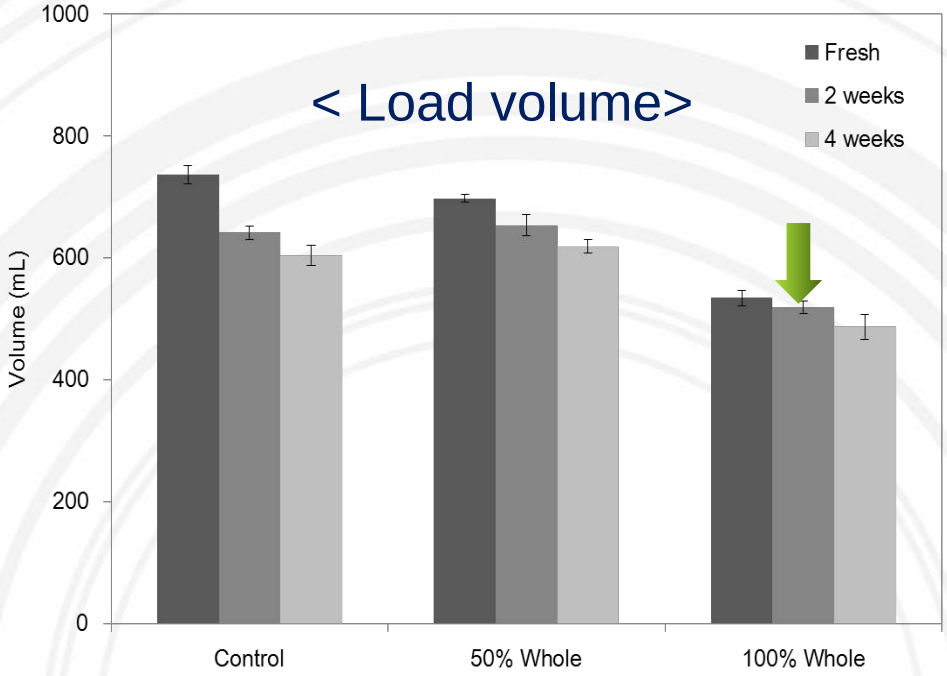


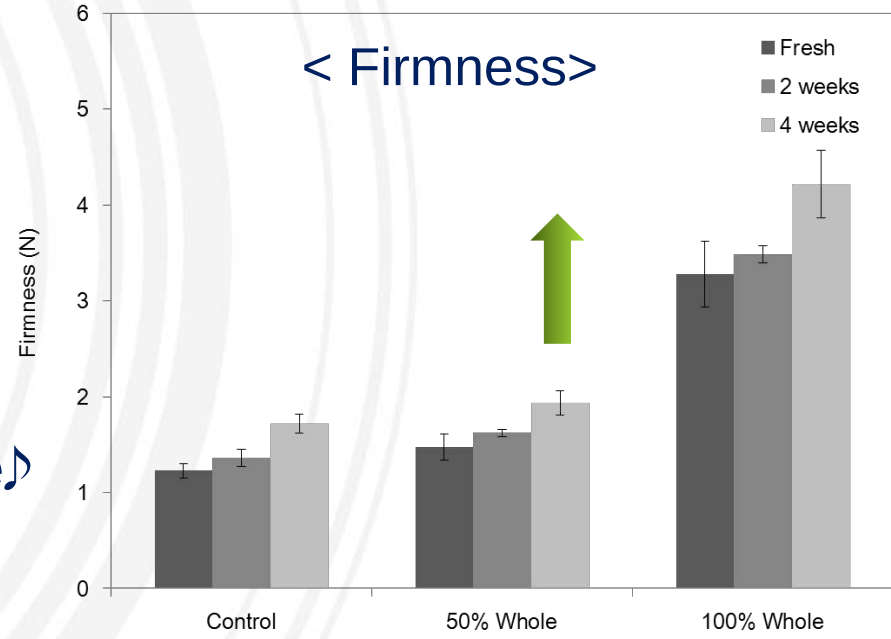
<Whole wheat bread>

- Porosity (%) = $\frac{\text{Volume of void space}}{\text{Total volume of material}}$

(%)	Wheat bread	Whole wheat bread
Closed porosity	4.60	3.62
Open porosity	79.49	60.40
Total porosity	80.43	61.84

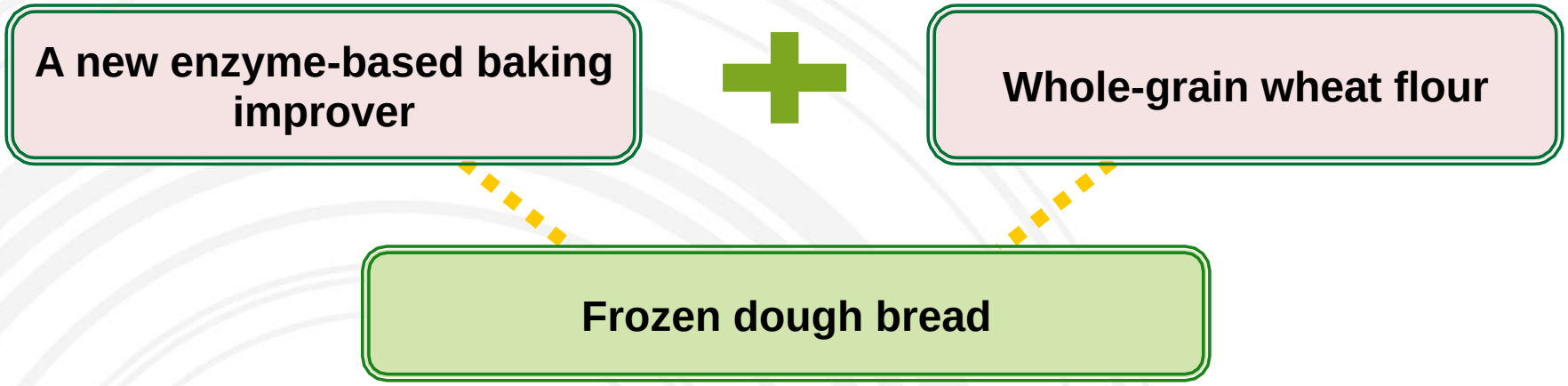
Loaf volume and texture of frozen dough bread





√ The use of whole-grain flour produced bread with low loaf volume and firm texture♪

Quality improvement of whole-grain bread

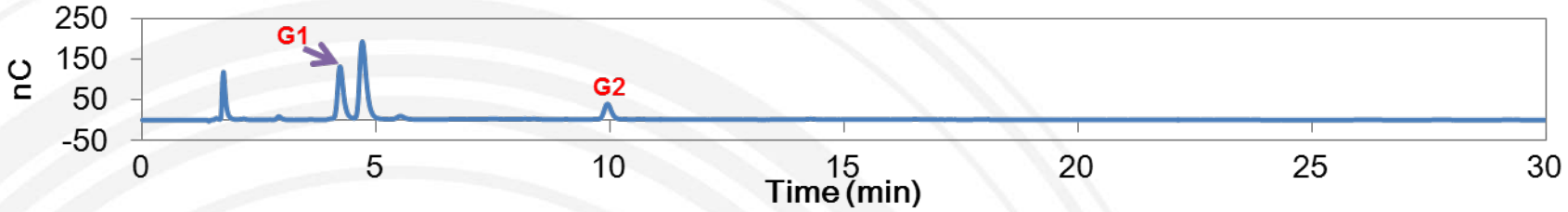


G4-amylase

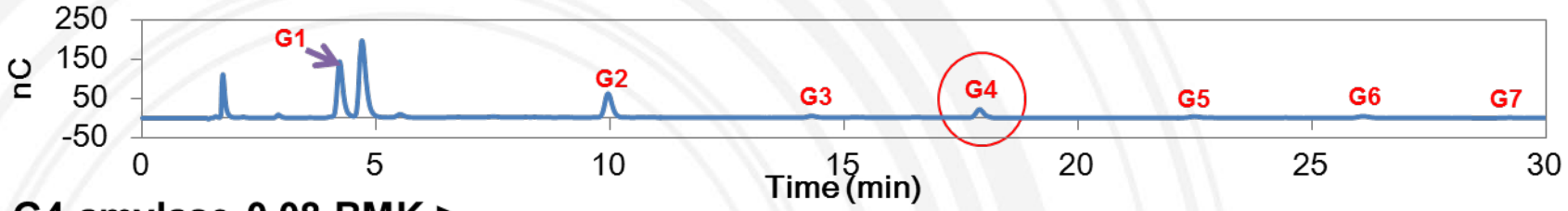
- ✓ A novel enzyme used in this study is commercially called Optimalt 4G. (EC3.2.1.60; glucan 1,4-alpha-maltotetraohydrolase)
- ✓ Optimalt 4G **hydrolyzes alpha-1,4 glucosidic bonds** of conventional liquefied starch, **producing high concentrations of maltotetraose.**
  - Optimum pH : 5.0 – 5.5
  - Optimum temperature : 61 - 65℃

Maltooligosaccharide profiles of bread

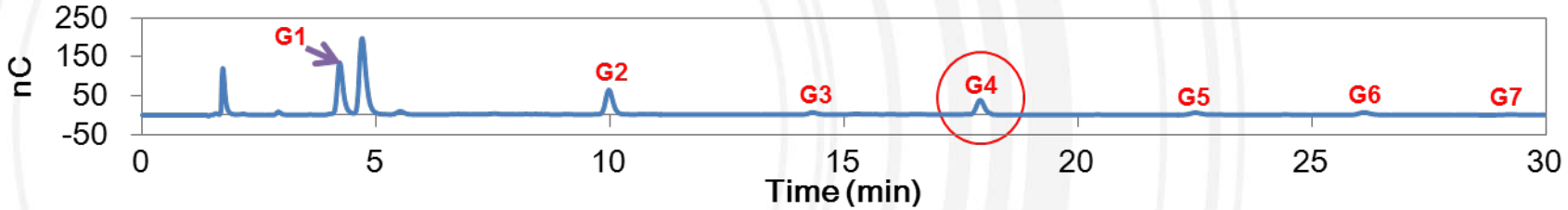
< Control >



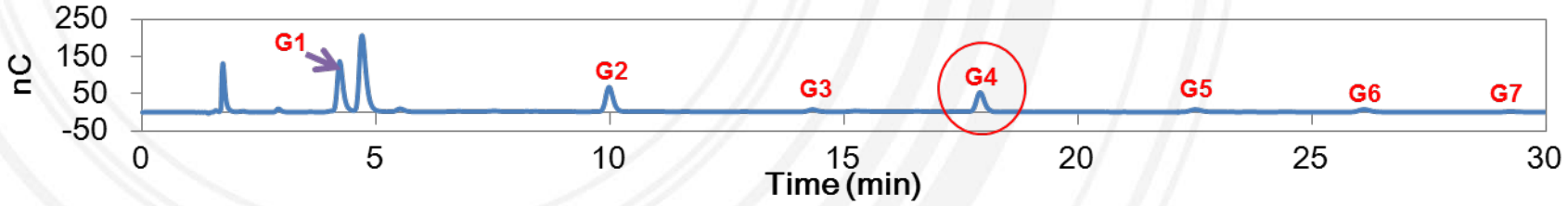
< G4-amylase 0.04 BMK >



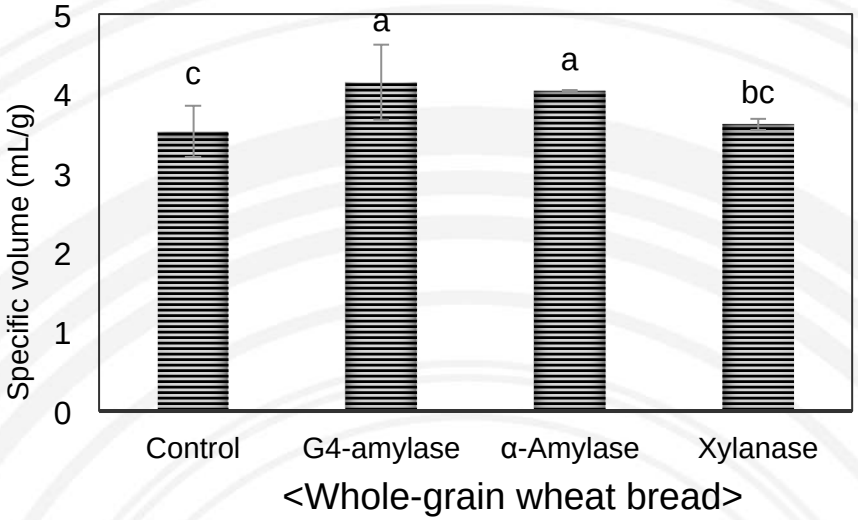
< G4-amylase 0.08 BMK >



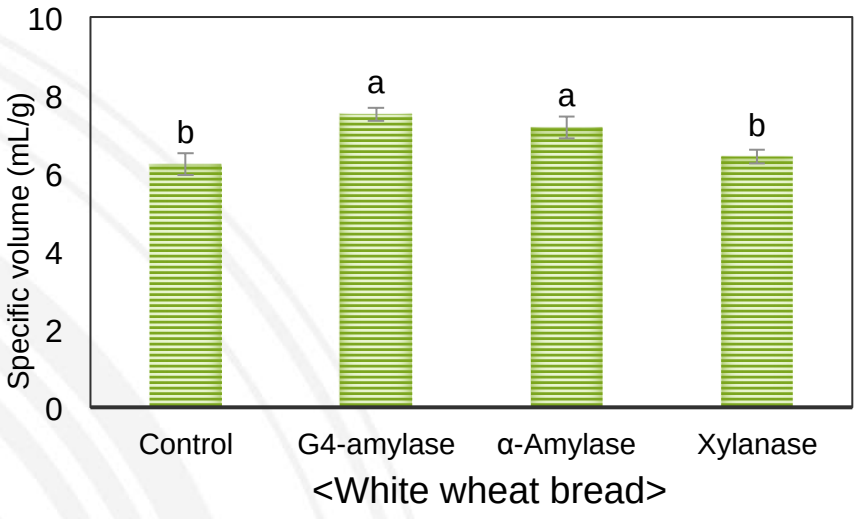
< G4-amylase 0.12 BMK >



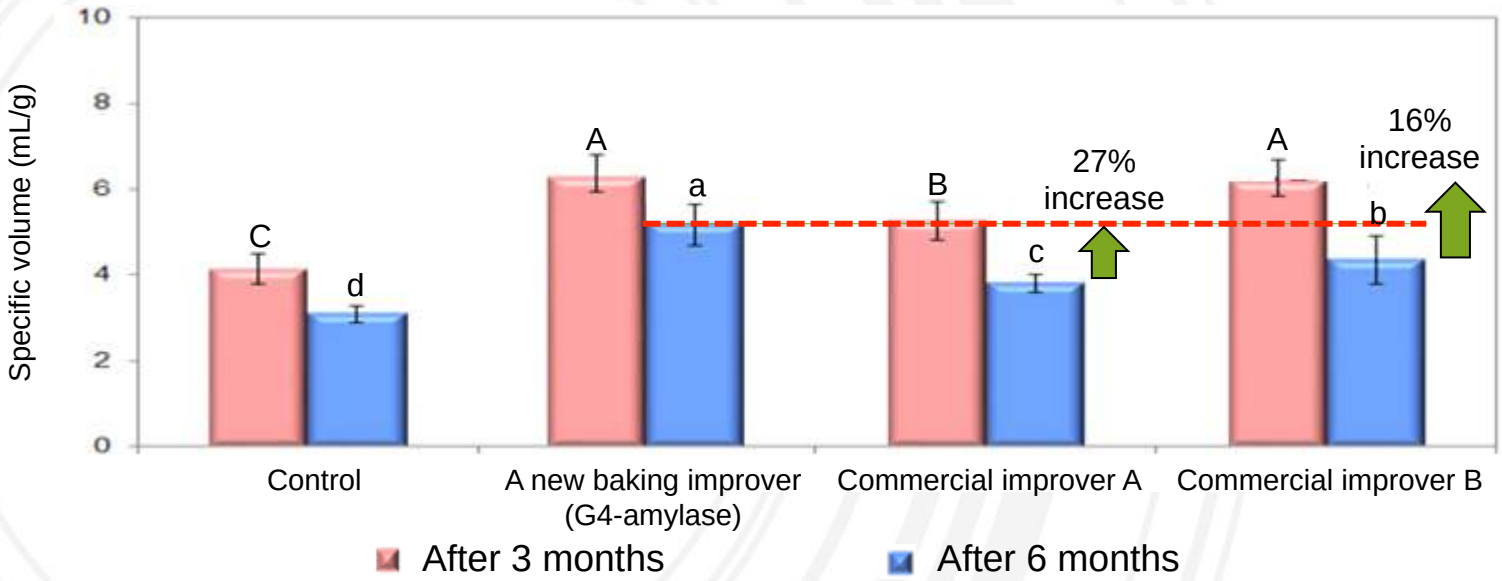
Improvement of bread volume



<Whole-grain wheat bread>

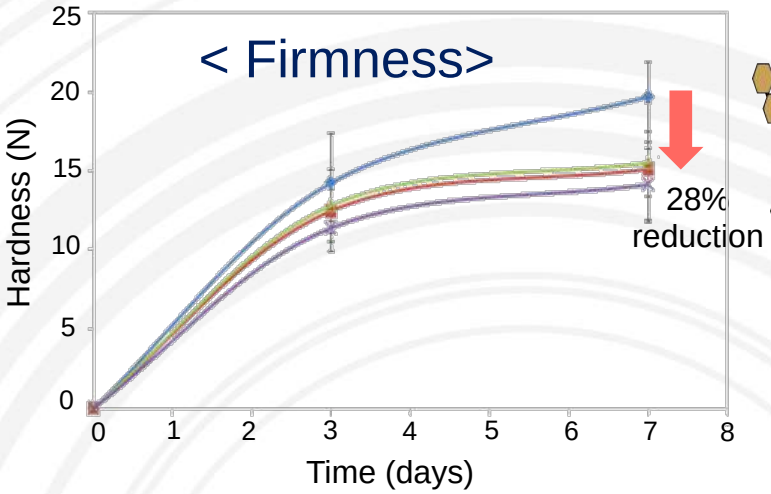


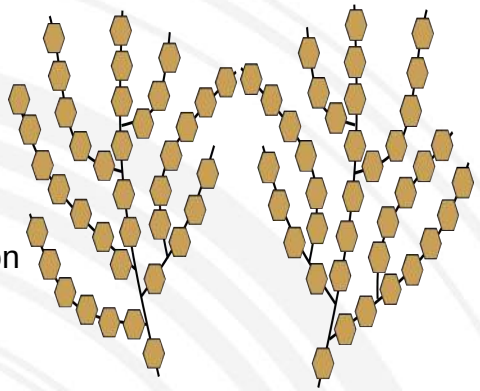
<White wheat bread>



√ The volume of bread was improved by G4-amylase, compared to other commercial improvers

Anti-retrogradation mechanisms

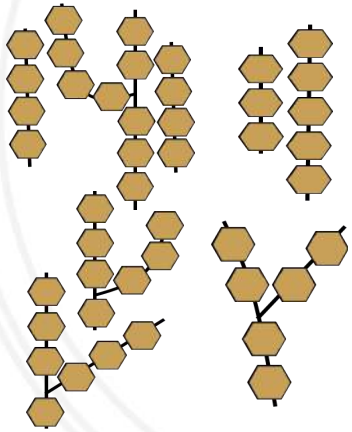




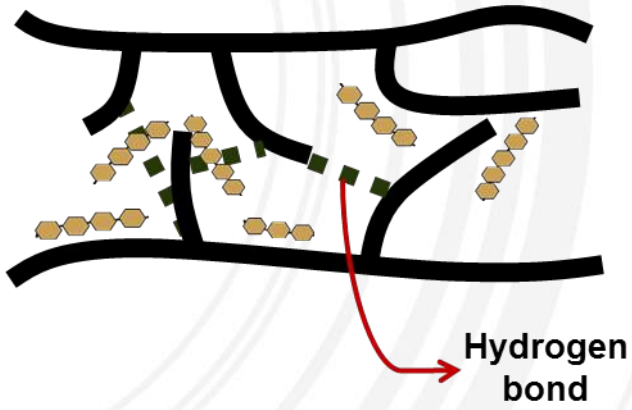
<Gelatinized starch>

Glucose H_2O

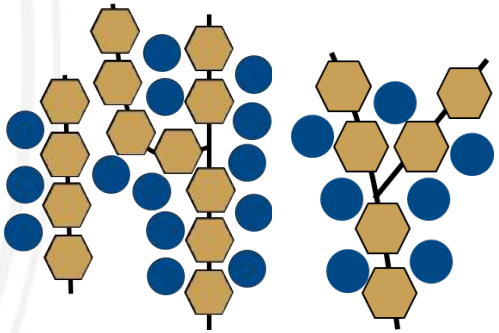
G4-amylase



<Reduced molecular size>



<Steric hindrance>



<High hydroscopicity>

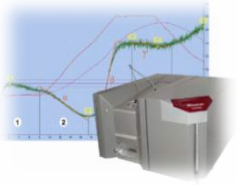
Noodles

Refined white flour

Whole-grain flour

Physicochemical characterization

- Chemical compositions
- Pasting property (Starch pasting cell)
- Thermo-mechanical property (Mixolab)
- Rheological property (Rheometer)



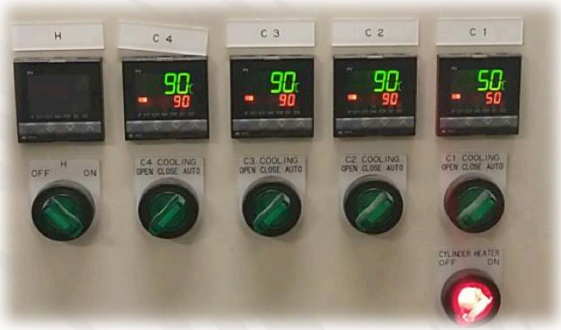
Extruded noodles (Brown rice flour)

Instant fried noodles (Whole wheat flour)

Functional characterization of noodles

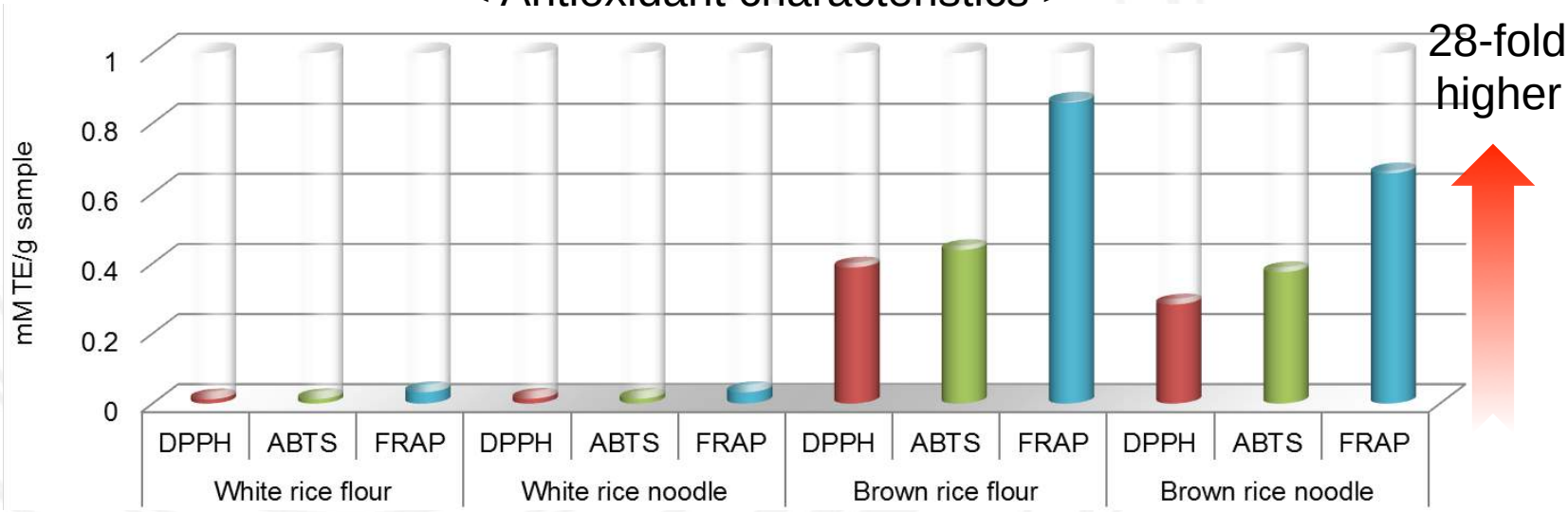
- Antioxidant characteristics (DPPH, ABTS, and FRAP assays)
- Expansion ratio and breaking stress (Snapping test)
- Tensile property (Kieffer dough and gluten extensibility rig)
- Cooking loss
- Peroxide value
- In-vitro stimulated digestion (glucose release and pGI)

Application of brown flour to extruded noodles

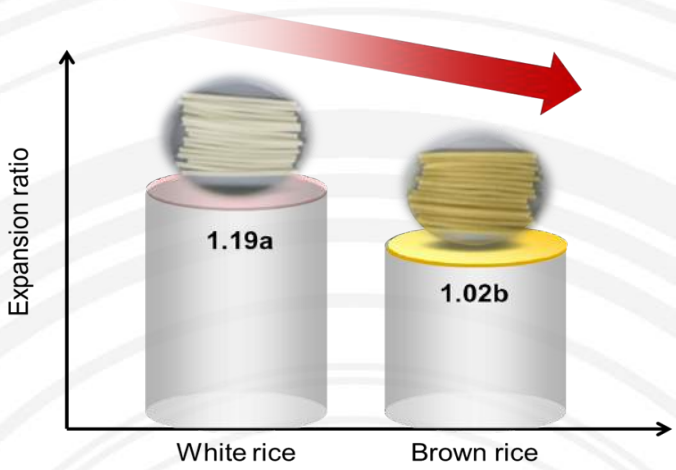


< Twin-screw extruder >

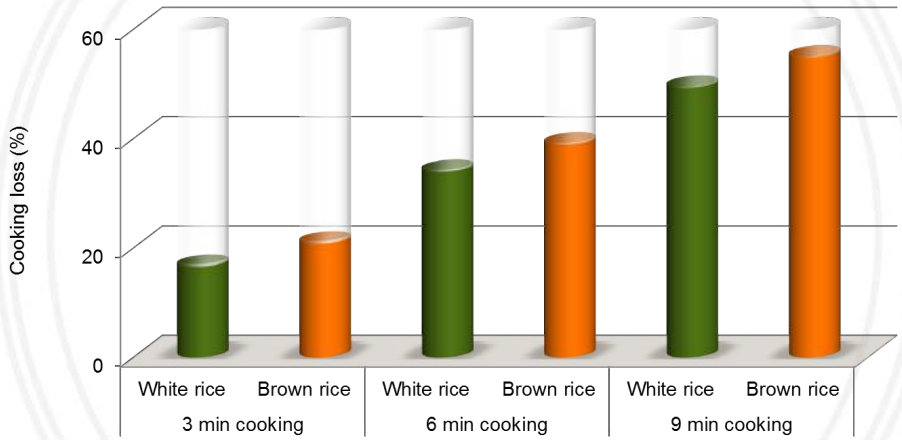
< Antioxidant characteristics >



Application of brown flour to extruded noodles♪

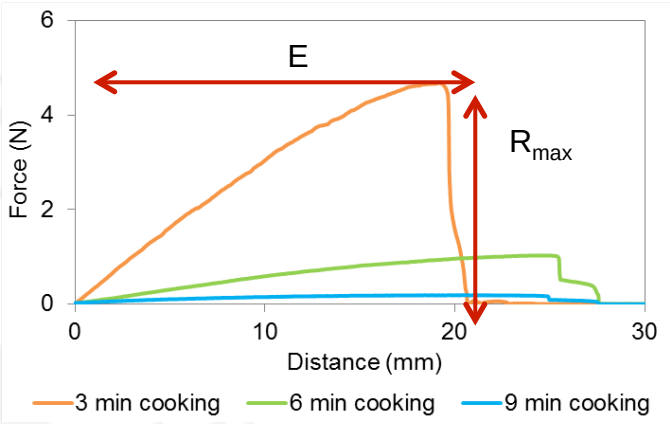


< Expansion ratio >

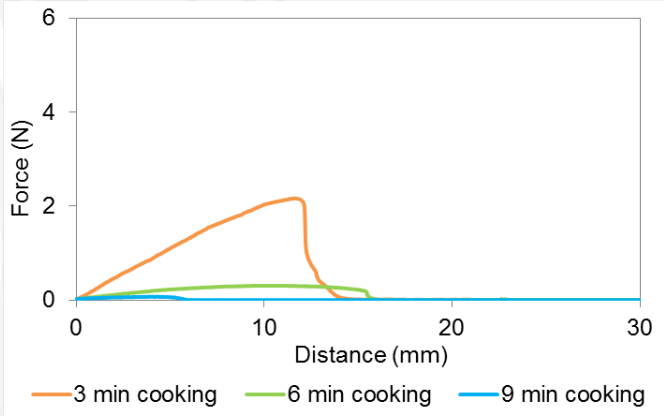


< Cooking loss >

✓ White rice noodles



✓ Brown rice noodles



< Tensile property >

√ Brown rice noodles → greater cooking loss and lower extensibility♪

Quality improvement of extruded noodles♪

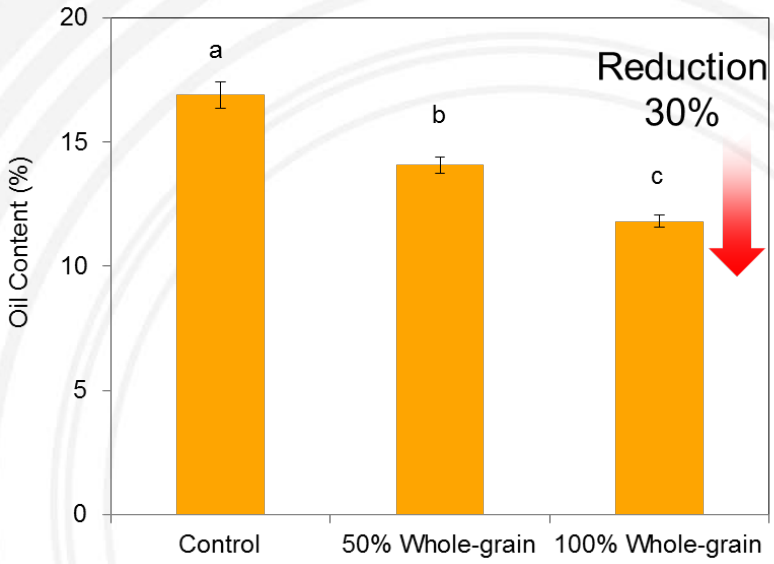
Variables	Coded X_i	Coded level			ΔX
		-1	0	1	
Moisture content of noodle dough	X_1	30	35	40	5
Barrel temperature	X_2	70	80	90	10
Drying temperature	X_3	20	40	60	20

Experimental no.	Coded variables			Process variables			Cooking loss (%)	Turbidity	Tensile property	
	X_1	X_2	X_3	X_1	X_2	X_3			Rmax (N)	E (mm)
1	-1	-1	0	30	70	40	45.42±3.96	1.25±0.07	1.52±0.17	11.56±1.05
2	1	-1	0	40	70	40	43.58±3.10	1.38±0.07	0.13±0.02	8.40±1.25
3	-1	1	0	30	90	40	14.63±1.62	0.34±0.05	10.50±0.85	18.87±4.04
4	1	1	0	40	90	40	27.64±1.65	0.68±0.05	2.31±0.29	23.86±3.85
5	-1	0	-1	30	80	20	45.38±7.35	1.05±0.13	0.19±0.08	13.96±4.54
6	1	0	-1	40	80	20	31.43±2.49	0.86±0.07	0.58±0.09	23.83±3.29
7	-1	0	1	30	80	60	44.18±4.02	1.05±0.07	1.88±0.33	15.39±2.08
8	0	0	1	35	80	60	41.35±4.85	1.05±0.08	1.25±0.11	20.88±2.09
9	0	-1	-1	35	70	20	49.07±7.26	1.36±0.11	0.19±0.04	9.56±1.13
10	0	1	-1	35	90	20	18.84±1.94	0.44±0.04	3.82±0.28	34.08±2.78
11	0	-1	1	35	70	60	51.78±8.94	1.44±0.14	0.22±0.07	9.26±2.26
12	0	1	1	35	90	60	20.55±1.70	0.45±0.05	5.01±0.62	7.65±1.95
13	0	0	0	35	80	40	37.34±6.10	1.00±0.07	0.76±0.13	24.75±2.29
14	0	0	0	35	80	40	37.56±4.80	0.97±0.09	0.80±0.10	25.68±1.97
15	0	0	0	35	80	40	34.96±4.25	0.95±0.11	0.71±0.05	26.07±4.83

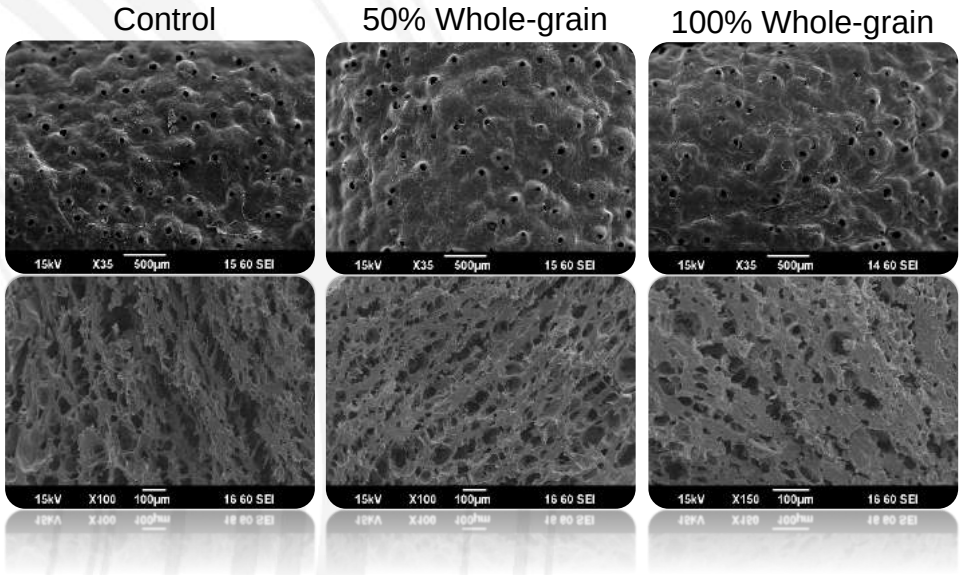
√ The quality attributes of brown rice noodles were distinctly enhanced by controlling extrusion parameters.♪

Application of whole wheat flour to instant fried noodles

< Oil uptake >



< SEM images >



√ The fried noodles prepared with the whole-grain flour had a less porous structure, which contributed to reduced oil uptake during frying.

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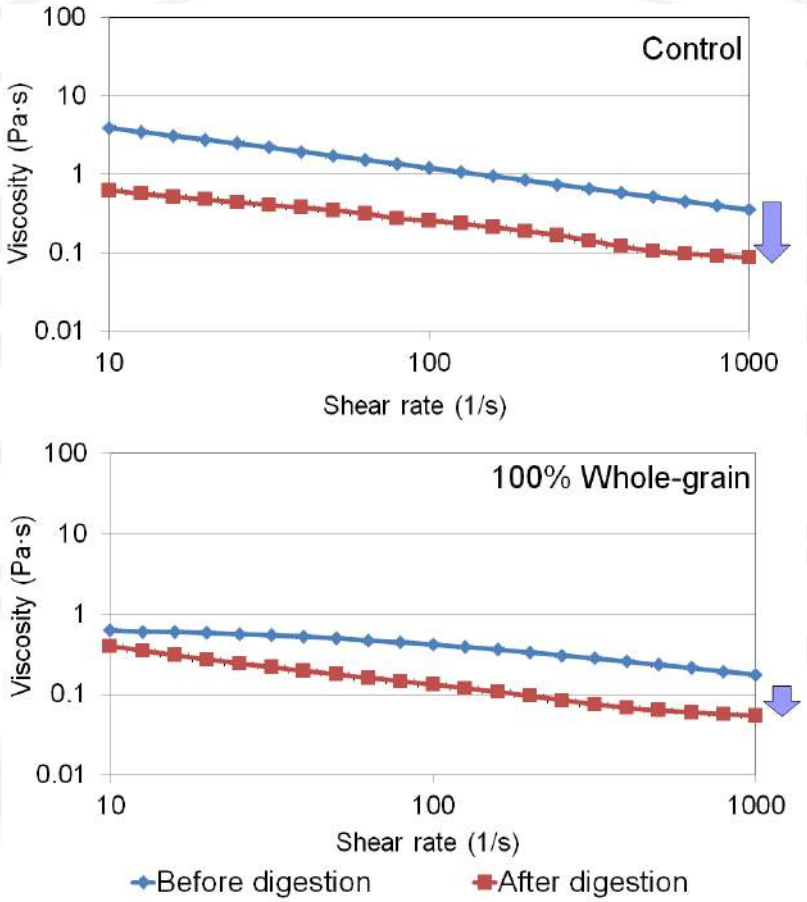
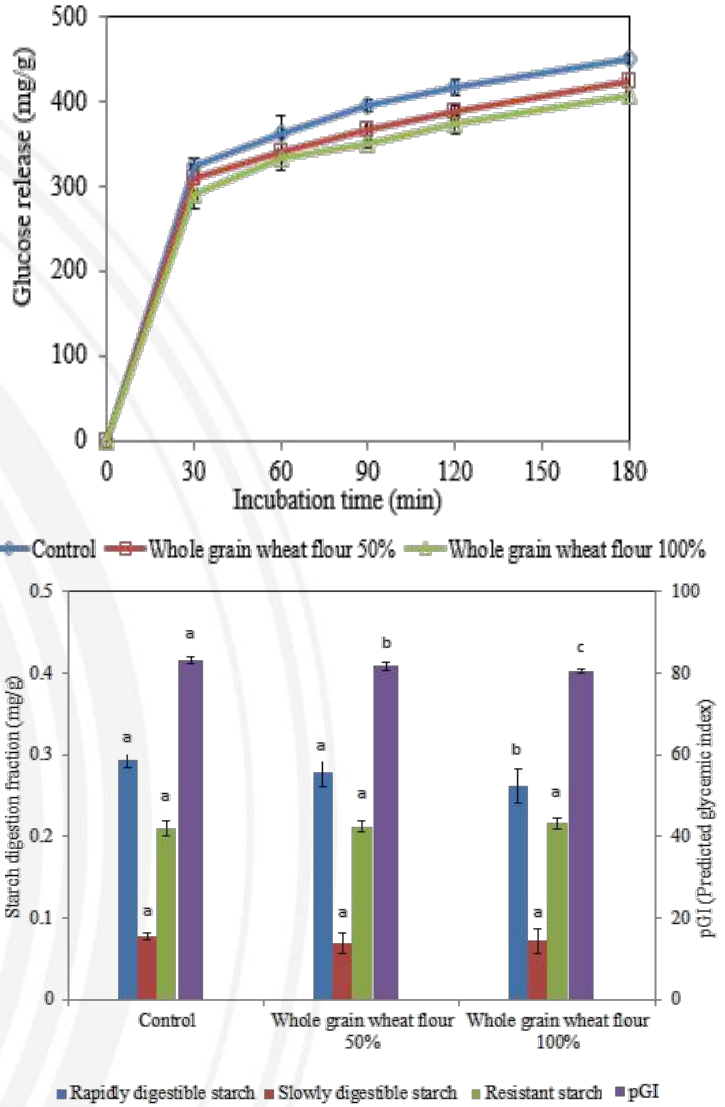
In-vitro starch digestibility of instant fried noodles





√ The use of whole-grain wheat flour was effective in suppressing the hydrolysis of starch in the noodles, lowering the predicted glycemic index.

Thank you