

Research paper

Mechanical characterization of buckwheat noodles mixed with seaweed (fu-nori)

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DOI <https://doi.org/10.3986/fag0006>

Received: December 5, 2018; accepted: January 30, 2019

Keywords: common buckwheat, mechanical characteristics, noodles, seaweed

ABSTRACT

The present study was conducted to clarify the effect of incorporation of seaweed, i.e. *funori* (*Gloiopeltis tenax* (Turner) J. Agardh) into buckwheat noodles on their mechanical characteristics. Mechanical analysis of buckwheat noodles with *funori* showed that incorporation of *funori* into buckwheat noodles enhanced breaking stress and energy. On the other hand, incorporation of *funori* into buckwheat noodles enhanced decreased solubility of the albumin plus globulin fraction. The present study findings suggest that the endogenous protein may be an important factor responsible for the mechanical characteristics of buckwheat noodles with seaweed.

INTRODUCTION

Buckwheat (*Fagopyrum spp.*) is an important crop in some regions of the world (Kreft et al., 2003; Ikeda, 2002). Buckwheat flour contains various beneficial components for human health such as protein, polyphenolics, rutin and minerals at high levels (Ikeda 2002; Ikeda and Yamashita 1994). Thus, buckwheat can contribute as an important dietary source of such beneficial components.

There is a large variety of buckwheat products produced on a global basis (Ikeda, 2002). Attention has been currently paid to the palatability and acceptability of buckwheat products from the perspective of their cooking and processing. However, there are still unanswered questions on the palatability and acceptability of buckwheat products. As buckwheat flour has low cohesiveness, dough-binders, such as wheat flour, egg, seaweed, Japanese yam flour, are often added in preparing buckwheat noodles (ZMCS, 2004). A variety of buckwheat noodles with various dough-binders has been traditionally available in Japan. We reported mechanical effects by addition of various dough-binders to common and Tartary buckwheat noodles in view of two analysis, i.e., tensile analysis and breaking analysis (Ikeda, et al., 2005). However, further systematic analysis is needed to understand the exact mechanical effects of various dough-binders to buckwheat products.

In Niigata district, located in the middle region of Japan, there is a famous buckwheat dish. This dish is

called “*hegi-soba*”. These buckwheat noodles are prepared by incorporating into buckwheat dough a kind of seaweed, i.e. *funori*, (*Gloiopeltis tenax* (Turner) J. Agardh) as a dough-binder (Zen-men-kyo, 2014). Before ingestion, the noodles prepared with *funori* are usually put on a unique wooden-tray which is called “*hegi*”; so these buckwheat noodles are called “*hegi-soba*”. Although this buckwheat dish is traditionally utilized only in Niigata region, many Japanese people currently often enjoy these local buckwheat noodles. *Hegi-soba* noodles have a unique masticatory sense with refreshing sense on ingestion. Mechanical characterization of “*hegi-soba*” noodles is an interesting subject in view of buckwheat research. In this background, the present study was conducted to characterize noodles made from buckwheat flour with seaweed.

MATERIALS AND METHODS

Materials

Buckwheat flour (*Fagopyrum esculentum* Moench, var. Kitawase-soba), which was harvested in Hokkaido (in 2017), was used in this research. Buckwheat flour was kindly provided prepared from Terao Milling Co. (Hyogo, Japan) and stored at -80°C until use. Ground seaweed, i.e. *fu-nori* in Japanese, *Gloiopeltis tenax* J. Agardh) used in this study was a commercial product (Oowaki-man-zou-shoten Co., Fukui, Japan).

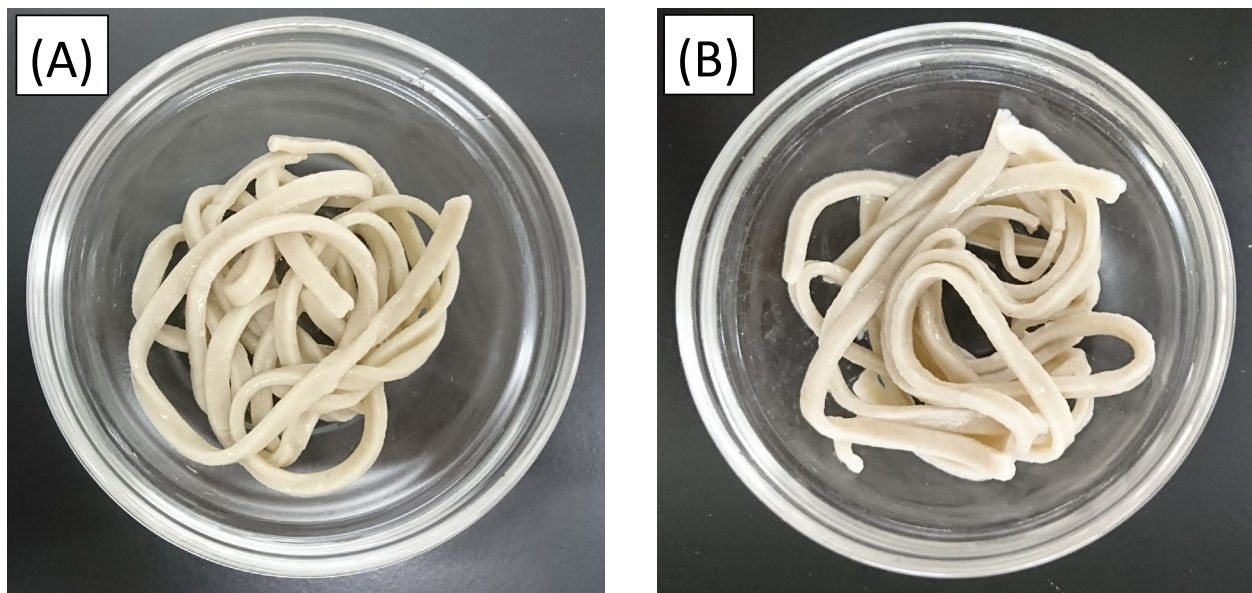


Fig. 1. Buckwheat noodles. (A), non added seaweed; and (B) added seaweed (1.7% addition).

Mechanical measurements

For the study of the effects of the seaweed on the mechanical characteristics of buckwheat noodles, buckwheat noodles were prepared by hand. The mechanical characteristics of buckwheat noodles were evaluated by breaking analysis. Prior to the mechanical analysis, the buckwheat flour which had been stored at -80°C was placed in a desiccator at room temperature until the flour exhibited a constant moisture content. The moisture of the flour was measured with a moisture analyzer (ML-50, A&D Co. Ltd., Japan). Seaweed was boiled, and sticky seaweed was added to buckwheat flour. The buckwheat dough was prepared just prior to mechanical analysis to have a moisture content of 42% by adding the appropriate amount of distilled water. Then the buckwheat noodles were made from the buckwheat dough using a hand-made pasta machine (SP-150, Imperta Co., Torino, Italy). Figure 1 shows buckwheat noodles prepared in this study. The buckwheat noodles obtained were subjected to mechanical analysis. Before the mechanical analysis, buck-

wheat noodles prepared were heated in boiling water for 150 seconds and subsequently were cooled for 150 seconds at 4°C . Immediately after cooling, mechanical measurements of the noodles were performed. The breaking analysis of the buckwheat noodles was performed with Rheoner RE2-3305C (Yamaden Co. Ltd., Japan). Measurements of breaking analysis were performed with a load cell of 200N and measurement speed of 0.50 mm/sec. A wedge-style plunger (No.49: W 13mm, D 30mm, H 25mm) was used in measurements with the Rheoner RE2-3305C. Mechanical measurements were replicated twenty times for each sample.

Protein determination

For chemical analysis of the combined fractions of buckwheat albumin plus globulin (AG) in the heated 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

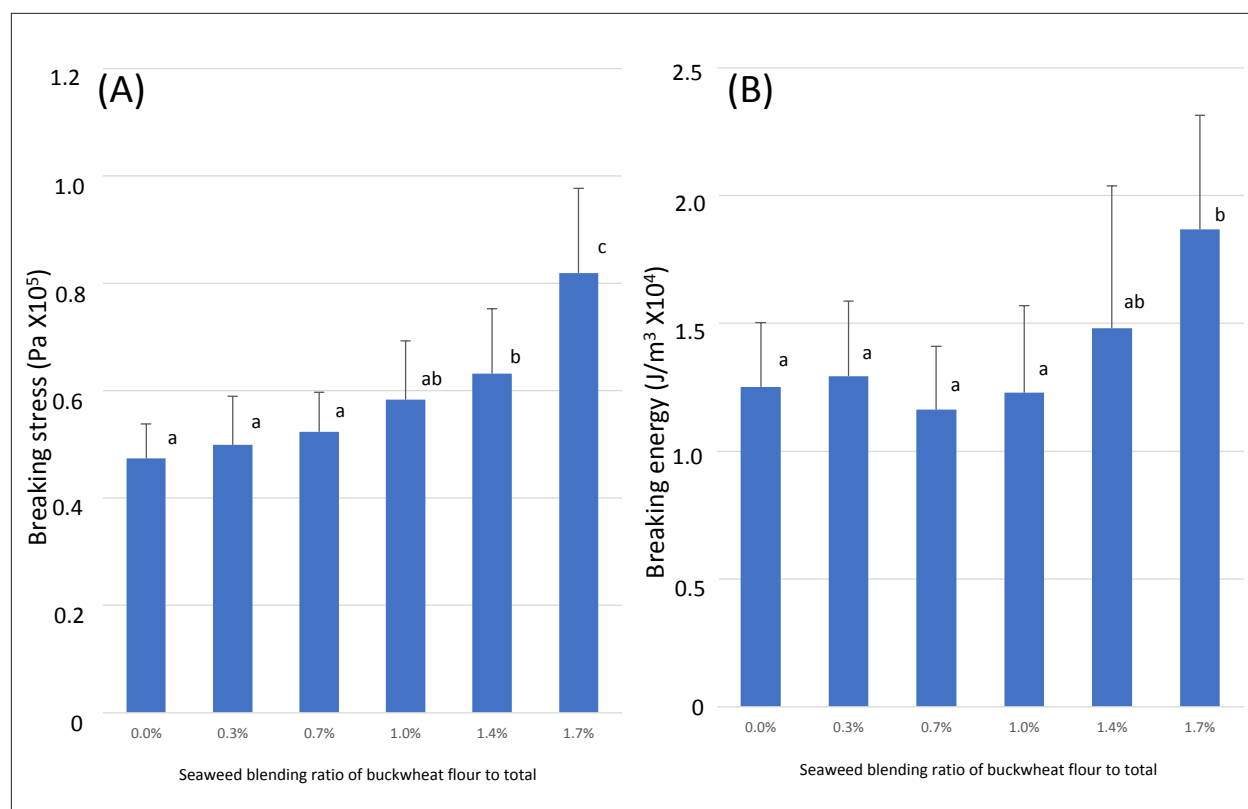


Fig. 2. Breaking characteristics of buckwheat noodles made with seaweed. (A), breaking stress; and (B), breaking energy. Vertical bars in the figure show the standard deviations. Values that within the same row that are not followed by the same letter are significantly different at $P < 0.05$.

40°C. After extraction, the suspensions were centrifuged at 17,000 Xg for 20 min. Protein concentration was determined using the Bradford method with bovine serum albumin as a standard protein.

Statistical analysis

Statistical analysis was conducted using a personal computer with the program Excel (Microsoft Co., USA), Ekuseru-Toukei 2015 (Social Survey Research Information Co., Japan) and SPSS Ver.23.0 (IBM, USA).

RESULTS AND DISCUSSION

Mechanical characteristics of buckwheat noodles made with seaweed

Figure 2 shows the breaking characteristics of *hegi-soba* buckwheat noodles prepared with *funori*-seaweed. The breaking stress and energy of the *hegi-soba* noodles gradually increased as the added concentration of *funori*

seaweed increased (Fig. 2 (A and B)). A significant high breaking stress (Fig. 2 (A)) was found with *hegi-soba* buckwheat noodles with a concentration of *funori* seaweed with 1.4% or over as compared the buckwheat without *funori* seaweed ($P < 0.05$). Similarly, a significant high breaking energy (Fig. 2 (B)) was found with buckwheat noodles with a concentration of *funori* seaweed with 1.7% as compared the buckwheat without *funori* seaweed ($P < 0.05$). These findings characterize showed the unique mastication characteristics of *hegi-soba* noodles.

Protein compositions of buckwheat noodles made with seaweed

Figure 3 shows the NaCl-soluble protein content of buckwheat noodles made with seaweed. The NaCl-soluble protein exhibits the combined fraction of the major buckwheat proteins, i.e., albumin plus globulin (Ikeda, 2002), designated as the AG fraction below. Changes by the addition of the seaweed in solubility of the AG fraction were found (Fig. 3). Incorporation of seaweed

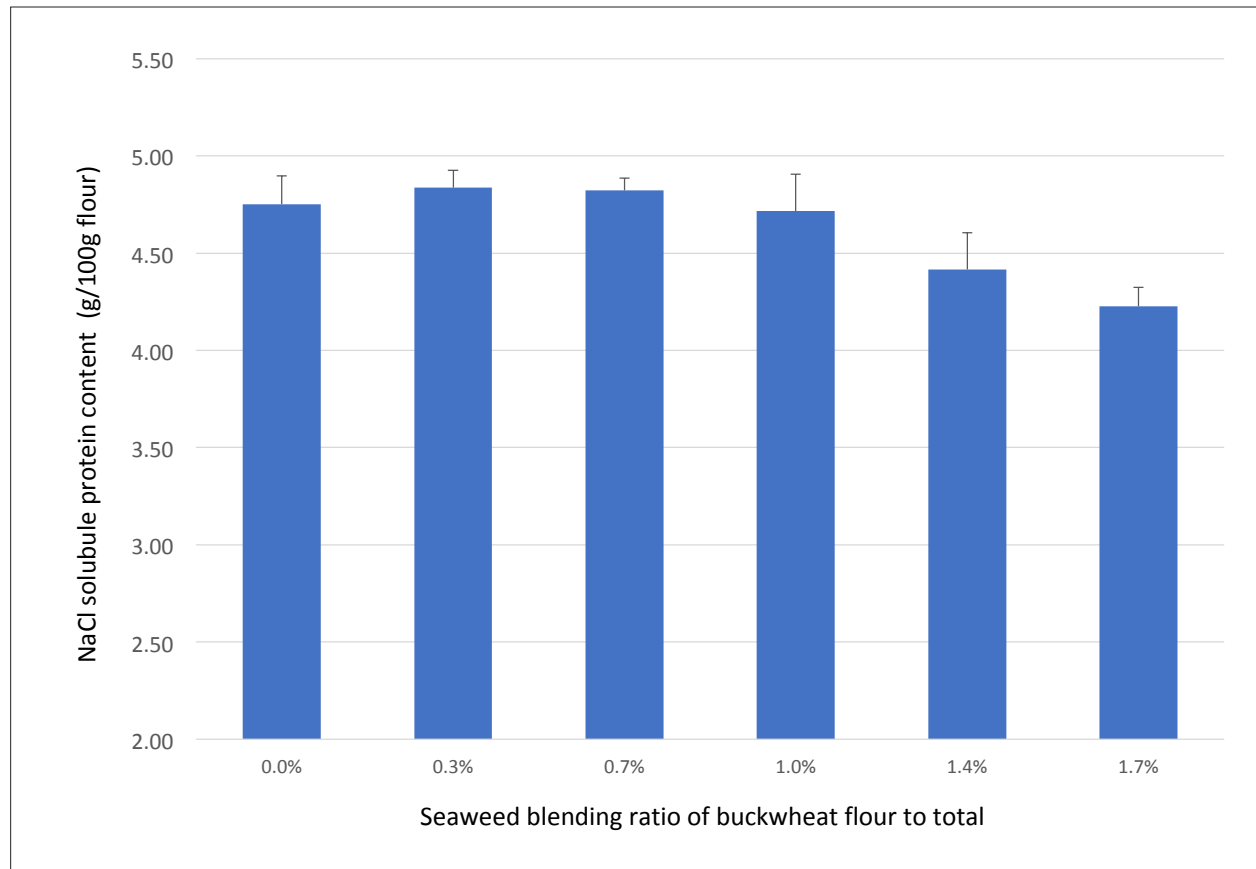


Fig. 3. NaCl-soluble protein content of buckwheat noodles made with seaweed. Vertical bars in the figure show the standard deviations.

into buckwheat dough was found to reduce the solubility of the AG fraction in buckwheat dough as the *funori* seaweed added increased (Fig. 3). The seaweed contains dietary fiber at high levels (Ooishi, 1993). Judged from our previous findings (Ikeda and Kusano 1983), this phenomenon may be due to in-solubilization of proteins arisen by dietary fiber in seaweed. Interest in the nutritional function of dietary fiber for humans is currently increasing. Dietary fiber has many beneficial effects on human such as blood glucose increase suppression and antihypertensive (Mori and Tsuji, 1997). Considering in view of current nutritional science concerning the beneficial effects of dietary fiber, the intake of buckwheat noodles with seaweed with high level of dietary fiber, should be recommended as a key source of dietary fiber.

Relationships of the observed breaking characteristics (Fig. 2) to the protein components (Fig. 3) was analyzed. The AG fraction content (Fig. 3) negatively correlated to their observed breaking stress (Fig. 2 (A)) with

$r = -0.934$ ($P < 0.01$), breaking energy (Fig. 2 (B)) with $r = -0.942$ ($P < 0.01$). These findings suggest that proteins in the AG fraction may be an important factor involved in the observed changes in mechanical characteristics arisen by the addition of *funori* seaweed.

Finally, the present study shows changes in mechanical characteristics of buckwheat noodles made with seaweed. The present study suggests that changes in the protein of AG fraction in buckwheat noodles with seaweed may be an important factor affecting the mechanical characteristics of buckwheat noodles, although the exact mechanism remains uncertain. The present findings provide a scientific basis in the understanding of palatability and acceptability of buckwheat noodles.

ACKNOWLEDGMENT

This work was supported by the Research Institute for Food and Agriculture of Ryukoku University, Japan.

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IZVLEČEK

Mehanska karakterizacija ajdovih rezancev z dodatkom morskih alg *funori*.

Namen raziskave je bil ugotoviti kako vpliva dodatek morskih alg *funori* (*Gloiopeltis tenax* (Turner) J. Agardh) na mehanske lastnosti ajdovih rezancev. Ugotovljeno je, da dodatek alg poveča občutljivost na lomljenje in energijo. Dodatek alg *funori* pospeši zmanjšanje topnosti albuminske in globulinske frakcije beljakovin. Rezultati raziskave kažejo, da so proteini testenin pomemben dejavnik, ki vpliva na mehanske lastnosti rezancev z dodatkom alg.