

[Short Report]

Effects of Sprouting on Texture of Cooked Buckwheat (*Fagopyrum esculentum* Moench) Noodles

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Abstract : The firmness of buckwheat noodles plays an important role in its palatability. We investigated the effects of artificial sprouting after harvest and preharvest sprouting in the field of buckwheat grains on the firmness of cooked buckwheat noodles by measuring the force required to compress the cooked noodles. Sprouting significantly decreased the peak force and peak strain to compress cooked noodles, suggesting that sprouting lowers the palatability of cooked buckwheat noodles. Sprouting significantly decreased the force needed to compress cooked noodles largely, suggesting that the cooked noodles made from sprouting grains lead to the perception of less resistance to completely cut off by mastication.

Key words : Buckwheat noodle, Germination, Pasting property, Preharvest sprouting, Starch.

Common buckwheat (*Fagopyrum esculentum* Moench) is widely cultivated around the world. Buckwheat flour has high nutrient value and is processed into various foods (Ikeda, 2002), among which cooked noodles are the most popular in Japan.

Rain after grain maturity but before harvest sometimes induces preharvest sprouting (Choi et al., 1992; Morishita and Tetsuka, 2001; Hara et al., 2007, 2008). Preharvest sprouting in buckwheat decreases the pasting viscosity of buckwheat flour and buckwheat – wheat composite flour (Hara et al., 2007). Functional materials such as gamma-amino butyric acid have been found to be increased in buckwheat grains sprouted artificially (Miyake et al., 2004).

However, it is difficult to predict clearly the effect of the decreased pasting viscosity of buckwheat flour on the texture of the cooked noodle. In the experiment using various types of buckwheat flour obtained by a gradual milling system, pasting viscosity was positively correlated with cooked noodle firmness (Hung et al., 2007), whereas in another experiment using buckwheat flour obtained from several buckwheat cultivars, pasting viscosity was negatively correlated with cooked dough firmness (Mukasa et al., 2003). In wheat, sprouting increased α -amylase activity (Noda et al., 2001; Ichinose et al., 2002), decreased the stickiness and firmness of cooked pasta (Grant et al., 1993), and lowered the palatability of udon noodles (Nagao, 1984). On the other hand, wheat flour with high

α -amylase activity did not affect the textural characteristics of cooked wheat noodles (Niihara and Yonezawa, 1983; Dexter et al., 1990). Therefore, it is necessary to examine the effects of artificial sprouting after harvest and preharvest sprouting of buckwheat grains on the texture of cooked buckwheat noodles.

Firmness is the textural characteristic of buckwheat noodle which plays an important role in its palatability (Kimura et al., 2000, 2002). Buckwheat noodles with different firmness are produced by adding wheat flour (Tsuji, 1984) or changing the cooking time (Tsuji, 1984; Kimura et al., 2002). Wheat flour is often mixed with buckwheat flour to reduce the fragility of buckwheat noodles (Tsutsumi et al., 1990; Ikeda, 2002). Traditionally, a blending ratio of 8:2 of buckwheat flour : wheat flour is often preferred (Yoshinaka et al., 1984; Tsutsumi et al., 1990).

In this study, we investigated the effects of artificial sprouting after harvest and preharvest sprouting in the field of buckwheat grains on the firmness of cooked buckwheat noodles. Buckwheat noodles were made from both buckwheat flour and buckwheat-wheat composite flour. Among the parameters of the textures of the cooked buckwheat noodles, peak compressive force, peak strain and compressive force at large deformation were examined, because they are reported to be related with noodle palatability (Tsuji, 1984; Kimura et al., 2000, 2002; Sasaki et al., 2004; Hung et al., 2007).

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Abbreviations : AS, artificial sprout; CT, control; NS, natural sprout.

Table 1. Sprouting of buckwheat grain and pasting viscosity of buckwheat flour.

Treatments	Sprouting (%)	Peak viscosity (RVU)
CT	0 a	254 a
NS	46 b	53 c
AS	88 c	65 b
ANOVA	***	***

***, Significant at 0.1% level. Values with the same letter are not significantly different by the Tukey HSD (5%) test.

AS, artificial sprout; CT, control; NS, natural sprout.

Materials and Methods

1. Plant materials

We used a common buckwheat cultivar “Kitawasesoba”, which is most widely cultivated in Japan. Plants were grown at the National Agricultural Research Center for the Kyushu Okinawa Region, Koshi, Kumamoto, Japan. Seeds of Kitawasesoba were supplied by the National Agricultural Research Center for the Hokkaido Region. Seeds were sown at 150 seeds m^{-2} in rows of 30 cm apart on 12 April 2004. Fertilizer was applied prior to seeding at the rates of 4 g m^{-2} N, 8 g m^{-2} P_2O_5 and 6 g m^{-2} K_2O . A part of plants were harvested at maturity on 16 June (CT). After a week of continuous rain, the remaining plants were harvested on 29 June (NS). Grains were threshed from the harvested plants. A part of grains from the CT were subjected to artificial sprouting treatment described below (AS). Grains were soaked in distilled water for 6 hr. Water was discarded through a mesh, followed by incubation for 24 hr at 25°C, and then grains were dried at 40°C over 3 d.

2. Determination of sprouting percentages and measurement of pasting viscosity of buckwheat flour

The percentages of sprouting grains in CT, NS and AS were determined by counting sprouting grains per 100 sample grains with 3 replications. Buckwheat flour was obtained by milling grain with a Quadrumat Junior laboratory mill (Brabender OHG, Disberg, Germany), equipped with a screen with 231- μ m openings.

The Rapid Visco Analyzer (RVA-3D, Newport Scientific Pty Ltd, Warriewood, NSW, Australia) was used to determine pasting viscosity. We measured the pasting viscosity of the paste made from 3.2 g (in wet base) of buckwheat flour and 23 mL of distilled water (Hara et al., 2007). The temperature was held initially at 50°C for 1 min, and then increased linearly up to 95°C for 3 min 42 s, held at 95°C for 2 min 30 s, and cooled to 50°C for 3 min 48 s; and held at 50°C for 2 min (Qian and Kuhn, 1999, Hara et al., 2007). Measurements of pasting viscosity were repeated 2 times.

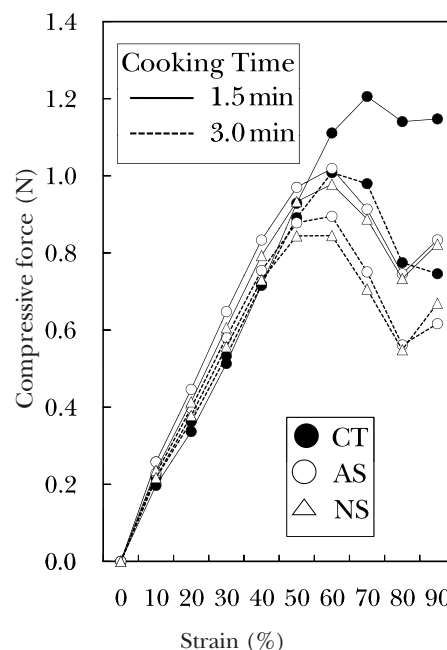


Fig. 1. Compressive force-strain curves for cooked buckwheat noodle. Each symbol is average force value of buckwheat flour and buckwheat-wheat composite flour with 3 replicates.

AS, artificial sprout; CT, control; NS, natural sprout.

3. Noodle preparation

We used 20 g buckwheat flour and buckwheat-wheat composite flour to prepare dough on a dry weight basis. The composite flour was prepared by mixing 4 g wheat flour and 16 g buckwheat flour. The flour was mixed with distilled water to the total weight of 36 g and kneaded by a glass rod in a beaker to make dough. The dough was sheeted through the rolls of a pasta machine (Imperia, Italy). The dough sheet was then cut into strands 1.6 mm in width 6 cm in length. The noodles were cooked for 1.5 min or 3 min in 300 mL of boiling water with continuous stirring. The cooked noodles were immediately placed in cold water for 30 s and used for measuring noodle texture. Each treatment was replicated 3 times.

4. Measuring noodle texture

Texture parameters of the cooked noodles was measured with TA-TXplus Texture Analyzer fitted with a perspex knife blade with a constant surface of 1.0 × 60 mm (Stable Micro Systems Ltd., Surrey, UK). Two cooked noodle strands were cut crosswise with a knife blade at a constant rate of 0.2 mm s^{-1} to 99% of the original noodle thickness.

The compressive force required for given strains (Sasaki et al., 2004), peak compressive force and peak strain (Tsuji, 1984; Kimura et al., 2002; Hung et al., 2007) were used for comparison. The measurements were performed at 5 min after the end of cooking with no replication. Analysis of variance of the data

Table 2. Peak strain and peak compressive force of cooked noodle made of buckwheat flour and buckwheat-wheat composite flour.

Buckwheat flour (B)	Mixing wheat flour (W)	Peak Strain (%)			Peak Compressive Force (N)				
		Cooking time (C)		Average	Cooking time (C)		Average		
		1.5 min	3 min		1.5 min	3 min			
CT	-	71	66	68	a	1.17	1.06	1.13	a
	+	71	64			1.27	1.01		
NS	-	58	56	58	b	1.03	0.90	0.93	b
	+	62	57			0.94	0.84		
AS	-	59	56	59	b	1.10	0.93	0.97	b
	+	61	59			0.95	0.90		
Average		64	59			1.08	0.94		
ANOVA		B		***		***			
		W		n.s.		n.s.			
		C		***		***			
		B×W		n.s.		n.s.			
		B×C		n.s.		n.s.			
		W×C		n.s.		n.s.			
		B×W×C		n.s.		n.s.			

***, Significant at 0.1% level. n.s., not significant. Values with the same letter are not significantly different by the Tukey HSD (5%) test. AS, artificial sprout; CT, control; NS, natural sprout.

was performed in a randomized block design of three factors; buckwheat flour, mixing with wheat flour and cooking time with 3 blocks.

Results

1. Sprouting and pasting viscosity of buckwheat flour

There were no sprouting grains in CT which was harvested at maturity (Table 1). On the other hand, 46 and 88% grains sprouted in NS and AS, respectively. Peak viscosity of buckwheat flour paste was lower in NS and AS than in CT. The peak viscosity value in CT was similar to that obtained previously by the same method, where buckwheat plants were harvest at maturity (Hara et al., 2007).

2. Effects of sprouting and cooking time on peak compressive force and peak strain

Fig. 1 shows the force-strain curves. The compressive force showed a peak, which was consistent with the previous reports on cooked buckwheat noodle (Tsuji, 1984; Kimura et al., 2000, 2002). At the peak, samples were fractured.

Peak strains ranged from 49 to 76%. Both artificial and natural sprouting significantly decreased the peak strain in comparison with CT (Table 2). Cooking longer significantly decreased the peak strain. Mixing with wheat flour did not significantly affect the peak strain.

Both artificial and natural sprouting significantly decreased the peak compressive force in comparison with CT (Table 2). Cooking longer significantly decreased the peak compressive force. Mixing with wheat flour did not make significant difference in the peak compressive force.

3. Effects of sprouting and cooking time on the compressive force at given strains

We compared the force values under a small strain before the peak where no sample was fractured, and those under a large strain after all the samples were fractured. The differences in compressive force with the buckwheat flour and cooking time were significant at a strain of 80 and 90% after the peak (Table 3), although not significant at a strain of 40% or less before the peak (data not shown). Both artificial and natural sprouting significantly decreased compressive forces at 80 and 90% strain in comparison with CT (Table 3). Cooking longer significantly decreased the compressive forces at 80 and 90% strain in comparison with CT. Mixing with wheat flour did not cause any significant difference in compressive force.

Discussion

The firmness of buckwheat noodle plays an important role in its palatability (Kimura et al., 2000, 2002). Buckwheat noodle firmness is positively correlated

Table 3. Compressive force (N) at large deformation of cooked noodle made of buckwheat flour and buckwheat-wheat composite flour.

Buckwheat flour (B)	Mixing wheat flour (W)	80% strain			90% strain				
		Cooking time (C)		Average	Cooking time (C)		Average		
		1.5 min	3 min		1.5 min	3 min			
CT	–	1.11	0.83	0.96	a	1.18	0.75	0.95	a
	+	1.17	0.72			1.11	0.74		
NS	–	0.71	0.54	0.64	b	0.90	0.67	0.75	b
	+	0.76	0.56			0.75	0.67		
AS	–	0.73	0.55	0.65	b	0.78	0.66	0.73	b
	+	0.77	0.58			0.89	0.58		
Average		0.87	0.63			0.93	0.68		
ANOVA		B		***		***			
		W		n.s.		n.s.			
		C		***		***			
		B×W		n.s.		n.s.			
		B×C		n.s.		n.s.			
		W×C		n.s.		n.s.			
		B×W×C		n.s.		n.s.			

***, Significant at 0.1% level. n.s., not significant. Values with the same letter are not significantly different by the Tukey HSD (5%) test. AS, artificial sprout; CT, control; NS, natural sprout.

with peak viscosity of buckwheat flour paste (Hung et al., 2007). Peak viscosity of buckwheat flour paste is decreased by preharvest sprouting even when mixed with wheat flour (Hara et al., 2007). In our experiment, both artificial and natural sprouting decreased the peak compressive force with which noodle strands made from buckwheat flour and buckwheat–wheat composite flour were cut. These results suggest that sprouting leads to decreased peak viscosity and less firm buckwheat noodle. Starch of buckwheat and wheat may be digested by starch degrading enzymes, since α -amylase is activated by sprouting in buckwheat grains (Miyake et al., 2004).

A longer cooking time also decreased the peak compressive force and peak strain of buckwheat noodle strands in our experiment, consistent with previous reports (Tsuji, 1984; Kimura et al., 2002). Such decrease in peak compressive force and peak strain of buckwheat noodle strands are considered to be less preferred (Tsuji, 1984; Kimura et al., 2000, 2002). Therefore, the change in texture of cooked buckwheat noodle caused by sprouting is not preferred.

The compressive force at large deformation is considered to correlate with human masticatory parameters (Kohyama et al., 2008). The compressive force at over 80% strain may be related to a resistance to completely cut off cooked wheat noodles (Sasaki

et al., 2004). Compressive force at slight deformation may be related to the initial perception of the palate (Sherman, 1969; Arai and Yamada, 1993; Sasaki et al., 2004). In our experiment, the differences in compressive force among buckwheat flours were clear at 80 and 90% strains, when noodle strands were cut largely, although the differences were not detected at a strain of 40% or less, when noodle strands were cut slightly. These findings suggest that the decreased firmness of cooked noodles caused by sprouting would lead to masticatory perception of less resistance to completely cut off.

Appropriate measures must be taken to increase the firmness of cooked buckwheat noodles made from sprouted grains which lowers the palatability. We released a new cultivar with improved preharvest sprouting resistance (Hara et al., 2009), and suggested that the cultivar with less preharvest sprouting had a higher pasting viscosity (Hara et al., 2007). The higher pasting viscosity of the new cultivar would expectedly stabilize the firmness of buckwheat noodle against rainfall. Breeding buckwheat cultivars with a higher amylose content and higher starch content may increase the firmness of cooked buckwheat noodles and alleviate the decrease in the firmness caused by sprouting, since wheat flour with a higher amylose content is related with a firmer wheat noodle (Sasaki

et al., 2004) and a higher amount of starch may be related with firmer buckwheat noodles (Hung et al., 2007). Mixing konjak powder may improve the palatability of cooked buckwheat noodle made from sprouting buckwheat grains, because it increases firmness of cooked buckwheat noodles (Kimura et al., 2000, 2002).

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