

# Tartary Buckwheat, *Fagopyrum tataricum* (Linn) Gaertn: A Functional Food Ingredient from Eastern Asia

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## ABSTRACT

Tartary buckwheat is widely grown and utilized in western China. In some Asian countries, dietary intake of tartary buckwheat foods is considered to be highly beneficial to human health. Many nutraceutical compounds in tartary buckwheat have been found to play critical roles in its health benefits. This review summarizes findings of recent studies in East Asia on protein, flavonoids, inositol, and inhibition of bitter taste and rutin loss in tartary buckwheat.

**Keywords:** bioactive protein, flavonoid, inositol, rutin, rutin-degrading enzyme

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## INTRODUCTION

Tartary buckwheat (*Fagopyrum tataricum*) is an edible plant in the genus *Fagopyrum* of the family *Polygonaceae*. It originated in eastern Tibet or northwestern Yunnan Province in China and is cultivated in a number of countries in Asia, Europe, and North America (Tsuji and Ohnishi 2001). Compared with its congener, common buckwheat, tartary buckwheat has a more bitter taste and higher rutin content.

Tartary buckwheat, until recently a largely forgotten crop, is attracting increasing interest from food technologists and consumers for its significant antihyperglycemic, antihyperlipidemic, and antihypertensive functions. Renewed interest in tartary buckwheat has led to new findings on its nutritional values and medical roles.

## PROTEINS

Protein, which constitutes about 10% of the volume of tartary buckwheat grains, is the second main contributor to the grain's composition, after starch. Tartary buckwheat protein has high lysine content of approximately 6 mg/100 g of protein and is composed of 43.8% albumin, 14.6% glutelin, 10.5% prolamin, and 7.82% globulin (Guo and Yao 2006).

Alkali extraction followed by isoelectric precipitation has typically been used to prepare tartary buckwheat protein for physiological function examination. Chromatography has also been employed to purify single fractions from tartary buckwheat protein. **Table 1** presents some new findings on the bioactive activity of tartary buckwheat protein.

Tomotake *et al.* (2006, 2007) found that although the apparent protein digestibility of tartary buckwheat was 10% lower than that of casein in animal models, tartary buckwheat protein showed strong activities against hypercholes-

**Table 1** Some bioactive proteins isolated from tartary buckwheat grains.

Name	Preparation	MW (kDa)	Biological activities	References
TBPC or TBP	alkali extraction followed by isoelectric precipitation	24–25	anti-fatigue, anti-aging, anti-hypercholesterolemia, gallstone-formation inhibition	Zhang <i>et al.</i> 1999, 2005; Tomotake <i>et al.</i> 2007
TBWSP31	ammonium sulfate precipitation followed by ion-exchange and gel filtration chromatography	57	mammary cancer cell Bcap37-proliferation inhibition	Guo <i>et al.</i> 2007
TBTI	ammonium sulfate precipitation followed by ion-exchange and affinity chromatography	12–15	trypsin activity inhibition, leukemia HL-60 cell-proliferation inhibition	Wang <i>et al.</i> 2002
DTPF	pepsin hydrolysis followed by chymotrypsin and trypsin hydrolysis	<1	anti-hypertensive	Li <i>et al.</i> 2002
TBa, TBb, TBt	salt extraction followed by gel filtration chromatography ion-exchange chromatography	24, 34, 56	allergic reaction	Wang <i>et al.</i> 2004

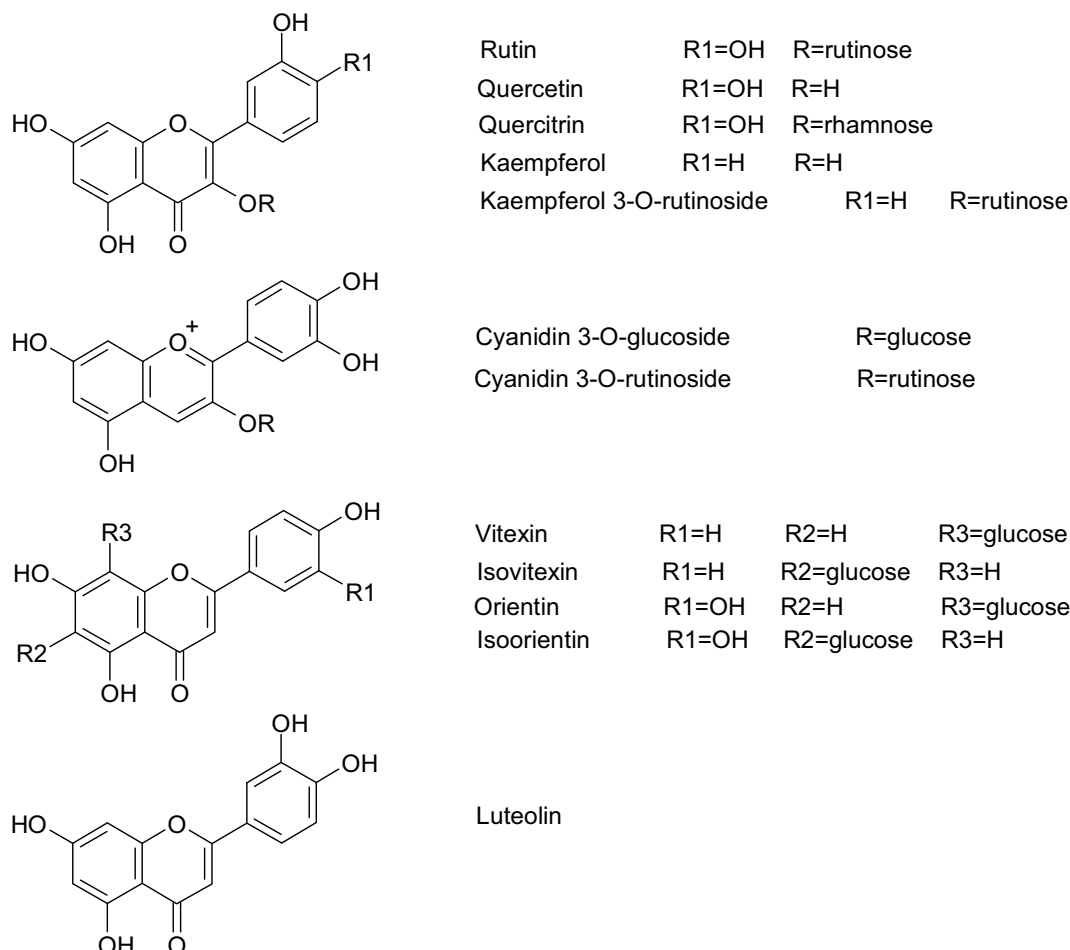


Fig. 1 Some of the flavonoids in tartary buckwheat.

terolemia, obesity, and gallstone formation by enhancing excretion of fecal neutral sterols and bile acids. Tartary buckwheat protein was recommended as an alternative dietary supplement for reducing cholesterol, which is closely linked with conditions such as cardiovascular disease.

In other experiments, mice fed tartary buckwheat protein were found to have reduced concentrations of brain serotonin and increased superoxide dismutase activities. Anti-fatigue (Zhang *et al.* 2005) and anti-aging (Zhang *et al.* 1999) functions were also confirmed.

Tartary buckwheat protein may also have potential anticancer and anti-hypertension effects. Guo *et al.* (2007) and Wang *et al.* (2002) purified two antitumor proteins, 57 kDa TBWSP31 and 12-13kDa TBTI, from tartary buckwheat grains by ammonium sulfate precipitation and chromatography, respectively. These proteins clearly inhibited the proliferation of human breast cancer cells (Bcap37) and human acute myelogenous leukemia cells (HL-60) in a dose-dependent and time-dependent manner, with low cytotoxicity on normal human peripheral blood mononuclear cells.

Li *et al.* (2002) identified the di-/tri-peptide fraction (DTPF) with angiotensin I-converting enzyme (ACE) inhibitory activity in tartary buckwheat protein digested together with pepsin, chymotrypsin, and trypsin. A single oral administration of protein digest lowered the systolic blood pressure of spontaneously hypertensive rats. Tartary buckwheat proteins were considered to be a potential resource for producing ACE inhibitory peptides during the human digestion process.

The consumption of tartary buckwheat also led to allergic reactions, such as asthma and atopic disorders (Wieslander *et al.* 2000). Three allergic proteins, TBa, TBb, and TBt, were identified and characterized in tartary buckwheat (Wang *et al.* 2004), and the 24 kDa TBa was successfully overexpressed with *Escherichia coli* (Wang *et al.* 2006).

## FLAVONOIDS

Flavonoids are polyphenolic compounds that occur ubiquitously in plants. Tartary buckwheat seeds contain up to 100 times the concentration of rutin found in common buckwheat seeds (0.8–1.7% vs. 0.01% dry weight). Tartary buckwheat has been recommended as a source of dietary rutin (Fabjan *et al.* 2003).

In addition to rutin, other flavones including quercetin 3-glucosylrhamnosylglucoside, kaempferol 3-rutinoside, quercitrin, and quercetin were also identified in the hull, testa, embryo, and endosperm of tartary buckwheat grains by high-performance liquid chromatography (HPLC) photodiode array detector (PDA)-tandem mass spectrometry (MS) (Li 2001). The testa had the greatest concentration of flavonoids (67.9947 mg/g) among all parts of tartary buckwheat seed. Of edible parts, the embryo amassed the largest flavonoid concentration (30.0919 mg/g). Rutin was the predominant flavonoid in all parts of tartary buckwheat seed.

Tian (2008) isolated and purified luteolin from tartary buckwheat seed. Watanabe and Shimizu (2004) recently found C-glycosylflavones such as orientin, isoorientin, vitexin, and isovitexin in 3-day-old tartary buckwheat sprouts. Kim *et al.* (2007) identified two anthocyanins (cyanidin 3-O-glucoside and cyanidin 3-O-rutinoside) in tartary buckwheat sprouts using HPLC-MS techniques. These flavonoids (Fig. 1), as natural antioxidants, are presumed to be involved in many of the health benefits of tartary buckwheat. They were found to possess special medicinal properties, such as anti-hypercholesterolemia (Qi 2003) and anti-hyperglycemia (Qi *et al.* 2003) effects at nontoxic concentrations in humans. Tartary buckwheat flavonoids also had protective effects on cerebral ischemia reperfusion injury in rats (Huang *et al.* 2006) and may potentially have an anti-cancer role (Ren *et al.* 2001). These flavonoids were

shown to inhibit the growth of human acute myelogenous leukemia HL-60 cells (Ren *et al.* 2003).

## RUTIN AND RUTIN-DEGRADING ENZYMES

Although tartary buckwheat, with its high rutin content, has been promoted as a healthy food, its consumption is not widespread. One of the major reasons is its strong, bitter taste, which may be derived from quercetin. Free quercetin is only present at 0.01–0.05% in tartary buckwheat seeds. However, the rutin-degrading enzymes RDE (Yasuda *et al.* 1992) and F3G (Suzuki *et al.* 2004) that occur in seeds can convert rutin into quercetin immediately after the addition of water to tartary buckwheat flour during dough making; this has been considered the mechanism of bitter taste production in the manufacture of tartary buckwheat foods.

However, after whole tartary buckwheat grains were soaked in water at room temperature for 8 hr, the embryo flour contained less than 0.2% quercetin, suggesting that rutin and rutin-degrading enzymes are present in different regions of tartary buckwheat seeds (Li *et al.* 2008). Suzuki *et al.* (2002, 2004) also showed that the major proportion of the rutin was found in the embryo of tartary buckwheat seeds, whereas almost all F3G activity was detected in the testa. These experiments provided further evidence that rutin in the embryos of whole seeds is not affected by a rutin-degrading enzyme in the testa and is only available to the enzyme when the seeds are turned into flour.

Li *et al.* (2008) found that the bitter taste of tartary buckwheat could be inhibited by moist heat or extrusion pretreatment. Steaming (120 sec) or boiling buckwheat grains (90 sec) or extruding the flour (180 rpm/min at 140°C) resulted in the retention of >85% of the original rutin and eliminated the bitter taste in the hydrated flours. In contrast, dry heating at 140°C for 9 min or microwaving at 2450 MHz for 3 min did not reduce the rutin loss, and the bitter taste remained.

## D-CHIRO-INOSITOL

D-*chiro*-inositol is known to be an important secondary messenger in insulin signal transduction. Administration of D-*chiro*-inositol has been shown to accelerate glucose disposal and sensitize insulin action, and also to be helpful in relieving diabetes and polycystic ovary syndrome.

Horbowicz *et al.* (1998) first reported that fagopyritols, mono-, di-, and trigalactosyl derivatives of D-*chiro*-inositol, occurred in maturing common buckwheat seeds. They quantified the fagopyritol A and B series by GC-MS after trimethylsilylation. Xu *et al.* (2003) identified the D-*chiro*-inositol and fagopyritol B1 (Fig. 2) of tartary buckwheat by GC-MS and nuclear magnetic resonance (NMR) methods. They found that bran contained more D-*chiro*-inositol than did other parts of seeds. Yang and Ren (2008a, 2008b),

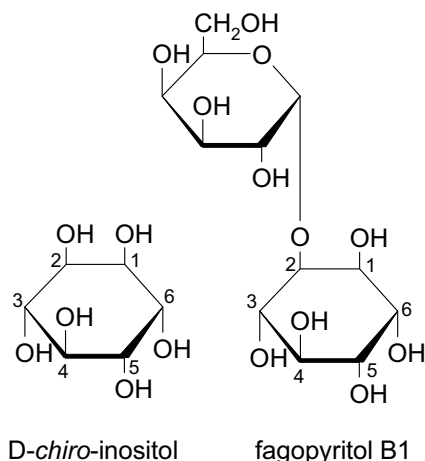


Fig. 2 Inositols in tartary buckwheat.

using HPLC or near-infrared reflectance spectroscopy after trifluoroacetic acid hydrolysis, determined the D-*chiro*-inositol content of tartary buckwheat seeds and related products to be in the range of 0.099–0.387%. Oral administration of D-*chiro*-inositol-enriched tartary buckwheat bran extract lowered plasma glucose, C-peptide, glucagon, triglyceride, and blood urea nitrogen, improve glucose tolerance, and enhance insulin immunoreactivity in KK-A(y) mice (Yao *et al.* 2008).

## OTHER BIOACTIVE COMPONENTS

$\gamma$ -Aminobutyric acid and 2''-hydroxynicotianamine, helpful in reducing blood pressure in humans, were recently also detected in the leaves of tartary buckwheat at 2–6 weeks after sowing (Suzuki *et al.* 2009). The abovementioned bioactive components give tartary buckwheat many beneficial health effects. Tartary buckwheat is now being used as a functional ingredient in many foods.

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