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Contemporary Traditional Vegetables in Japan: Physiological Function of Buckwheat Sprouts

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Abstract

Sprouted buckwheat (germinated buckwheat seeds) has been traditionally used in the Tsugaru region of Japan. It has been consumed in the Aomori Prefecture, Tsugaru area, for over 350 years. As these buckwheat sprouts are technically the shoots of the plant, they offer several beneficial nutrients. Phytochemicals (metabolic products of plants), such as amino acids and polyphenols, are known to increase markedly upon seed germination. In recent years, attention to the worldwide slow-food orientation and low-glycemic index foods (low-GI foods) has increased. Phytochemicals such as rutin and quercetin, which are abundant in vegetables of the area are attracting attention; thus, studies on the effects of these compounds are increasing. The increase in phytochemical and antioxidant power during germination has turned buckwheat sprouts into a possible functional food, which can allegedly be proclaimed a new vegetable of high commercial value. Here, we discuss traditional vegetables and the phytochemicals present in them and elaborate on the results of our recent study.

Keywords: Buckwheat sprouts; Phytochemicals; Total antioxidant capacity; Obesity

Introduction

Buckwheat (*Fagopyrum esculentum*) is an annual grass belonging to the Tadaceaceae family, which is cultivated in inland Asia, various parts of Europe, mountains in southern Europe, and the Americas [1]. The history of its cultivation in Japan is long. Buckwheat seeds and pollen have been found in 17 Jomon ruins, suggesting that it has been cultivated and consumed in Japan as far back as 900 BC [2]. The use of buckwheat powder for cooking is also known worldwide, for example, as French garret (buckwheat flour crepe), Italian pizzokeri (buckwheat pasta), Nepalese roty (thin buckwheat flour) and Russian brineu (buckwheat flour pancake). Soba (buckwheat noodles prepared from buckwheat flour) was commonly consumed around the Edo period in Japan, and they are often used as a motif in ukiyo-e (Figure 1A and B). In recent years, attention to the worldwide slow-food orientation and low-Glycemic index foods (low-GI foods) has increased, whereby phytochemicals, such as rutin and quercetin contained in vegetables of the area, are attracting attention, and researchers in charge of biological studies on the effects of these compounds are actively working in this area [3-5]. Sprout vegetables that germinate, such as this nutrient-rich buckwheat species, are abundant in worldwide. Among Japanese traditional vegetables, buckwheat sprouts are grown using hot spring-heat and have been consumed for over 350 years in the Tsugaru District, in Aomori Prefecture, in the north of Japan (Figure 2). In the old days, they were cultivated to compensate for vegetable shortages during the winter and, by and large, they were produced/consumed locally. In recent years, however, buckwheat sprouts are attracting attention as old and new vegetables due to the growing interest in health foods and cities developing activities that promote the use of local agricultural products (slow-food movement) [6].

Sprout vegetables, such as buckwheat sprouts, have the greatest advantage of being shoots. It is said that phytochemicals (metabolic products of plants) such as amino acids and polyphenols are increase markedly upon germination [7]. It is a well-known fact that vegetables and fruits have beneficial effects on human health; additionally, vegetables and fruits, which are rich in vitamins and minerals, are recognized as healthy foods [8-10]. In recent years, any such phytochemical, besides vitamins and minerals, is regarded as an essential nutrient, and abundant ingestion is mainly recommended for the prevention of cancer [11]. In the next section, we describe the phytochemicals and the biological/physiological activities contained in buckwheat seeds and buckwheat sprouts.

Phytochemicals in Buckwheat Seeds and Buckwheat Sprouts (Physiological Action of Flavonoids)

Buckwheat seeds contain large amounts of two important phytochemicals (flavonoids with a flavan skeleton) called rutin and quercetin, which exhibit high antioxidant power, as well as anthocyanins [12]. The total phenol content contained in buckwheat species ranks as follows among other grain foods: buckwheat>quinoa>wheat>amaranth. It has been shown that the antioxidant power of buckwheat extracts, measured by radical 2,2-diphenyl-1-psylhydrazyl scavenging and ferric ion reducing ability using the antioxidant measurement method, is also higher than that of quinoa, wheat, or amaranth [13]. Buckwheat sprouts also contain chlorogenic acid, catechin, isoridine, orientin, vitexin, quercitrin, and rutin, as well as quercetin in the soba palm form, which are beneficial to health [14,15].

Sprout vegetables (broccoli, buckwheat, mustard, chinese water spinach, okura, green peas, mung bean) were obtained from neighboring supermarkets and their phytochemical content was determined by using the OxiSelect Total Antioxidant Capacity (TAC) Assay Kit (CELL BIOLABS, INC., USA). Comparing total antioxidant capacity (TAC) of buckwheat sprouts and broccoli sprouts containing large amounts of sulfurafan that known to exhibit high oxidizing power, showed similar TAC (Figure 3). In addition, buckwheat sprout showed 7.4 times higher TAC than green mung sprouts (Table 1). We found that TAC of buckwheat sprouts ranked very high among sprout vegetables.

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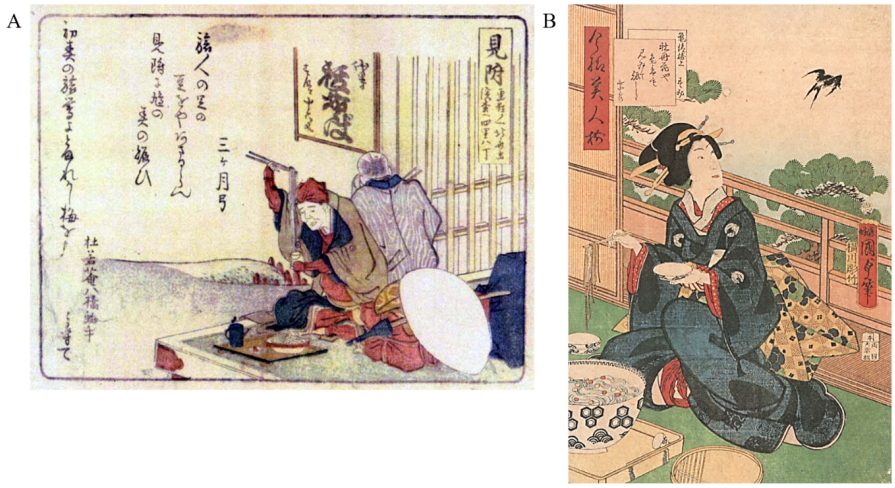

Figure 1: The ukiyoe picture of the person who eats soba. (A) Tokaido Gojyusantugi Mitukinoyado (Hokusai Katsusika), (B) Imayo bijin soro (Kunisada Utagawa).

Figure 2: Japanese buckwheat sprouts grown at Asunariro Riken Co., Ltd.

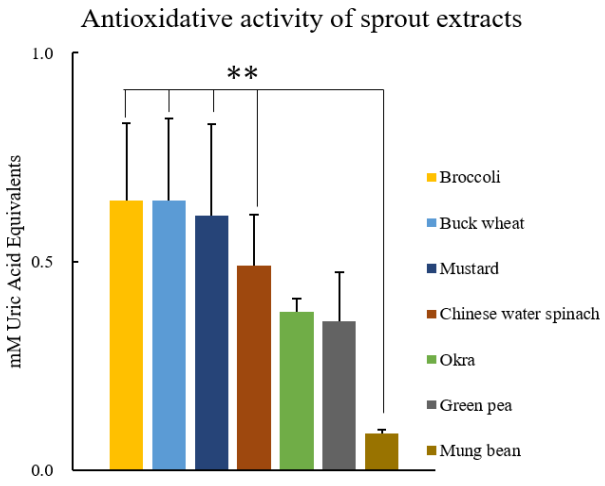

Figure 3: TAC comparison of sprout vegetables purchased at supermarkets; 30 g of sprout vegetables were ground with a hood mixer and filtered with a sterilized gauze to obtain a sprout filtrate. The filtrate was centrifuged at 8,500 × g for 10 minutes to remove contaminants from the plant and the supernatant sprout extract was used for measurement (n = 6). The asterisks indicate a significant difference (˜p <0.01), when compared with all sprout samples according to the Anova tukey test. All statistical analysis were conducted in Origin Ver. 8.1 (OriginLab, USA).

Flavonoids, similar to antibiotics, anti-tumor drugs, and anti-inflammatory drugs, have been used to counter various diseases such as hypertension, allergy, hyper-cholesterolemia, and other diseases [16-18]. The effects of such flavonoids on health depends on the antioxidant power, which polyphenols tend to possess. In other words, flavonoids exert their effect by trapping free radicals generated from oxygen molecules [19,20]. Flavonoids such as rutin and quercetin contained in buckwheat seeds and buckwheat sprouts are also effective as therapeutic agents against diseases involving free radicals [21].

The occurrence of free radicals is closely related to various lifestyle-related diseases. We examined the health effects of buckwheat sprouts, which targeted obesity. C57BL/6 NJcl female mice, aged 38 to 39 weeks (middle age group), were obtained from Japan CLEA. The animals were provided 10% fat-containing control feed and 60% fat-containing meal, and buckwheat sprout extract was continuously administered to a middle-aged healthy mice group (MH group) and to a middle-aged obesity mice group (MO group) via automated water supply for two weeks. The experimental groups were performed with n=6 in four groups tap water administration MH group, 20% buckwheat sprout extract administration MH group, tap water administration MO group, and 20% buckwheat sprout extract administration MO group. All experiments involving animals were conducted in compliance with the guidelines for the use of laboratory animals of Hirosaki University (experimental animal approval number: G14007).

Obesity is often characterized by increased oxidative stress associated with immune cell infiltration into visceral fat cells and worsening of inflammation. Oxidative stress-related mechanisms and inflammatory signaling are interrelated; furthermore, it leads to the development of insulin resistance and cardiovascular diseases, as well as risk of type 2 diabetes [22,23]. Mice serum TAC of the MH and the MO experimental groups, which continuously ingested 20 % buckwheat sprout extract, was higher than that of the tap water intake group, suggesting a decrease in free radicals *in vivo*. In addition, the increase in antioxidant activity not only in the MO group but also in the MH group is expected to be effective for *in vivo* oxidation and disease prevention due to aging (Figure 4A and B).

Germination and Phytochemicals

During germination, as there is an increase in flavonoid content, antioxidant power also tends to increase [7,12,13]. Increase in flavonoid content along with germination has also been shown to protect the plants not only from bacteria, fungi, and insects but also from environmental stresses such as harmful ultraviolet rays [24-26]. Therefore, as a part of production technology development, research aiming to increase flavonoids and antioxidant activity intentionally in plants is currently an ongoing effort in many places worldwide. It has been recognized that rutin content increases when buckwheat sprouts are cultivated under UV-B irradiation, and that this increase is accompanied by an increase in antioxidant activity [5,27,28]. Moreover, under stress conditions, such as freezing and dryness, rutin glucosidase activity increases and the production of quercetin, a degradation product of rutin, increases as well [29]. Quercetin is known to show strong antioxidant activity like rutin, and buckwheat sprouts subjected to environmental stress are highly functional foods.

Conclusion and Discussion

With phytochemical research gaining momentum around the 1980s, the functionality of sprout vegetables for the enhancement of human health has been solidly established [30]. If one stops by a local supermarket, one can easily find more than 10 varieties of sprout vegetables. The use of sprout vegetables is widespread in modern food culture, and it seems that the functionality of food is a growing popular demand among consumers.

Originally, when researchers began to examine the functionality of sprout vegetables, they focused mainly on anti-cancer action. However, in recent years, research interests have shifted toward lifestyle diseases and allergic diseases, which are on the rise in modern society. Buckwheat has long been noted as a valuable gluten-free source of nutrition. However, buckwheat sprouts have not gained the required recognition at a global scale. Nonetheless, looking at the increase in research on buckwheat sprouts in various countries around the world, it seems that buckwheat sprouts are being proved highly functional for

Types of sprouts	TAC (mM Uric Acid Equivalents)
Broccoli	0.645 ± 0.187
Buck wheat	0.646 ± 0.198
Mustard	0.611 ± 0.218
Chinese water spinach	0.490 ± 0.123
Okra	0.378 ± 0.032
Green pea	0.357 ± 0.118
Mung bean	0.087 ± 0.008

Table 1: The value of TAC in each sample.

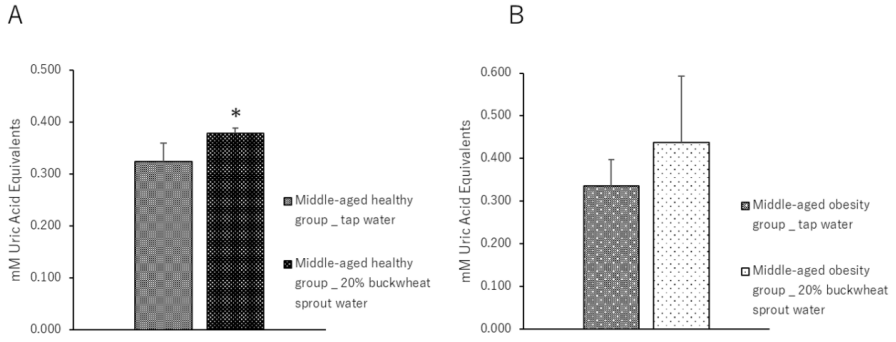

Figure 4: Serum TAC of middle-aged healthy mice and middle-aged obese mice after administration of buckwheat sprout extract. (A) Comparison of middle-aged healthy mice group (Tap water administration group *vs.* 20% Buckweat sprout extract administration group). (B) Comparison of middle-aged obesity mice group(Tap water administration group *vs.* 20% Buckweat sprout extract administration group). The asterisks indicate a significant difference ($^{*}p<0.05$) when compared with the tap-water group according to the *t* test. All statistical analysis were conducted in Origin Ver. 8.1 (OriginLab, USA).

health as well as having high commercial value. Moreover, our findings have shown that not only buckwheat sprouts but also bacteria adhering to buckwheat sprouts have beneficial effects against obesity, owing to their blood-glucose suppression effect [6].

If various functionalities of sprout vegetables are elucidated in the near future, buckwheat sprouts will be regarded familiar vegetables with high functionality around the world.

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