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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

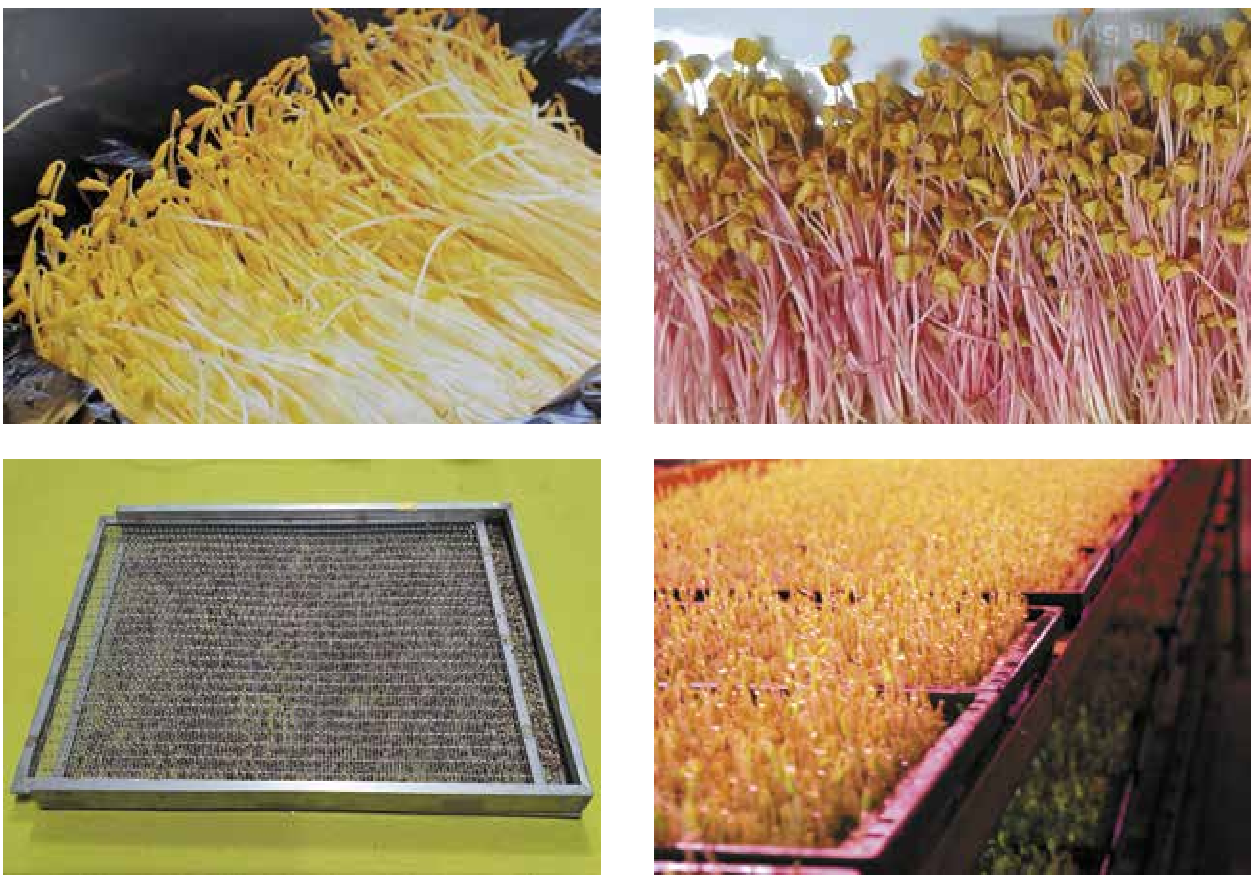

Fig. 1. *Buckwheat sprouts (a:white, b: red), a double layer- steel net for buckwheat sprout production (c), and a mass-production of buckwheat sprouts in a factory (d)*

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.