

Review Article

Adzuki Beans- Physical and Nutritional Characteristics of Beans and Its Health Benefits

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ABSTRACT

Adzuki (*Vigna angularis*) has been grown and consumed by humans for centuries in various parts of the world like China. However, adzuki's global use for human consumption has been restrained partly due to limited knowledge about its nutrient composition and the processing challenges faced in making adzuki-based food products. Over the past decade, the recognition that *Vigna angularis* is gluten-free has raised global interest. Consequently, literature on the nutritional composition, processing quality, and health benefits of adzuki has grown considerably. The existing literature suggests that adzuki is composed of complex carbohydrates with slowly digestible starch. Adzuki has similar protein content to other more common cereals like wheat, but is relatively richer than other cereals in the essential amino acid lysine. Adzuki is also a good source of essential fatty acids, fiber, minerals (especially calcium and iron), and phytochemicals such as polyphenols and phytates. Existing studies of the nutrition and health benefits of adzuki are limited since they fail to take into account differences in adzuki varieties and growing conditions. Nevertheless, the studies undertaken so far confirm adzuki's excellent nutrient profile and suggest it has considerable potential globally to be a functional food for health promotion and disease prevention.

Key words: China, polyphenols, amino acids, functional, digestible.

INTRODUCTION

Human genetic potential is maximized by the nutritional well being which is also the driving force for development also. Thus to maintain human health and physical well being, nutritional quality of food is most important parameter. (Radika et al, 2011). The problem of deep rooted malnutrition can be cured and overall human health can be maximized by taking into consideration the dietary quality of food. To maintain the equilibrium with increasing yields and household techniques, diversification of food production must be encouraged both at national and household level (Singh & Raghuvanshi, 2012). Unawareness of people is to the extent that they are not using few agricultural foods as

main food despite of their high nutritional quality. Beans are also one of such things that have many nutritious and medical properties but underestimated (Yang et al, 2012). Dried beans may supply to some of the health enhancing nutrients associated with plant based diets. Beans are important source of protein and are rich in number of micronutrients, including potassium, magnesium, folate, iron and zinc. Vegetarians have important role of dried beans in their diets because it contributes to some of the health benefits (Haddad and Tanzman, 2003).

Adzuki bean (*Vigna angularis*) is grown in more than 30 countries of the world which is an important legume crop. Starch, digestible protein, mineral elements,

and vitamins are abundantly present in adzuki beans. Adzuki bean (*Vigna angularis*) was majorly grown in East Asia (Kramer et al, 2012) and domesticated in China ~12,000 year ago (Liu et al, 2013). Several cultivators of *Vigna angularis* can be referred as adzuki, azuki and small red beans (Gohara et al, 2016). Adzuki beans are available in many varieties around the world depending on grain size and color, harvest time, climate and region where it is cultivated. In Asiatic countries, variety of foods can be prepared by millions of people using adzuki beans (e.g., paste in pastries, desserts, cake, porridge, adzuki rice, jelly, adzuki milk, ice cream) (Lestari, 2014). Many traditional Japanese confections such as amanatto, manju and youkan can also be prepared using this bean. It is believed in China that various medical ailments like diuretic functions, and other disease such as dropsy and beri beri can be treated using it (Yoshida et al, 2009).

In this review, nutrient composition, physical and chemical characteristics of adzuki are described. Recent research advances to solve these challenges are discussed. Finally, the potential health benefits that could be associated with higher consumption of adzuki are highlighted.

Physical characteristics

There are at least 60 varieties of adzuki bean are present on the basis of their seed size ranging from 5 to 8 mm in length and 3 to 5 mm in width. These may be divided into two main categories:

- Small size- They are the regular seeds which have dimension of >4.2 to <4.8 mm in length. It is called Erimo type. Ann is mainly processed by this type of bean, which can be eaten as a sweet and is used as a filler for sweet buns and pastries, spread on cooked rice cakes, or set with agar agar to form jellies.
- Large size is also known as Dainagon which is >4.8 mm in length. It is used whole fundamentally in several traditional confectioneries and sweet soups. They are

available at costlier price than the Erimo (Yousif et al, 2007).

Existence of grooves, pits, or fissures make it irregular in shape, the usual shape is oval or spherical. There are deep fissures present in adzuki beans which can be observed under polarised light. They are caused by the way the granules are placed within the protein matrix and this also acts as a characteristic of adzuki starch granules. The adzuki beans are available in different colors starting from red to brown, black and green, and different combinations of these colours. The red-purple colour is most preferred in Japan, which is called “adzuki” after the name of the bean. The quality of adzuki beans may be determined by the shade, uniformity and degree of lightness of color.

Nutritional composition

The cereals have wide number of chemical composition that depends on the environmental conditions like variety of soil, fertilizer used etc. The importance of adzuki beans is not only due to its attractive nutritional profile but also because it has no gluten that is found in other common cereals such as wheat, barley and rye. As more and more patients are diagnosed with gluten intolerance and celiac disease, the demand for gluten-free foods is also growing.

Carbohydrate

The major source of energy for human body is carbohydrate and it plays an essential role in metabolism and in the process of homeostasis. Carbohydrates can be classified into sugars, oligosaccharides, starch (amylose, amylopectin), and non-starch polysaccharides on the basis of its molecular size and degree of polymerization. The amylose and resistant starch contribute 11.08–26.19% and 19.92–26.90% of total starch, respectively. The highest resistant starch content was found in variety Jingnong 6. Resistant starch has its importance because of the characteristic feature of its non-digestibility in the small intestine. It is generally recognized as the main components in cereals that could

improve gut microbiota composition due to its fermentation in the gut (Nielsen et al, 2015).

Protein

The major proteins of the adzuki bean are water-soluble rather than salt-soluble unlike most of the legume proteins. This unique quality of high solubility of adzuki bean attracts food industry to put adzuki beans at favorable position keeping in mind its possible application. In a whole bean, the total extractable proteins, albumin and globulins of the adzuki bean constituted 21.6, 15.8 and 2.3%, respectively. A trypsin inhibitor with a molecular weight of 13 kDa from adzuki bean was isolated by heating at 70°C for 10 min and ammonium sulfate precipitation (Wati *et al.*, 2010).

Table 1: Amino acid composition of adzuki beans

Amino Acid	WHO/FAO amino acid scoring pattern	Adzuki bean
Cystine	4.0	2.02
Aspartic acid	4.0	11.33
Threonine	4.0	3.74
Serline	4.0	4.53
Glutamic acid	4.0	17.70
Proline	4.0	5.51
Glycine	4.0	3.74
Alanins	4.0	4.10

Valine	5.0	5.63
Methionine	5.0	1.70
Isoleucine	4.0	5.02
Leucine	7.0	0.70
Tryrosine	7.0	3.31
Phenylalanine	6.0	6.31
Histidine	6.0	3.55
Lysine	5.5	8.45
Ammonia	5.5	1.71
Arginine	5.5	7.78
Trptophan	1.0	-

Fat

Adzuki bean seed is an important source of protein, starch, mineral elements, and vitamins. Adzuki bean is referred to as the “weight loss bean” because of its low calorie and fat content, digestible protein and ample bioactive compounds (Kitano-Okada, 2012).

The principal profiles in adzuki beans are unsaturated FA, especially linoleic (18:2n-6) acid and saturated FA, especially palmitic acid (16:0) and stearic (18:0) acids. AgNO₃-TLC and GC were applied to analyze fatty acid distributions and

molecular species of triacylglycerols. The lipids were mainly made up of phospholipids (74.3%), triacylglycerols (13.5%), hydrocarbons (4.6%) and sterol esters (4.0%). The lipids of adzuki beans from five cultivators comprised mainly phospholipids (72.2-73.4 wt-%) and triacylglycerols (20.6-21.9-%) (Yoshida et al, 2010)

Minerals

Adzuki beans have higher content in phosphorus, potassium, calcium and magnesium content in comparison to other beans.

Minerals	ppm DB
Phosphorus	4787
Potassium	12915
Calcium	705
Magnesium	1530
Aluminum	11
Iron	60
Manganese	14
Zinc	35
Copper	11
Boron	13
Nickel	2

Antioxidants

The total antioxidant activity of adzuki bean extract was the highest among seven beans (faba bean, broad bean, adzuki bean, red bean, pea, red lentil, and green lentil). The adzuki bean extract was declared as potential antioxidant after it was evaluated for antioxidant effectiveness in cured and uncured pork sausages supplied by Cosmo Foods Co., Lts, Tokyo (Jayawardana *et al.*, 2011). The pulse crop of the subgenus *Ceratotropis* is mainly produced and consumed in Asia. The adzuki bean is also one of the suck kind (Shi et al. 2017). Black variety of adzuki bean showed superoxide anion radical scavenging capacity of 56.1%, while red adzuki bean showed 40%. Red adzuki bean showed significantly higher ferrous ion chelating activity than black adzuki bean (Sreerama *et al.*, 2012).

Adzuki beans can have several seed coat colors, including red, black, speckled purple, brown, green, and white Beans with a black seed coat contains the most varied

types of phenolic acids (Gallic acid, protocatechuic acid, gentisic acid, chlorogenic acid, (+)-catechin, caffeic acid, phloretic acid, \bar{n} -coumaric acid, ferulic acid, veratric acid, hesperidin, and biochanin) while with a yellow-white seed coat showed limited phenolic acids composition (Gallic acid and (+)-catechin) However, another yellow-white cultivar, contained the highest flavonoid and phenolic acid contents compared to the other cultivars. Therefore, seeds coat can affect the phenolic content in seeds but is not the only and very significant factor to determine the phenolic content (Hori *et al.*, 2006). Thus, presence of phenolic and flavonoid contents positively contributes to antioxidant activity (Mahatma *et al.*, 2016). A polyphenolic compound, Catechin is widely found in plants. We found that (+)-catechin was the major phenolic acid in adzuki beans. Catechin is a major contributor to antioxidant properties in biological systems (Lu *et al.*, 2011). Catechin effectively scavenges reactive oxygen and nitrogen species, including singlet oxygen, superoxide, peroxy nitrite, peroxy radicals, and hypochlorous acid (Frei and Higdon, 2003). Moreover, total phenolic content and total flavonoid content were highly correlated with the antioxidant capacity (Yao *et al.*, 2012).

Health benefits

1. Act as a medicine: Adzuki bean is a traditional medicine that has been used as a diuretic and antidote, and to alleviate symptoms of dropsy and beriberi in China.
2. Anti microbial activity: there was a study conducted in which the antimicrobial activity of these beans are found. Extracts of four types of colored adzuki were prepared using distilled water that were, green, black, red and white adzuki beans. Antibacterial activity was evaluated using eight bacterial species. Extract from white adzuki bean inhibited the growth of all eight bacterial species. Extract from black adzuki bean inhibited the growth of *Bacillus subtilis*, *Enterococcus faecalis*, *Escherichia coli* and *Pseudomonas aeruginosa*. Extract from red adzuki bean inhibited the growth of *E. coli*, *P. aeruginosa* and *Salmonella choleraesuis*. Extract from green adzuki bean inhibited the growth of *E. faecalis*, *E. coli* and *P. aeruginosa*. The authors highlighted that antibacterial activity in adzuki beans might be present due to the polyphenols associated with the colour of bean (Liu R and Xu B, 2016).
3. Anti-allergic: Itoh *et al.* (2012) fractionated the hot water extract of adzuki bean to 4 fractions by column chromatography of Diaion HP-20. 40% ethanol elute extract had the strongest inhibition on antigen-stimulated degranulation in rat basophilic leukemia RBL-2H3 cells. The passive cutaneous anaphylaxis reaction was suppressed by total water extract of adzuki bean and 40% ethanol elute extract. So adzuki bean was good for alleviating type allergic symptoms.
4. Anti-inflammatory: Methanol extract of adzuki bean showed the inhibitory activity on the progress of atopic dermatitis- like skin lesions in NC/Nga mice induced by 1-chloro-2,4 -dinitrobenzene (Collantes *et al.*, 2012). Methanol extract of adzuki bean showed to lessen the eosinophil ratio in peripheral leucocytes, significant reduction in the numbers of mast cells in the skin, and relative mRNA expression of inflammatory cytokines in the spleen.
5. Anti-diabetic: Glycosidase is a key enzyme involved in intestinal glucose absorption. Inhibition of alpha-glycosidase may be a way to help reduce glucose absorption and contribute to anti-diabetes. Alpha-Glycosidase inhibition activity of extracts and compounds obtained from adzuki bean were evaluated *in vitro* (Yao *et al.*, 2011a). Ethanol extract of adzuki bean exhibited the highest alpha-glycosidase inhibition activity, and the inhibitory rate was 64.33%. All ethanol extracts of

adzuki beans with altitudinal variation exhibited inhibitory effects on α -glycosidase activity and the inhibitory rates ranged from 15.04% to 62.57% (Yao *et al.* 2011b). The results showed that extract of adzuki bean (black) had the stronger effects on inhibiting α -glycosidase activity.

6. Blood pressure adjusting effect: Mukai and Sato (2009) reported that 80% ethanol extract of adzuki bean attenuated the elevation of blood pressure of spontaneously hypertensive rats. It is consistent with a previous article which reported that adzuki bean extract suppressed the elevation of blood pressure in hypertensive rats (Sato *et al.*, 2008). The mechanism of lowering blood pressure might be due to the increase of nitric oxide production and the decrease of the expressions of endothelial nitric oxide synthase and inducible nitric oxide synthase in the aorta and kidney of hypertensive rats (Mukai and Sato, 2009). Adzuki bean (*Vigna angularis*) seed coats containing polyphenol attenuated the vascular oxidative stress and the inflammation during the progression of hypertension in spontaneously hypertensive rats (Mukai and Sato, 2011).
7. Anti- hyperlipidemic effect: Wu *et al.* (2011) reported that ethanol extract from adzuki bean decreased blood lipid parameters, especially blood triglyceride level of the Kunming male and female mice fed with a high-fat diet, and the effect was greater in female mice than in the male mice. (Kitano-Okada, 2012) reported that adzuki bean extract from Cosmo Foods inhibited liver lipid accumulation and increased lipid metabolism like faecal weight and faecal lipid excretion in rats with high-fat diet. The similar trend also existed in rats fed with normal diet. Adzuki bean extract helped in showcasing better human lipid metabolism by reducing triglyceride level and suppressed glycerol phosphate

dehydrogenase activity in human pre-adipocytes.

8. Anti-obesity: Phenolic extract of adzuki bean increased the concentration of oleic acid release through lipase-catalysed hydrolysis. Adzuki bean juice and concentrated adzuki bean juice also inhibited pancreatic lipase activity 29.2% and 56.9% respectively (Maruyama *et al.*, 2008). In addition, adzuki bean polyphenols significantly decreased body weights in pregnant. This was observed in Wister rats fed who were fed with adzuki bean polyphenolics helps in controlling diet during lactation (Mukai *et al.*, 2013).
9. Anti- cancer activity: Heat-stable extract from adzuki bean exhibited the greatest stimulation of differentiation of bone marrow cells into immature dendritic cells of 13 edible beans (Nakaya *et al.*, 2012). It indicated that, to prevent cancer and immunotherapy, adzuki bean extract was beneficial. Adzuki bean extract increased the level of IL-6 produced by sequential treatment of dendritic cells with lipopolysaccharide. Adzuki bean extract inhibited the growth of human leukemia U937 cells and increased the induction of its apoptosis.

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Conflict Of Interest

There is no conflict of interest between the authors.

REFERENCES

- Collantes TM, Rho MC, Kwon HJ, Jung BG, Alfajaro MM, Kim DS, Kim HJ, Hosmillo M, Park JG, Son KY, Park SI, Kang MI, Park SJ, Lee SW, Lee WS and Cho KO. Adzuki bean (*Vigna angularis*) extract inhibits the development of experimentally induced atopic dermatitis-like skin lesions in NC/Nga mice. Food Chem. 2012;132(3):1269-1275.

- Gohara AK, Pereira de Souza, Gomer STM, Evelazode de Souza N, Visentainer JV, Matsushia M. Nutritional and bioactive compaound of adzuki beans cultivators using chemometric approach. Science and Agrotechnology. 2016;40(1):104-113.
- Hadad EH and Tanzman JS. What do vegetarians in the United states eat? Am J of Clin Nutr. 2003;78(3),6265-6325.
- Higdon JV, Frei B. Tea catechins and polyphenols: Health effects, metabolism and antioxidant functions. J. Nutr..2010: 89-143
- Hori Y, Murakoso T, Fukumura M, Toriizuka K, Ida Y. Constituents and Antioxidative Activity of a Hot-Water Extract of Adzuki (*Vigna angularis*) Beans. Nippon Eiyo Shokuryou Gakkaishi. 2009;62:3-11.
- Itoh T, Hori Y, Atsumi T, Toriizuka K, Nakamura M, Maeyama T, Ando M, Tsukamasa Y, Ida Y and Furuichi Y. Hot water extract of adzuki (*Vigna angularis*) suppresses antigen-stimulated degranulation in rat basophilic leukemia RBL-2H3 cells and passive cutaneous anaphylaxis reaction in mice. Phytother. Res. 2012;26(7): 1003–1011.
- Jayawardana BC, Hirano T, Han KH, Ishii H, Okada T, Shibayama S, Fukushima M, Sekikawa M and Shimada K. Utilization of adzuki bean extract as a natural antioxidant in cured and uncured cooked pork sausages. Meat Sci. 2011;89(2):150–153.
- Kitano-Okada T, Ito A, Koide A, Nakamura Y, Han KH, Shimada K, Sasaki K, Ohba K, Sibayama S, Fukushima M. Anti-obesity role of adzuki bean extract containing polyphenols: in Vivo and in vitro effects. J Sci Food Agric. 2012;92(13):2644–2651
- Kramer C, Soltani S, Robinson D, Swanton CJ. Control of volunteer adzuki bean in soybean. Agri Sci. 2012;3(4):501–509.
- Lestari P, Kang YJ, Han KS, Gwag JG, Moon JK, Kim YH, Lee YH, Lee SH Genome-wide single nucleotide polymorphism discovery and validation in adzuki bean. Mol Breed. 2014;33(2):497–501.
- Liu L, Bestel S, Shi J, Song Y, Chen X (2013) Paleolithic human exploitation of plant foods during the last glacial maximum in North China. Proc Natl Acad Sci USA 110(14): 5380–5385.
- Liu R and Xu B. Bioactive Compositions and Health Promoting Effects of Adzuki Bean. Phytotherapeutics-III. 2016;44:23-43.
- Mahatma MK, Thawait LK, Bishi SK, Khatediya N, Rathakumar AL, Lalwani HB, Misha JB. Nutritional composition and antioxidant activity of spinach and virgina groundnuts (*Arachis hypogaca L.*): a comparative study. J. Nutr. 2016;53(5). 2279-2286.
- Maruyama C, Araki R, Kawamura M, Kondo N, Kigawa M, Kawai Y, Takanami Y, Miyashita K and Shimomitsu T. Adzuki bean juice lowers serum triglyceride concentrations in healthy young women. J. Clin. Biochem. Nutr. 2008; 43(1):19–25.
- Mukai Y and Sato S. Polyphenol-containing adzuki bean (*Vigna angularis*) seed coats attenuate vascular oxidative stress and inflammation in spontaneously hypertensive rats. J. Nutr. Biochem. 2011;22(1): 16–21.
- Mukai Y, Sun Y and Sato S. Adzuki bean polyphenols intake during lactation upregulate AMPK in male rat offspring exposed to fetal malnutrition. Nutrion. 2003;29(1): 291–297.
- Mukai Y. and Sato S. Polyphenol-containing adzuki bean (*Vigna angularis*) extract attenuates blood pressure elevation and modulates nitric oxide synthase and caveolin-1 expressions in rats with hypertension. Nutr. Metab. Cardiovasc. Dis. 2009;19(7): 491–497.
- Nakaya K, Nabata, Y and Ichiyanagi T. An Stimulation of dendritic cell adzuki bean (*Vigna angularis*), a promising immune potentiating food and dietary maturation and induction of apoptosis in leukemia cells by a heat-stable extract from mice. Food Chemistry. 2012;132: 1269–1275.
- Nielsen TS, Theil P, Purup S, Nørskov N, Bach Knudsen KE. Effects of resistant starch and arabinoxylan on parameters related to large intestinal and metabolic health in pigs fed fat rich diets. Journal of Agricultural & Food Chemistry. 2015; 63(48):10418–10430.
- Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P & Sudha A. Dietary Profile of Urban Adult Population in South India in the Context of Chronic Disease Epidemiology (CURES-68). J. Public Health Nut. 2011; 14(4): 591–598.

- Sato S, Mukai Y, Yamate J, Kato J, Kurasaki M, Hatai A and Sagai M. Effect of polyphenol-containing adzuki bean (*Vigna angularis*) extract on blood pressure elevation and macrophage infiltration in the heart and kidney of spontaneously hypertensive rats. Clin. Exp. Pharmacol. Physiol. 2008;35(1): 43–49.
- Shi Z, Yao Y, Zhu Y, Ren G. Nutritional composition and biological activities of 17 Chinese adzuki bean (*Vigna angularis*) varieties. 2015;78-89.
- Singh P & Raghuvanshi RS. Finger Millet for Food and Nutrition Security. African Journal of Food Science. 2012; 6(4): 77-84.
- Sreerama YN, Takahashi Y, Yamaki K. Phenolic antioxidants in some *Vigna* species of legumes and their distinct inhibitory effect on α – glucosidase and pancreatic lipase activities. Journal of food Science. 2012;77(9):C927-C933.
- supplement for cancer prevention. Asian Pac. J. Cancer Prev. 2012;13(2): 607–611.
- Wati RK, Theppakorn T, Benjakul S and Rawdkuen S. Trypsin inhibitor from 3 legume seeds: Fractionation and proteolytic inhibition study. J. Food Sci. 2010;75(3): C223–228.
- Wolter A, Anna-Sophie H, Zannini E, Elke KA. "< I> in Vitro</I> Starch Digestibility and Predicted Glycaemic Indexes of Buckwheat, Oat, Quinoa, Sorghum, Teff and Commercial Gluten-Free Bread. Journal of Cereal Science. 2013;58(3):431-436.
- Wu B, Liu XR, Pu SJ, Zhao B, Wan P and Gao JM. Effect of adzuki beans alcohol extract on decreasing lipid and anti-obesity of the mice fed a high-fat diet. Journal of Chinese Institute of Food Science and Technology. 2011;11(6): 13–19.
- Yang X, Wan Z, Perry L, Lu H, Wang Q, Hao C, Li J, Xie F, Yu J, Cui T, Wang T, Li M, Ge QH. Early Millet Use in Northern China. Proc Nat Acad Sci. 2012;V(NO):1–5.
- Yao Y, Cheng X, Wang L, Wang S and Ren G. A determination of potential α -glucosidase inhibitors from adzuki beans (*Vigna angularis*). Int. J. Mol. Sci. 2011a; 12(10):6445–6451.
- Yao Y, Cheng X, Wang L, Wang S. and Ren G. Biological potential of sixteen legumes in China. Int. J. Mol. Sci. 2011b; 12(10): 7048–7058.
- Yao Y, Cheng X, Wang S, Wang L and Ren G. Influence of altitudinal variation on the antioxidant and antidiabetic potential of adzuki bean (*Vigna angularis*). Int. J. Food Sci. Nutr. 2012; 63(1): 117–124.
- Yoshida H, Tomiyama Y, Yoshida N, Shibata K and Mizushina Y. Regiospecific profiles of fatty acids in triacylglycerols and phospholipids from adzuki beans (*Vigna angularis*). Nutrients. 2010; 2(1):49–59.
- Yoshida H, Tomiyama Y, Yoshida N, Saiki M, Mizushina Y. Characteristics of lipid components, fatty acids distributions and triacylglycerol molecular species of adzuki beans (*Vigna angularis*). Journal of food lipids. 2009;115:1424-1429.
- Yousif AM, Kato J and Deeth HC. Effect of storage on the biochemical structure and processing quality of adzuki beans (*Vigna angularis*). 2007.1-33.

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