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Front page photo: Buckwheat dumpling soup with sesame seeds, roasted sesame powder (small fragments), seaweed fragments (black), fried egg garnish (yellow), buckwheat sprouts (see the paper Park et al., pp. 19-26).

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Research paper

Leaving Buckwheat Noodles after their Making and Subsequent Cooking Leads to Remarkable Changes in Mechanical Characteristics

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Keywords: common buckwheat, mechanical characteristics, noodles, making, cooking

ABSTRACT

The present study was conducted to analyze the mechanical effects of leaving buckwheat noodles after their fleshly making with or without subsequent cooking. Remarkable reduction with time in breaking characteristics after their freshly making and subsequent cooking were found. The observed decrease in breaking stress and energy showed that the buckwheat noodles might be softened with the leaving time. On the other hand, no brittleness was found in buckwheat noodles from the beginning until leaving time of 1 min, whereas brittleness appeared that after leaving time of 2 min after subsequent cooking. Implications for the observed finding were discussed in view of the palatability of buckwheat products.

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench) is an important crop in some world areas (Ikeda, 2002; Kreft et al., 2003). Common buckwheat flour is processed into various products such as noodles, pasta etc. There is a large variety of common buckwheat products globally. In view of their processing, increasing attention has been currently paid to the palatability and acceptability of various buckwheat products. Clarifying the scientific basis involved in the palatability and acceptability of common buckwheat products is a subject of great interest. Mechanical characteristics may be an important factor responsible for the palatability and acceptability of common buckwheat products. We have presented some observations relating to mechanical characteristics of common buckwheat products, i.e., relationships between components of buckwheat and its mechanical characteristics (Ikeda et al., 1997); mechanical comparison among doughs of various cereals including buckwheat (Asami et al., 2006); mechanical effects of various binders to buckwheat dough (Ikeda *et al.*, 2005; Asami et al., 2019); scientific basis responsible for traditional processing techniques for buckwheat noodles (Asami et al., 2008; Asami et al., 2009; Asami et al., 2010; Asami et al., 2012; Asami et al., 2016; Asami et al., 2018).

In Japan, buckwheat noodles are a popular, traditional food. There are various traditional proverbial sayings about the palatability and acceptability of buckwheat noodles. In such proverbial phrases, buckwheat noodles prepared with all parts of the following four conditions are believed to be more palatable and acceptable: firstly, noodles made from just-harvested and dried buckwheat seed; secondly, noodles made from just-ground buckwheat flour; thirdly, just-prepared buckwheat noodles; and lastly, just-boiled buckwheat noodles. In Japan it has been believed that buckwheat noodles made with all of the above four conditions may be the most palatable. However, the scientific reason responsible for the above common proverbial saying on buckwheat noodles remains largely uncertain. We have shown mechanical changes during buckwheat grain storage (Asami and Ikeda, 2005). In view of clarifying the above traditional proverbial saying, especially in focusing on mechanical changes in buckwheat noodles after just-making and after just-boiling, the present study has been conducted to analyze the mechanical characteristics of buckwheat noodles after their making with or without subsequent cooking.

MATERIALS AND METHODS

Materials

Common buckwheat (*Fagopyrum esculentum* Moench var. Kita-wase-soba), which was harvested in Hokkaido, was used in this study. Commercial buckwheat flours were obtained from Taniguchi-soba Milling Co. (Kyoto, Japan) and stored at -80 °C until used.

Preparation of buckwheat noodles

Buckwheat noodles were prepared according to the procedure described previously (Ikeda and Asami, 2000). Stated briefly, an appropriate amount of buckwheat flour was put in a mixing bowl. Distilled water was added little by little by hand to buckwheat flour with a final flour-to-water ratio of 2:1. The buckwheat flour-water dough was well kneaded by hand in the mixing bowl and then rolled into balls. The well-kneaded balls ware spread by hand and then subjected to a pasta-making machine (Industria Prodotti Stampati, Italy) to prepare buckwheat noodles. The buckwheat noodles were leaving at 4 °C and 27 °C after preparation. Changes in mechanical characteristics were measured daily and hourly. The daily change experiment at 27 °C was not measured because noodles would spoil.

Mechanical measurements

Breaking measurements of buckwheat noodles with a thickness of approximately 1.5 mm, a width of about 4.5 mm and an appropriate length were performed with a Rheoner RE3305 (Yamaden Co. Ltd., Tokyo, Japan). Measurement with a Rheoner RE3305 were performed with a load cell of 2kgf in a measurement speed of 0.50 mm/sec. A wedge style plunger (No.49: W 13mm, D 30mm, H 25mm) was used in the measurements with a Rheoner RE3305. Mechanical measurements of buckwheat noodles were repeated three to six times with those samples.

Protein determination

For chemical analysis of the combined fractions of buckwheat albumin plus globulin in the cooked noodle samples which had been subjected to the mechanical measurements, the noodle samples were lyophilized and then ground into flour. The flours obtained were extracted with a ten-fold (v/w) volume of 0.2M NaCl for 1hr at 4 °C. After extraction, the suspensions were centrifuged at 17,000 g for 20 min. The protein concentration was determined using the Buiret method with bovine serum albumin as the standard protein.

Statistical analysis

Statistical analysis was conducted using a personal computer with the program Excel (Microsoft Co., USA), Ekuseru-Toukei (Social Survey Research Information Co., Japan).

RESULTS AND DISCUSSION

Changes in mechanical characteristics of buckwheat noodles after their making with or without subsequent cooking

Figure 1 shows analytical results on mechanical effects of leaving buckwheat noodles after freshly making and subsequent cooking; Fig. 1 presents the mechanical load as the vertical axis versus mechanical strain as the horizontal axis. The square signs with cross mark in the Fig. 1 show the appearance of brittleness. Figure 2 shows the analytical results as a function of time based on the observed mechanical results of Fig. 1. Remarkable reduction with time in breaking characteristics after their freshly making and subsequent cooking were found (Fig. 2-(A) and (B)). The observed remarkable reduction in breaking stress and energy showed that the buckwheat noodles might be softened with the leaving time.

On the other hand, no brittleness was found in buckwheat noodles from the beginning to a leaving time of 1 min, whereas brittleness appeared after a leaving time of 2 min after cooking (Fig. 2-(C).). In general, it is known that no or low brittleness expresses low breaking energy on masticating foods. The previous studies (Asami et al., 2011) suggest that the appearance of the brittleness of buckwheat noodles may lead to unpalatability. The present finding agrees with our previous findings (Asami et al., 2011). In short, lowering breaking stress and energy

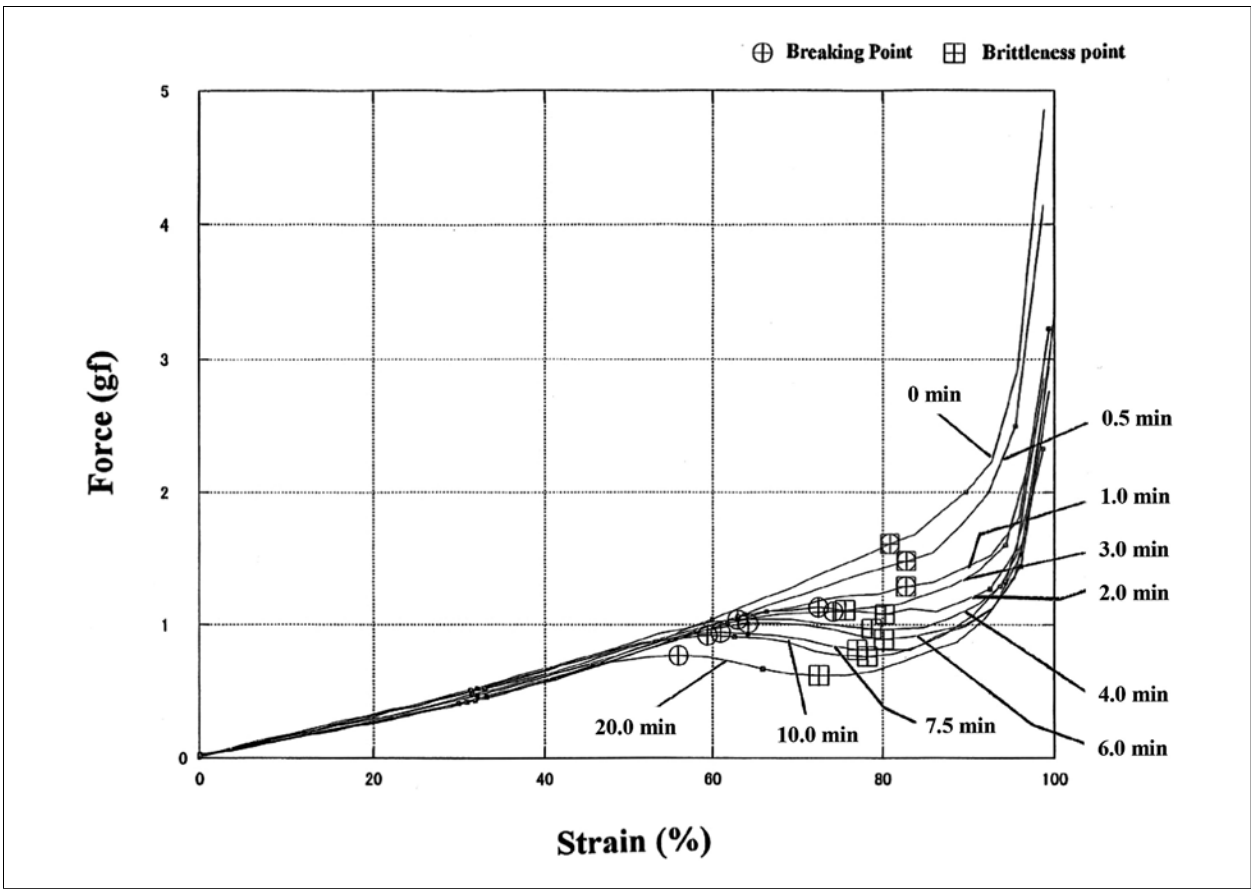

Fig. 1. Load-to-strain ratio plot curves on the breaking analysis of buckwheat noodles after their boiling.

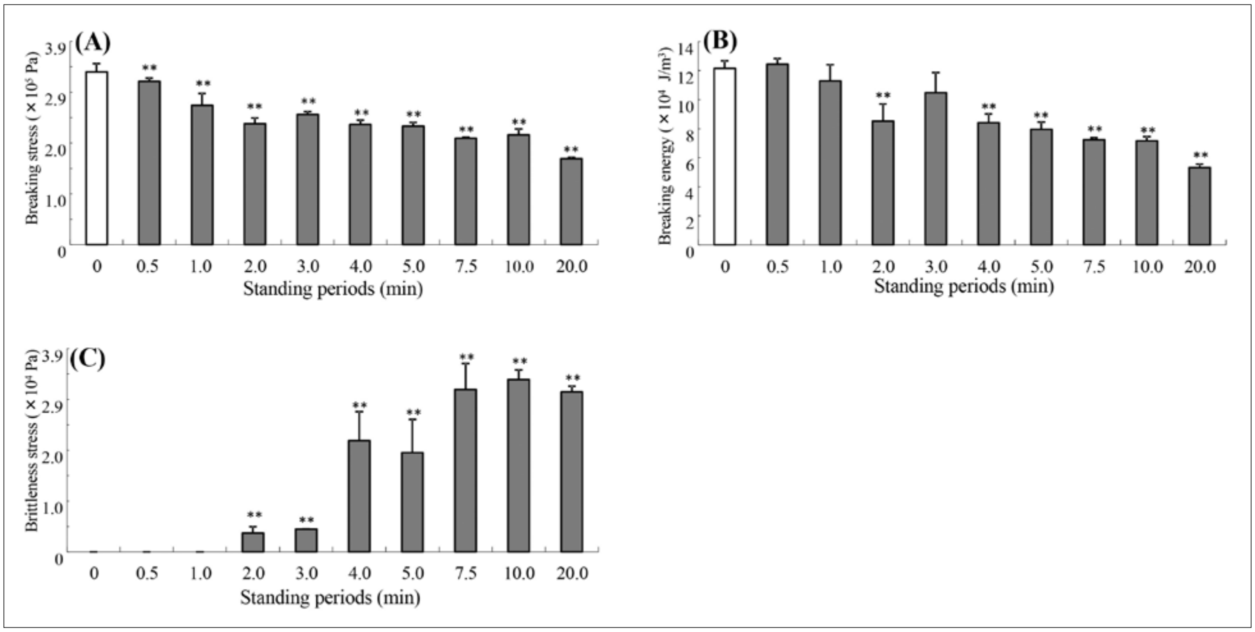

Fig. 2. *Changes in the breaking and brittleness characteristics of buckwheat noodles after their boiling. (A), breaking stress; (B), breaking energy; and (C), brittleness stress. Vertical bars in the figure show the standard deviations. Significant difference from 0 min: **p<0.001.*

and appearance of brittleness may become slowly unpalatable.

In this connection, there is a traditional proverbial indicating that buckwheat noodles just-cooking may be much palatable compared to long leaved buckwheat noodles. Our findings will give the scientific basis involved in such a traditional proverb.

Another experiment was conducted to clarify how leaving buckwheat noodles after freshly making without cooking may affect mechanical characteristics of the noodles. Figures 3 and 4 showed changes in the breaking characteristics of leaving buckwheat noodles after freshly making without cooking. In this case, after leaving, immediately prior to mechanical analysis, buckwheat samples were cooked and then subjected to analysis. Figures 3 and 4 show changes in the breaking characteristics on leaving at constant temperature buckwheat noodles after their freshly making without

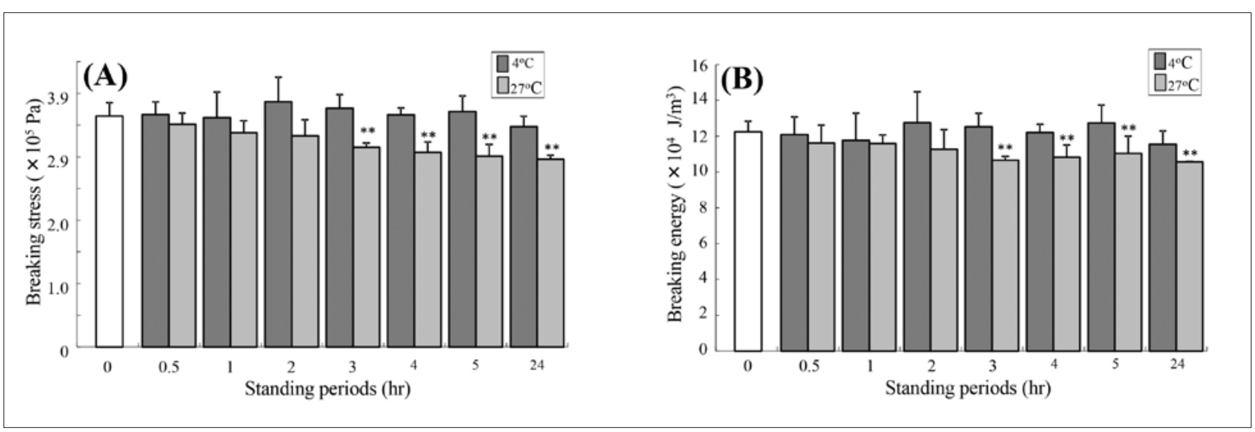

Fig. 3. *Hour-interval-changes in the breaking characteristics of buckwheat noodles after their preparing. (A), breaking stress; and (B), breaking energy. Vertical bars in the figure show the standard deviations. Significant difference from 0 hr: **p<0.001.*

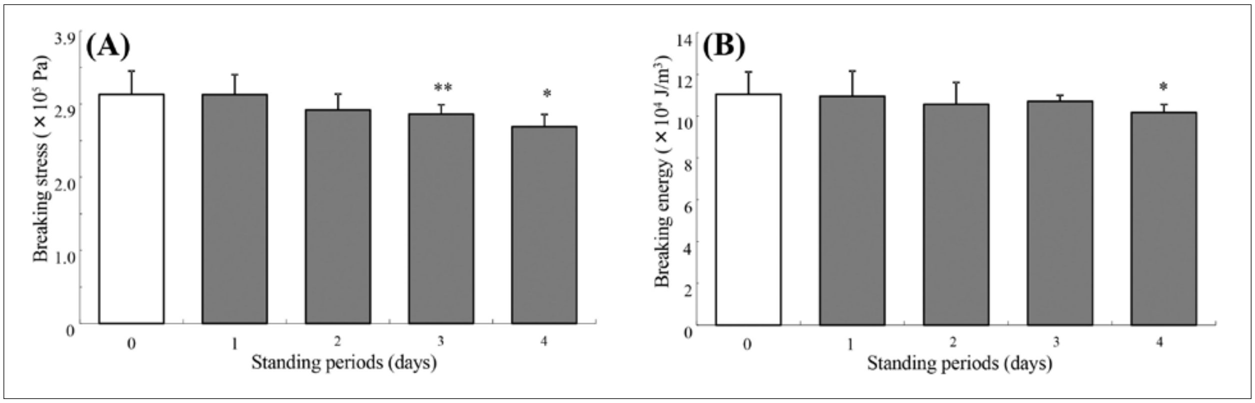

Fig. 4. *Daily changes in the breaking characteristics of buckwheat noodles after their preparing. (A), breaking stress; and (B), breaking energy. Vertical bars in the figure show the standard deviations. Significant difference from 0 day: *p<0.05, **p<0.001.*

cooking: Figure 3 shows hourly changes on leaving at 4 °C and 27 °C of buckwheat noodles produced; and Figure 4, their daily changes at 4 °C. A gradual decrease in the breaking stress (Fig. 3-(A)) and energy (Fig.4-(B)) of buckwheat noodles was found at 27 °C (Fig. 3), whereas less or substantially no changes in the breaking stress (Fig. 3-(A)) and energy (Fig. 3-(B)) of buckwheat noodles were found at 4 °C (Fig. 3). The breaking stress and breaking energy of buckwheat noodles daily decreased at 4 °C gradually (Fig. 4.). A significant (P<0.05) decrease in the breaking stress and energy, as compared with noodles made, was found only after 3 and 4 days. in fact, no or slight changes in mechanical changes were found with buckwheat noodles after freshly making without subsequent cooking. The present findings (Figs. 3 and 4) showed that a gradual, small decrease

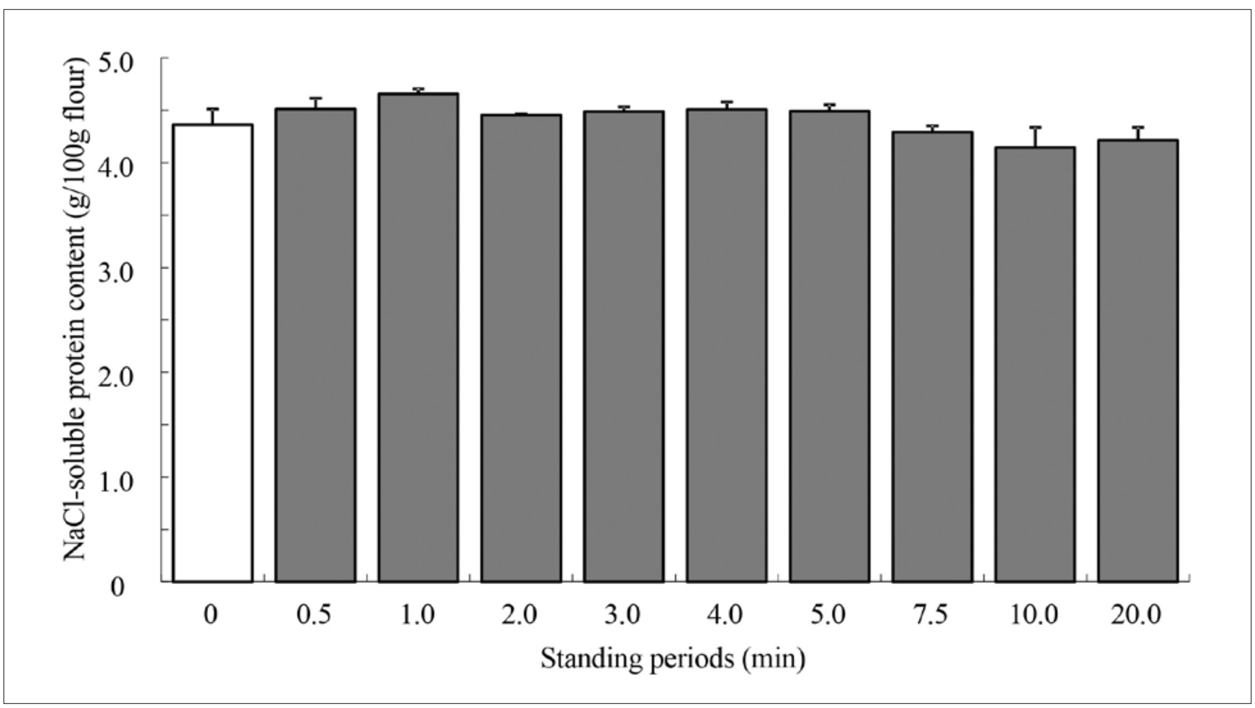

Fig. 5. *Changes in NaCl-soluble protein contents of buckwheat noodles after their boiling. Vertical bars in the figure show the standard deviations.*

in buckwheat noodles' breaking stress and energy occurred after their making without subsequent cooking. These findings show that endogenous enzymes such as proteases and amylases, if any, might not largely involve the mechanical characteristics of buckwheat noodles.

Our present analysis showed drastic changes in buckwheat noodles' mechanical characteristics after leaving and subsequent cooking (Figs. 1. and 2.). In contrast, there were very small changes in mechanical characteristics of buckwheat noodles after freshly making without subsequent cooking (Figs. 3. and 4.).

It remains unclear what factors were responsible for the observed drastic changes in the mechanical characteristics of buckwheat noodles after cooking (Fig. 2.). May be alterations in the chemical form of endogenous protein and starch by cooking are involved. Figure 5 shows changes in the NaCl-soluble protein of buckwheat noodles after their making and subsequent cooking. NaCl-soluble protein expressed the major protein fractions of buckwheat flour, i.e., the combined fraction of albumin and globulin. There were slight changes in the NaCl-soluble protein of buckwheat noodles after boiling (Fig. 5). Our analysis showed a relationship between the observed breaking energy of the buckwheat noodles (Fig. 2 (B)) and the NaCl-soluble protein content (Fig. 5) with r = 0.636 ($P<0.05$). This low correlation suggests that there may be other factors, such as starch and dietary fiber, in addition to NaCl-soluble protein, responsible for the observed mechanical changes after making and subsequent cooking (Fig. 2). Further analysis concerning this topic will be an interesting subject in the future.

Finally, the present study shows that remarked mechanical changes in buckwheat noodles occur after their freshly making and subsequent cooking.

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IZVLEČEK

Počivanje ajdovih rezancev po izdelavi in naknadno kuhanje povzročata velike spremembe nekaterih mehanskih lastnosti

Na Japonskem so ajdovi rezanci priljubljena tradicionalna hrana. Obstajajo različni ustaljeni pogledi na zagotavljanje okusnosti in sprejemljivosti ajdovih rezancev. Na splošno na Japonskem velja, da so ajdovi rezanci, ki so pripravljeni iz pravkar pridelanega in posušenega ajdovega zrnja; iz pravkar zmlete ajdove moke; pravkar pripravljeni ter pravkar kuhani najbolj okusni in sprejemljivi. Vendar znanstvene raziskave o vplivu posameznih od navedenih dejavnikov še potekajo. Že predhodno je bilo dokazano, da že med skladiščenjem ajdovih zrn nastajajo vzroki za kasnejše mehanske spremembe testenin (Asami in Ikeda, 2005). V tej raziskavi se avtorji osredotočajo na mehanske spremembe lastnosti svežih ajdovih rezancev takoj po izdelavi in takoj po kuhanju. Namen raziskave je bil analiza nekaterih mehanskih lastnosti ajdovih rezancev glede na počivanje izdelanih rezancev, po kuhanju ali brez kuhanja. Ugotovljeno je bilo, da se tekom časa počivanja zmanjšajo lastnosti prelamlanja. Avtorji prispevka so ugotovili, da postanejo po počivanju rezanci mehkejši. Nasprotno, lomljivost se je pojavila po počivanju testa za 2 minuti in zaporednem kuhanju. Avtorji so razložili pomen teh ugotovitev glede na okusnost ajdovih testenin.

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Research paper

Incorporation of yeast and hot melt extrusion enhance contents of total polyphenol and flavonoids and antioxidant ability in buckwheat flour

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Keywords: Common buckwheat, yeast, hot-melt extrusion, total polyphenol, rutin, antioxidants

ABSTRACT

A study was conducted to determine the degree of interaction between yeast and hot-melt extrusion on contents of total polyphenol, total flavonoid, and rutin and antioxidant ability in common buckwheat. The highest content of total polyphenol was 95mg/100g in buckwheat flour, which included 2% yeast and was dried for 8 hours after extrusion while that of total flavonoids was 181mg/100g. The highest content of rutin in this study was 4.23mg/100g (156% higher than control, non-extrusion without yeast) in buckwheat flour, included 2% yeast, and dried for 8 hours after extrusion. Antioxidant ability determined by DPPH free radical scavenging ability was higher in yeast-mixed buckwheat flour extruded and dried for 8 hours (23-61%) than non-extruded with or without yeast (19-40%). The highest antioxidant ability (61%) was shown in buckwheat flour mixed with 2% yeast, extruded, and dried for 8 hours after extrusion. These results may be attributed to incorporating extruded buckwheat flour with yeast powder during 8 hours of drying and fermentation followed.

INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench.) is annual melliferous crop and a pseudo cereal. For many years, the cultivation of buckwheat declined, but recent interest in and demand for dietary health care have led to the revival of its cultivation.

As a recognized medicine-food source, buckwheat contains a lot of bioactive substances having a variety of antioxidants such as flavonoids and phenolic acid along with proteins, carbohydrates, lipids, vitamins, and minerals (Krkoskova & Mrazova, 2005). In recent years, flavonoids and phenolic acids have attracted increasing interests due to their various beneficial pharmacological effects including antioxidative, anti-inflammatory, antiallergic, antiviral, anticancer, and antihypertensive properties (Kreft et al., 1999; Chao et al., 2002). Buckwheat is a good source of rutin, a flavonol glycoside plant metabolite, able to antagonize the increase of capillary fragility associated with hemorrhagic disease or hypertension in humans (Kreft et al., 1999; Park et al, 2000).

The extrusion process is traditionally employed via ram extrusion and screw (single or twin screw) extrusion. Twin screw extrusion generates high shear stress with a higher degree of mixing capacity than the single screw extruder. The solvent-free hot melt extrusion (HME) equipped with twin screw is widely used in the pharmaceutical and food industries, to develop solid composites with a nano-sized particle of the active compounds (Azad et al., 2019). In general, the high temperature of HME softens the polymer and favors the diffusion of active compounds such that they are dispersed into the polymer matrix. The processing ability in the HME can be enhanced by adding plasticizer, which lowers the melt viscosity of the extrudate. Hydrophilic plasticizer has a significantly positive effect on the increase in dissolution rate (Azad et al., 2019; Koo et al., 2019). HME contributes to enhancing the bioaccesibility, functionality, and thermal stability of nutraceutical compounds (Lee et al., 2019; Azad et al., 2020; Azad et al., 2021).

An interesting method of obtaining food of improved bioactive potential, increased digestibility, high nutritional value and favorable taste is solid-state fermentation of plant seeds. Yeast cells derived from *Saccharomyces cerevisiae* and related species have gained increasing attention as oral delivery systems for bioactive agents, including pharmaceuticals, supplements, and nutrients (Ten et al., 2021). Yeast cells have a rigid outer cell wall comprised of dietary fibers and glycoproteins that provide unique features for these applications. Indeed, yeast cells have several potential advantages such as their ability to deliver both hydrophobic and hydrophilic compounds and protect encapsulated substances from heat, light, oxygen, and moisture. The food-related bioactive compounds that have been successfully encapsulated using yeast cells include flavors, vitamins, carotenoids, phenolics, and other nutraceuticals (Ten et al., 2021).

This study is a preliminary trial for buckwheat flour to enhance contents of total polyphenol and flavonoids, including rutin, and antioxidant ability by incorporating hot melt extrusion with yeast powder during processing buckwheat flour for food or cosmetic materials.

MATERIALS AND METHODS

Sample preparation of common buckwheat

For experiment 200g of common buckwheat flour (Chuncheon Makguksu Agricultural Cooperation, Maemilgaru) was mixed with 1 or 2 percent of yeast powder (Beoma Food. Co., Instant yeast). Control was not mixed with yeast powder. With those mixed flour, t Three trials were done for hot melt extrusion (Han Kook Tech., AL-300); flour was non-extruded, flour dried just after extrusion, and flour dried for 8 hours after extrusion. Drying of buckwheat flour was conducted at 70 °C of dryer. Hot melt extrusion was done with an extruder at a temperature of 95-115 °C and pressure of 15 bar. Screwing speed was 160 rpm and time to ejection after extruding was 60-90 seconds.

Determination of total phenolic contents (TPC)

The total phenolic contents (TPC) were determined by the Folin-Ciocalteu assay (Singleton and Rosi, 1963). A sample aliquot of 200 μl was added to a test tube containing 200 μl phenol reagent (1N). The volume was increased by adding 1.8 ml of distilled deionized water. The solution was allowed to stand for 3 min for reaction. To continue the reaction, 400 μl of Na_2CO_3(10% in water v/v) was added and vortexed (Daihan Scientific, VM-30). The final volume 4 ml was adjusted by adding 1.4 ml of distilled water. The prepared sample was then incubated for 1 hour at room temperature. The absorbance was measured at 725 nm using a spectrophotometer (UV-1800 240V, Shimadzu Corporation, Kyoto, Japan).

The total phenolic content was expressed as tannic acid equivalents (TAE) in dry weight basis (DW)

Determination of flavonoid contents (TF)

The total flavonoid content (TF) was determined according to Ghimery et al. (2009) with slight modification. Briefly, an aliquot of 0.5 ml of sample (1 mg/ml) was mixed with 0.1 ml of 10% aluminum nitrate and 0.1 ml of potassium acetate(1M). In the mixture, 3.3 ml of distilled water was added to make the total volume 4 ml. The mixture was vortexed and incubated for 40 minutes. The total flavonoid was measured using spectrophotometer (UV-1800 240V, Shimadzu Corporation, Kyoto, Japan) at 415 nm. Total flavonoid content was expressed as μg/g quercetin equivalent in dry weight basis.

DPPH free radical scavenging ability (AA)

The antioxidant activity was determined on the basis of the scavenging activity of the stable 2, 2-diphenyl-1 picryl hydrazyl (DPPH) free radical according to methods described by Braca et al. (2003) with slight modification. 1 ml of extract was added to 3 ml of DPPH. The mixture was shaken vigorously and left to stand at room temperature in the dark for 30 minutes. The absorbance was measured at 517 nm using a spectrophotometer (UV-1800 240V, Shimadzu Corporation, Kyoto, Japan). The percent inhibition activities of the purple potato sample were calculated against a blank sample using the following equation. Inhibition (%) = (blank sample extract sample/blank sample) x 100.

RESULTS AND DISCUSSION

Buckwheat flour processed by hot melt extrusion showed 43-89% higher contents of total polyphenol and 30-48% higher total flavonoid than control, non-extruded treatment without yeast (Table 1). Rutin content was also 43-47% higher than control. Addition of yeast powder to buckwheat flour induced higher contents of total polyphenol and flavonoid as well as rutin content. In the treatment of non-extrusion, 1% and 2% of yeast increased 29% and 51% of total polyphenol contents and 38% and 42% of total flavonoid contents. Rutin content in the treatment of non-extrusion increased from 1.65mg/100g without yeast to 1.96mg/100g (19% higher) in 1% of yeast and 3.96mg/100g (140% higher) in 2% of yeast. Two types of extrusion caused increases of total polyphenol, total flavonoid, and rutin. Drying 8 hours after extrusion induced higher contents of total polyphenol, total flavonoid, and rutin than those obtained just after extrusion, indicating that fermentation in buckwheat flour hot-melt extruded by solid-state yeast was continuously proceeded during drying of 8 hours after extrusion. Addition of 2% yeast induced higher contents of total polyphenol, total flavonoid, and rutin rather than addition of 1% yeast. The highest content of total polyphenol was 95mg/100g in buckwheat flour included 2% yeast and dried for 8 hours after extrusion wwhile that of total flavonoid was 181mg/100g. The highest content of rutin in this study was 4.23mg/100g (156% higher than control, non-extrusion without yeast) in buckwheat flour included 2% yeast and dried for 8 hours after extrusion. Antioxidant ability determined by DPPH free radical scavenging ability was higher in yeast-mixed buckwheat flour extruded and dried for 8 hours (23-61%) than non-extruded with or without yeast (19-40%). The highest antioxidant ability (61%) was shown in buckwheat flour mixed with 2% yeast, extruded and dried for 8 hours after extrusion. These results indicate that extruded buckwheat flour incorporates with yeast powder during 8 hours of drying and following fermentation. HME processing technology was applied to several crops to maintain higher nutraceutical or pharmaceutical compound contents. HME increased the reactive surface area of compounds and de-structures the fibre matrix, thereby causing enhance decursin and decursinol angelate to be released into the solution in *Angelica gigas* (Azad, et al., 2020). HME resulted in prolongation of the thermal stability of anthocyanins in a biopolymer-mediated purple potato (Azad et al, 2021). This study showed a high potential of improvement from nutraceutical points of view. Effect of fermentation on buckwheat flour was determined in several cases of study using diverse microbials including yeast, *Saccharomyces* spp. The total phenolic content and antioxidant potential of fermented buckwheat dough significantly increased using *Lactobacillus delbrueckii* (Gandhi & Dey, 2013). Amino acid, glutamate and tryptophan in buckwheat increased through the serial repitching of *Saccharomyces pastorianus* (yeast) on the composition of the barley, buckwheat and quinoa fermentation medium (Deželak et al., 2015). Buckwheat groats fermented with *Rhizopus oligosporus* are a potential source of flour of advantageous antioxidant parameters for application as a food additive (Starazynska-Janiszewska et al., 2016). Raw buckwheat flour fermented with liquid-state fermentation by lactic acid bacterial and

Table 1. *Total polyphenol, total flavonoid, and rutin in different conditions of yeast and hot melt extrusion on buckwheat flour*

Treatment		Total polyphenol content (mg/100g)	Total flavonoid content (mg/100g)	Rutin content (mg/100g)
Yeast (%)	*Extrusion*			
0.0	Non-extrusion (Control)	35	64	1.65
	Just after extrusion	50	83	2.36
	Drying for 8 hrs after extrusion	66	95	2.43
1.0	Non-extrusion	46	88	1.96
	Just after extrusion	52	101	2.96
	Drying for 8hrs after extrusion	77	117	3.21
2.0	Non-extrusion	53	91	3.96
	Just after extrusion	59	131	3.69
	Drying for 8 hrs after extrusion	95	181	4.23

Rhizopus oligosporus fungi contained higher amount of rutin and total polyphenol contents (Zielinski et al., 2019). The ethanolic extracts of buckwheat fermented with three strains of *Agaricus* exhibited the higher total phenolic contents and superoxide anion radical scavenging ability (Kang et al., 2017).

CONCLUSIONS

This study was attempted through the combination of biological (yeast) and mechanical (hot-melt extrusion) approaches for improving quality of buckwheat flour. In this preliminary study, we found a potential of incorpora-

Table 2. *Antioxidant ability in different conditions of yeast and extrusion on buckwheat flour*

Treatment		DPPH free radical scavenging ability (%)
Yeast (%)	*Extrusion*	
0.0	Non-extrusion (Control)	18.5
	Just after extrusion	23.1
	Drying for 8 hrs after extrusion	31.8
1.0	Non-extrusion	35.7
	Just after extrusion	47.5
	Drying for 8 hrs after extrusion	57.0
2.0	Non-extrusion	39.7
	Just after extrusion	50.9
	Drying for 8 hrs after extrusion	60.6

tion of yeast with hot melt extrusion to enhance antioxidant parameters including rutin content of buckwheat flour. Further studies are needed to clarify a decisive mechanism of the incorporation based both biological and mechanical approaches resulting in quality improvement of buckwheat flour.

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IZVLEČEK

Uporaba kvasa in vročega ekstrudiranja poveča vsebnost celotnih polifenolov, flavonoidov in antioksidacijsko sposobnost pri ajdovi moki

Namen raziskave je bil ugotoviti interakcijo dodanega kvasa in vročega ekstrudiranja mešanice ajdove moke s kvasom na vsebnosti celotnih polifenolov, flavonoidov in antioksidacijske sposobnosti pri moki navadne ajde. Ajdovi moki je bilo dodanega 2% kvasa, rezanci so bili sušeni 8 ur po ekstruziji. Najvišja vsebnost skupnih polifenolov je bila 95mg/100g z dodatkom 2% kvasa, vsebnost celotnih flavonoidov je bila 181mg/100g. Najvišja vsebnost rutina je bila 4,23mg/100g (156% več kot kontrola, brez ekstrudiranja, s kvasom) pri ajdovi moki z 2% kvasa in sušeno 8 ur po ekstruziji. Antioksidativna sposobnost, določena z DPPH, je bila višja pri uporabi kvasa, ekstruzije in sušenja 8 ur (23-61%), kot brez uporabe kvasa in ekstruzije (19-40%). Najvišja antioksidacijska sposobnost (61%) je bila določena pri ajdovi moki z dodatkom 2% kvasa, ekstrudirano in po ekstruziji sušeno 8 ur. Pričakovati je, da bodo rezultati te raziskave prispevali k uspešni uporabi ekstrudiranja ajdove moke z uporabo kvasa in osem urnega sušenja ter fermentacije.

Review

Development and utilization of buckwheat sprouts in Korea

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ABSTRACT

History and dishes of buckwheat sprouts in Korea were reviewed from both industrial factory production and non-industrial home cultivation. Industrialization of buckwheat sprouts was generally unsatisfactory because of limited demand in the market. Home-growing of buckwheat sprouts is recommended for individual health promotion. Research on buckwheat sprouts is being multifariously conducted such as component analysis, biological activity, application for food processing, creative culinary etc. Exploring and wide-spreading the protective effects of buckwheat sprouts on chronic disease are needed for the progress of buckwheat industry as well as the expansion of commercialized buckwheat sprout products.

HISTORY OF DEVELOPING BUCKWHEAT SPROUTS IN KOREA

Buckwheat sprouts were developed by Sun Lim Kim (Kim et al., 2004) in Crop Experiment Station, Rural Development Administration (RDA), Korea in 2004 and registered Korea patent (No. 0217884). He grew buckwheat sprouts in a germination bed under the dark for 8 days at 25 °C (Fig. 1a). However, he did not use any implement to remove husks from the germinated sprouts. After buckwheat husks were artificially removed, the sprouts were investigated for texture, fatty acid, free amino acid, phenolic compound, and soluble vitamins. RDA transferred the technology of sprouting from buckwheat seeds to a farmer, Mr. Dong Hyeok Kim who had produced good quality soybean sprouts. Farmer Mr. Kim invented an implement of removing husks from the sprouts after several trials and failure. He succeeded to remove husks by putting a double layer-steel net (Fig. 1b) on germination bed in 2006. Buckwheat seeds soaked into water were put on germination bed and a steel net was put at height of 2 cm from the seed lines. The germinated sprouts grew more and husks were removed from the sprouts when they pass through steel net. Farmer Mr. Kim registered Korea patent and tried mass-production of buckwheat sprouts in a factory (Fig. 1c).

Dehulled groats of buckwheat were also used to grow buckwheat sprouts in several countries including Korea. The double layer-steel net was not needed when we used the dehulled groat of which embryos were not damaged to germinate. There are a number of instances to produce the dehulled groats-produced buckwheat sprouts from Google. The buckwheat sprouts from dehulled groats are possible to produce using diverse containers at home. Recently, we showed growing buckwheat sprouts in a kettle through a Youtube channel, Park Cheol Ho's Buckwheat

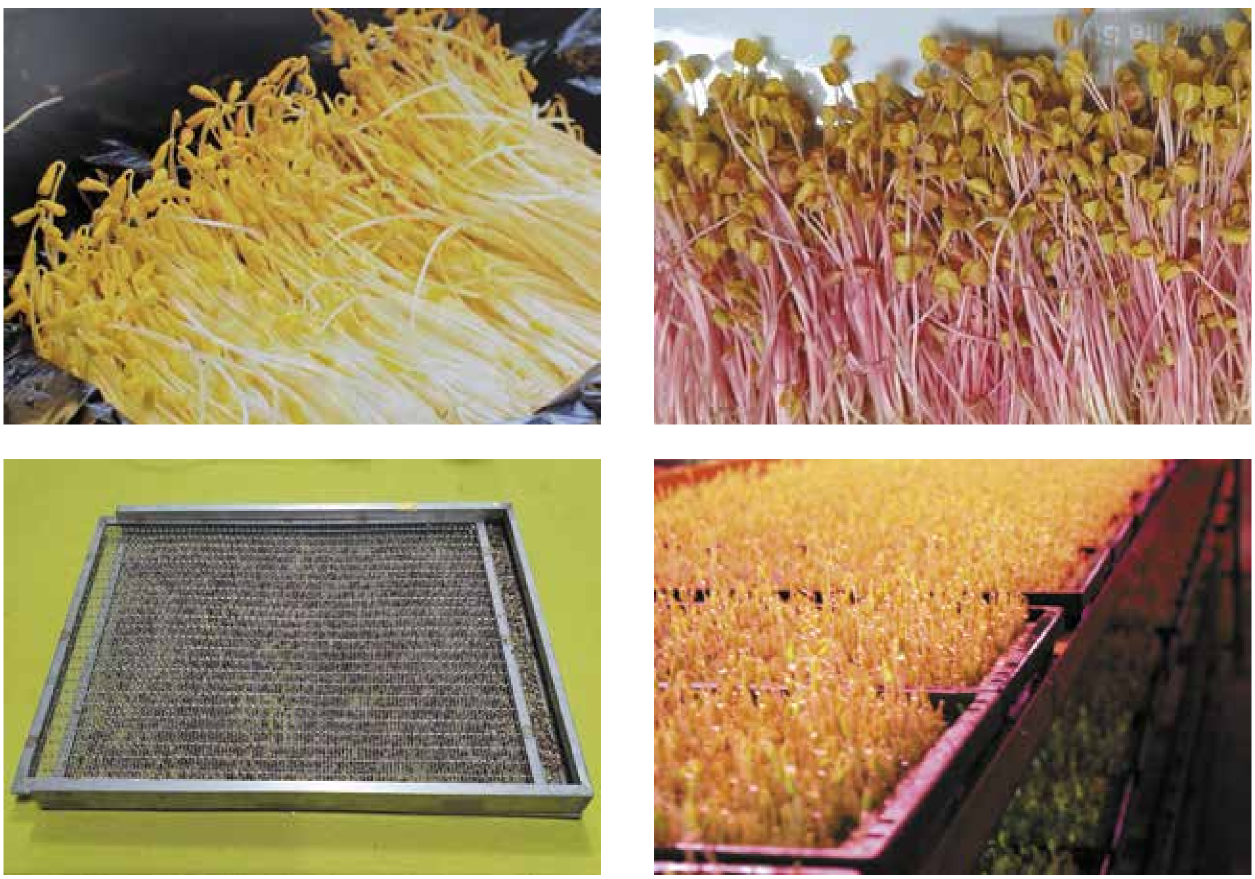

Fig. 1. *Buckwheat sprouts (a:white, b: red), a double layer- steel net for buckwheat sprout production (c), and a mass-production of buckwheat sprouts in a factory (d)*

Fig. 2. *Growing buckwheat sprouts in a kettle (from soaking of dehulled groats to sprouting, clockwise).*

TV. Kettle has a number of advantages to grow buckwheat sprouts; dark condition inside kettle, easiness to supply fresh water and drain wastewater, washing and decontamination with fresh water once a day, and easiness to handle.

The procedures of growing buckwheat sprouts in a kettle as follows:

- Soaked dehulled buckwheat groats in water for 6 hours
- Put the soaked groats into a kettle and close lid
- Draining water inside kettle
- Keep the kettle at 25 °C – Watering and washing three times shaking kettle one a day
- Draining again water inside kettle
- Repeating same work every day until harvesting.

DISHES OF BUCKWHEAT SPROUTS IN KOREA

Buckwheat sprouts are cooked in the forms of raw or seasoned vegetables in Korea. The fresh and raw sprouts of buckwheat are mostly for buckwheat noodles (called Makguksu in Korean) as a topping material on noodles. The raw sprouts are plain-tasted and good matched with earthy- tasting buckwheat noodles. Especially, noodles made with one hundred percent of buckwheat flour without adding wheat flour improves nutriceutical quality of noodles by mixing buckwheat sprouts which contained higher rutin and flavonoids. Buckwheat jelly mixed with sprouts is also popular as a low-calorie diet food for anti-obesity among the people. Dishes of buckwheat sprouts were not still industrially expanded across the nation even though they were usually used at buckwheat noodles restaurants in several cities, restaurants at rest area on a few routes of highway in Korea. At one time, buckwheat sprouts were introduced as an airplane food mixed with rice but not prolonged so long because of less industrialized producer. Home-grown buckwheat sprouts are used rarely and in small quantities. Buckwheat sprouts are mostly cooked on the spot. Processing food products using buckwheat sprouts is only juice hot water-extracted and powder dry-milled. They are not much traded in the market. It would be attributed to the insufficient publicity on the health benefits of buckwheat sprouts. Exploring and wide-spreading the protective effect of buckwheat sprouts on chronic disease are needed

Fig. 3. *Dishes of buckwheat sprouts in Korea. Clockwise, buckwheat noodles with red sprouts; buckwheat noodles with white sprouts; seasoned buckwheat sprouts with sesame seeds, pine seeds, and mushroom (manna lichen); fried egg roll with sprouts; sprouts double boiled juice, buckwheat pancake with sprouts and seasoned radish shreds inside; Korean Kimchi (seasoned and fermented Chinese cabbage) with sprouts; and buckwheat flour jelly with sprouts, and seaweed fragments. Noodles are made by filling a steel cylinder with buckwheat dough and pressing them immediately into a pot, and boiling in hot water for a few minutes.*

for the progress of buckwheat industry as well as the expansion of commercialized buckwheat sprout products.

RESEARCH OF BUCKWHEAT SPROUTS IN KOREA

A number of researches have been done on buckwheat sprouts. From comparison study of chemical composition between buckwheat sprouts and buckwheat seeds, fatty acids, mineral, and vitamin increased in buckwheat sprouts (Kim et al., 2005). Four anthocyanins such as cyanidin 3-*O*-glucoside, cyanidin 3-*O*-rutinoside, cyanidin 3-*O*-galactoside, and cyanidin 3-*O*-galactopyranosyl-rhamnoside were isolated from the sprouts of common buckwheat (Kim et al., 2007). Antioxidant and antigenotoxic effect was determined for the extracts of common buckwheat (Kim et al., 2007). Antimutagenic and cytotoxic effects of ethanol extract of buckwheat sprouts (Cui et al., 2008). Nitrite scavenging ability at pH 1.2 in buckwheat sprout was 54.2 and that of roasted buckwheat sprouts was 11.7% higher than compared to raw buckwheat sprouts, indicating a potent increase of antioxidant ability according to cooking methods (Kim et al., 2021). The evolution of flavonoid content and DPPH free radical scavenging activity in sprouts of Tartary buckwheat was investigated with 1 to 10 day-old sprouts (Kim et al, 2007). Tartary buckwheat sprouts cultivated for 7-9 days exhibited higher biological activity including antioxidant activity (Kim et al., 2020). Phenolic and flavonoid compositions of common and Tartary buckwheat sprouts were determined and recommended for their high antioxidative activity, as well as being an excellent dietary source phenolic and flavonoid compounds, particularly Tartary buckwheat sprouts, being rich in rutin (Lee et al., 2006; Kim et al., 2008; Nam et al., 2015).

The developed HPLC method was validated to separate and monitor flavonoids in common buckwheat sprouts (Jang et al, 2019). Different quality of light affected to the production of phenolic compound and antioxidant activity in common and Tartary buckwheat sprouts (Lee et al., 2014; Jeon et al., 2015), major flavonoid and antioxidant activity in common buckwheat sprouts (Nam et al., 2018), contents of rutin, free amino acid and vitamin C in common and Tartary buckwheat sprouts (Kim et al., 2006). Phenyalanine and LED lights enhanced phenolic compound production in Tartary buckwheat sprouts (Seo et al., 2015). 14,000 lux of LED light was determined to be optimal for manufacturing Tartary buckwheat sprouts by confirming higher rutin content and antioxidant activity (Shin et al, 2018).

Elicitation with sucrose and calcium chloride in buckwheat sprouts markedly enhanced the accumulation of bioactive compounds such as polyphenols, flavonoids, Gamma-aminobutyric acid, vitamin C and E, and antioxidant activity, without negatively affecting sprout growth (Sim et al., 2020). After treatment for 72 hours, Jamoni acid (150uM), chitosan(0.1%), and salicylic acid accumulated higher levels of phenolic compounds in common buckwheat sprouts (Park et. al., 2019). The exogeneous methyl jasmonate increased phytochemical production and antioxidant activity in buckwheat sprouts cultivated under dark conditions (Kim et al., 2011). Treatment of metyl jasmonate increased total polyphenols and flavonoids by about 1.6 fold and isoorientin, orientin, rutin, and vitexin were elevated by about 18% in buckwheat sprouts. Methyl jasmonate-treated buckwheat sprouts exhibited greater improvements in glucose and insulin tolerance than ovarectomized control and buckwheat sprouts (Yang et al., 2016). Common buckwheat sprout treated with methyl jasmonate improved anti-adipogenic activity associated with the oxidative stress system in 3T3-L1 adipocytes (Lee et al., 2013). Treatment of 1%, 2% or 3% sucrose increased the amount of vitamins, four C-glycosylflavones in common buckwheat sprouts and rutin, tocopherols, and beta-carotene in sprouts increased in a dose-dependent manner as well as increase in antioxidant capacity of buckwheat sprouts (Jeong H. et al, 2018). Far infrared irradiation altered total polyphenol, total flavonoid, antioxidant property and quercetin production in Tartary buckwheat sprout powder (Ghimeray et al., 2014).

Although the growth rate of sprouts decreased with less 50 mM NaCl, treatment of an appropriate concentration of NaCl (salinity stress) improves the nutritional quality of sprouts, including the level of phenolic compounds, carotenoids, and antioxidant activity (Lim et al., 2012). Common buckwheat sprouts treated with 10% deep sea water at 30 °C showed higher hypocotyl length and fresh weight of sprout than the control and treatment of 5% deep sea water (Briatia et al, 2011).

Fermented extracts from Tartary buckwheat sprouts contained higher phenol components and biological effects (Chang et al., 2010). Inoculation with a soil microbial, *Herbaspirillum* spp. at concentration of 10 to 20%(v/v), soaking time of 4 to 8 hours and temperature of 20 °C promote growth rates of Tartary buckwheat sprouts (Briatia X. et al., 2016).

Rutin or ethanolic extract from Tartary buckwheat sprouts decreased significantly serum glucose-level in animal model of type 2 diabetes (Lee et.al., 2016). Tartary buckwheat sprouts inhibits non-alcohoic fatty acid liver disease (NAFLD) transcription-modulating activity of lipogenesis-related genes through modification of histone acetylation (Hwang, et al, 2017). Hepatoprotective activity against *tert*-butyl hydroperoxide(*t*-BHP)-induced oxidative stress in HepG2 cells was the highest in red buckwheat sprouts (Yu et al., 2020).

Buckwheat sprouts were used for food processing to improve quality and functionality of food. Buckwheat sprouts were added to improve functionality of fermented liquor Yakju in Korean (Lee & Kim, 2011) and to determine the effect of single or mixture culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* on fermentation characteristics of buckwheat sprout added Yoghurt (Kang & Kim, 2010). Heat-stable emulsion was made from buckwheat sprout extracts (Cha 2014). Quality of soymilk was improved by adding buckwheat sprouts (Jeong and Kim, 2015). Noodles mixed with 2 to 4% of buckwheat sprout powder increased yellowness and redness and also improve significantly texture such as hardness, chewiness and gumminess (Kim et al., 2005).

The storage quality of fresh buckwheat sprouts was improved by dipping buckwheat sprouts in chlorine water (100ppm), rinsed twice with clean water, pre-cooled with iced water, de-watered, and packed in plastic trays after the investigation of microbiological flora on buckwheat sprouts (Lee et al., 2009; Lee et al., 2011). Quality in storage of buckwheat sprouts was improved by treating with combination of organic acid solutions such as 0.1% ascorbic acid, 0.5% citric acid, and 0.05% acetic acid (Chang et al., 2010). The combined sanitizer mixture such as 100mg/l aqueous chlorine dioxide (ClO_2) and 0.3% fumaric acid, and 2KJm^{-2} UV-C irradiation and modified atmosphere packaging improved the microbial safety and quality of buckwheat sprouts (Chun & Song, 2013).

CONCLUSION

In Korea, many interesting dishes are developed, which include buckwheat sprouts. These foods could be prepared, and further developed as well in other countries.

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IZVLEČEK

Razvoj in uporaba ajdovih kalic v Koreji

V delu je prikazan razvoj uporabe ajdovih kalic v Koreji, tako z vidika industrijske priprave kot tudi pridobivanja kalic v domačem okolju. Možnosti industrijske pridelave so omejene glede na majhno povpraševanje po takih izdelkih na tržišču. Pridobivanje ajdovih kalic v gospodinjstvih je priporočeno z vidika ohranjanja zdravja. Opravili so več vrst raziskav ajdovih kalic, na primer analize sestavin, biotsko aktivnost, uporabe pri predelavi živil, kreativni kulinariki itd. Raziskave in širjenje znanja o preventivnih vplivih ajdovih kalic glede kroničnih bolezni so potrebne za napredek v industrijski uporabi ajde, kot za širjenje sortimenta in ponudbe izdelkov iz ajdovih kalic.

Information

The organizing committee regrets to inform that due to the uncertainty related to the difficult situation affecting Eastern Europe, the **15th International Buckwheat Symposium** shall be postponed to 2023. The symposium will be held in Puławy, Poland from 1 to 8 of July 2023.

The website of the conference has been updated. We hope and wish that we can all meet next year in more peaceful times.

With the best regards,
Scientific and organizing committee
Prof. dr hab. Grażyna Podolska; dr hab. Jacek Kwiatkowski, prof. UWM; dr Krzysztof Dziedzic,

https://www.15thisb.com/

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FAGOPYRUM accepts scientific papers, and information and bibliographies on buckwheat.

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