Mini review

A brief Review: Lectins, Protease Inhibitors and Saponins in Cereals and Legumes

Comment [U1]: The title is suggested to be framed like this

Abstract

Cereals and legumes account for substantial amount in the human diet of tropical and sub-tropical regions. Anti-nutrient factors in cereals and legumes are secondary metabolites which can interfere with nutrient digestion and absorption after ingestion. This review will focus on different anti nutrient factors found in cereals and legumes including lectins, protease inhibitors, phytic acid and saponin. It is important to reveal about the treatments which are used to reduce the anti-nutrient factors in cereals and legumes. Therefore, this review also summarized the available literature on different control measures techniques that used to reduce the concentration of anti-nutrient factors in foods.

Comment [U2]: Change to contents and effect throughout the manuscript

Comment [U3]: Remove

Comment [U4]: Delete

Comment [U5]: Delete

Key words: Anti-nutrient contents factors, Cereals, Legumes

Comment [U6]: Delete

Introduction

In Asian dietaries, cereals and legumes are very important as major staple foods (Oghbaei and Prakash, 2016). They are significant sources of nutrients especially protein, dietary fiber, vitamins, minerals, and phytochemicals (Pereira *et al.,* 2002). Therefore It is important to know that the knowledge regarding various anti-nutritional substances are present in foods as well as which could be reduced/removed by different techniques to reduce them in the diet is essential for health and wellbeing of the population (EI- Hady and Habiba, 2003).

Comment [U7]: Delete

Comment [U8]: Delete

Comment [U9]: Delete

Comment [U10]: Delete

Comment [U11]: Delete

Anti-nutrient factors are considered as secondary metabolites of cereals and legumes. Some of them They are produced by the plants in order to protect themselves against attacks by herbivores, insects, and pathogens or to survive in adverse weather conditions such as droughts (Bora, 2014). However, they can interfere with digestion and absorption of nutrients in the digestive **track** after ingestion (Nadeeem *et al.,* 2010). Therefore, majority of these compounds may be labeled as anti-nutrients in the human diet.

Comment [U12]: Delete

Comment [U13]: Delete

Anti-nutrient factors in cereals and legumes include phytic acid, saponins, polyphenols, lathyrogens, α-galactosides, protease inhibitors, α- amylase inhibitors and lectins. Different methods are widely employed to reduce or remove anti-nutritional factors from cereals and

legumes. Those methods include soaking, cooking, germination, fermentation, selective extraction, irradiation and enzymatic treatment (EI- Hady and Habiba, 2003). Moreover, application of combination of different techniques has been proven more effective with compared with single techniques. However, complete removal is impossible (Khokhar and Apenten, 2003).

This article will focus on phytic acid, saponins, protease inhibitors, and lectins which are found throughout almost in all grains and forage legumes. It also elucidates some emphasizes knowledge regarding ways and techniques that could be used to lower down or reduce theem content of anti-nutritional factors in cereals and legumes before consumption of constituent grains.

Lectins

Lectins are proteins or glycoproteins which are commonly found in beans. Lectins can be commonly found in beans and they are proteins or glycoproteins by structure. They include erythroagglutinating and leucoagglutinating phytohemagglutinins are different types of lectins that can be found in legumes (Lioi *et al.,* 2003). Most of the lectins have ability to agglutinate erythrocytes (Puztai, 1991). Besides, In addition to erythrocyte agglutination; they can bind with glycoproteins on the epithelial surface of the small intestine, interfering with nutrient absorption (Sgarbieri, 1982). It has been proven *in vitro* studies that isolated lectin can induce enlargement of the small intestine and cause damage to the epithelium of the small intestine (Zucoloto, 1991). Although considerable indications are there and these legume lectins can be harmful to humans, there is no evidence/indication of anti-nutritional effect of cereal lectins (Jansman *et al.,* 1998). However, lectins can be easily disintegrated (Mubarak, 2005).

Highest Lectin contents was had been reported to be higher in for Kidney beans (*Phaseolus Vulgaris*), among soybeans (*Glycine max*), cowpeas (*Vigna unguiculata*), and lupin seeds (*Lupinus augustifolius*) (Grant *et al.,* 1995).

Germination can be used is one method to reduce concentration of lectins in legumes before consumption. During germination concentration is reduced. The reduction is due to proteolysis proteolytic action of different enzymes taken place inside legumes (Savelkoul *et al.,* 1992). However, it has reported that, after proper thermal treatment, lectins present in the diet do not pose health risks to humans or cause anti-nutritional effects in normal conditions of consumption (Lajolo and Genovese, 2002).

Comment [U14]: Delete
Comment [U15]: Delete
Comment [U16]: Delete
Comment [U17]: Delete
Comment [U18]:
Comment [U19]: Delete
Comment [U20]: delete
Comment [U21]: Delete
Comment [U22]: Delete
Comment [U23]: Delete
Comment [U24]: Not listed (NL)
Comment [U25]: Delete
Comment [U26]: The citation is very old
Comment [U27]: Delete
Comment [U28]: The citation is very old
Comment [U29]: Delete
Comment [U30]: Delete
Comment [U31]: Delete
Comment [U32]: Delete
Comment [U33]: Delete
Comment [U34]: Delete
Comment [U35]: Delete
Comment [U36]: Delete
Comment [U37]: How and why?

Protease Inhibitors

Protease inhibitors can interfere with the action of proteoloytic enzymes in the digestive track especially with pancreatic trypsin and chymotrypsin (Birk, 1989). There are two types of protease inhibitors. They are Kunitz and Bowman-Birk. Kunitz type specially acts against trypsin, while Bowman-Birk type inhibits both trypsin and chymotrypsin simultaneously (Lajolo *et al.,* 1991). However, protease inhibitors are known to be effective in their ability to suppressing carcinogenesis in many different in *vivo* and in *vitro* assay systems, but the mechanisms for the anti-carcinogenic activity of protease inhibitors are unknown and yet to be discovered (Ei Morsi, 2001).

Protease inhibitors have been reduced by using cooking and autoclaving due to the heat sensitivity of proteins. In contrast, there is no significant reduction after germination, However, it had been reported that germination did not have significant effect in reducing protein inhibitors in grains (Shimelis & Rakshit, 2017).

Phytic Acid

Phytic acid is generally regarded as the major storage form of phosphorous in cereals which exists mainly in the form of phytates (Wu *et al.,* 2009). It has been reported that Phytic acid content of cereals varies from 0.5%- 2.0%. Besides, legumes are found to contain more phytic acids than grains as reported by in Hungary (Hidvegi & Lasztity, 2002). In contrast, phytic acid content of legumes was higher than the cereals in a study conducted in Hungary (Hidvegi & Lasztity, 2002). Phytic acid contents in some cereals and legumes are indicated in Table 1.

Phytic acid has a strong ability to form complexes with multivalent metal ions, especially zinc, calcium, and iron. . In addition, These complexes are insoluble salts (Weaver and Kanna, 2002). Therefore, anti-nutrient phytic acid which reduce the bioavailability of minerals in such foods (Lesteinne *et al*., 2005).

Germination has been an effective treatment to reduce phytates. During germination, phytates are hydrolyzed by phytase enzyme and release phosphate groups (Pawar and Ingle, 1988).

Comment [U38]: Include short introduction of protein inhibitors

Comment [U39]:

Comment [U40]: Delete

Comment [U41]: Delete

Comment [U42]: Delete

Comment [U43]: Delete

Comment [U44]: Delete

Comment [U45]: Delete

Comment [U46]: NL

Table 1: Phytic acid content in cereals and legumes (Adapted from Hidvegi & Lasztity, 2002)

Cereal/Legume	Average phytic acid content (g/100g)
Wheat (MV-4)	0.85
Wheat (Besostaya-19)	0.93
Wheat (durum, GK Basa)	0.72
Maize (yellow dent)	1.02
Maize (flint)	0.90
Maize (sweet)	0.85
Barley	0.97
Oats	1.01
Soybean	1.43
Cowpea	0.42
Common bean	0.55
Peas	1.02

(Hidvegi & Lasztity, 2002).

Saponins

Saponins are widely distributed in all cells of leguminous plants. They have ability to form stable, soap like foams in aqueous solutions. Furthermore saponins are diverse group of compounds, in chemical structure and they contain a carbohydrate moiety attached to a triterpenoid or steroids (Bora, 2014).

Moreover, saponins can bind to cholesterol and therefore reduce absorption (Sidhu and Oakenfull. 1986). However, saponins are not destroyed during cooking or processing (Birk, 1980). Fermentation had been reported to reduce their level. Tempeh, a fermented soya product had been found to contain half the saponin contents present in the unfermented soy bean seeds. Fermented soya product-tempeh in to half with compared to raw soy (Potter et al., 1980).

Table 2: Saponin content in legumes

Source	Saponin content (% dry weight)
Soybeans (*Glycine max*)	5.6

Comment [U47]: Delete

Comment [U48]: Delete

Comment [U49]: Not clear

Comment [U50]: Delete

Chickpea *(Cicer arietinum* L.)	3.6
Lucerne (*Medicago sativa)*	2.5
Lupine (*Lupinus angustifolius*)	1.5

(Khokhar and Apenten, 2003)

Future research needs

Even though anti-nutrient factors reported to have adverse effects, *in vivo* studies related to those factors are lacking. Therefore, they should be extensively investigated using human studies. Furthermore, it is vital to carry out studies related to effectiveness of different techniques such as soaking, fermentation, germination and heat treatment etc. in order to find out the best methods to reduce the concentration of anti-nutrient factors in cereals and legumes. In addition, positive impact of these factors such as anticancer, anti-diabetic and anti-cholestremic effects should be investigated using *in vivo* studies.

Comment [U51]: There are many in vivo studies pls.

Comment [U52]: Funny

Comment [U53]: This depends on the grains/legumes

Comment [U54]: Sheck literature pls

References

Abd El-Hady, E. A., & Habiba, R. A. (2003). Effect of soaking and extrusion conditions on antinutrients and protein digestibility of legume seeds. *LWT - Food Science and Technology,* 36, 285–293. http://dx.doi.org/10.1016/S0023-6438(02)00217-7

Belitz, H.D., Weder, J. K. P. (1990) Protein inhibitors of hydrolases in plants foodstuffs. Food ReV. Int, 6, pp.151-211.

Birk Y. (1989) Protein protease inhibitors of plant origin and their significance in nutrition. In: Recent advances of research in antinutritional factors in legume seeds: J Huisman, AFB Van der Poel, IE Liener (Eds), PUDOC, Wageningen, The Netherlands, pp.83-94

Birk Y (1980) Saponins. In: Liener IE (ed.) Toxic Constituents of Plant Foodstuffs, 2nd edn. pp. 169-211. New York: Academic Press

Bora, P., 2014. Anti-Nutritional Factors in Foods and their Effects. , 3(6).

El-Morsi Abou El-Fotoh El-Morsi (2001) Legume seed protease inhibitors: their functions, actions and characteristics, Proceedings of the First International Conference (Egyptian British Biological Society, EBB Soc) *Egyptian Journal of Biology*, 3, pp. 164-173

Grant, G.; Dorward, P. M., Buchan, W. C., Armour, J. C., Pusztai, A. (1995) Consumption of diets containing soya beans (*Glycine max*), kidney beans (*Phaseolus Vulgaris*), cowpeas

Comment [U55]: Not properly sited

Comment [U56]: Not cited

(*Vigna unguiculata)* or lupin seeds (*Lupinus augustifolius*) by rats for up to 700 days: effects on body composition and organ weights. *Br. J. Nutr*. 73, 17-29.

Hidvegi, M. & Lasztity, R. (2002). Phytic acid content of cereals and legumes and interaction with proteins. Periodica Polytechnica Series in Chemical Engineering, 46, pp.59–64.

Jansman, A.J., Hill, G.D., Huisman, J. and Vander Poel, A.F. (1998) Recent advances of research in anti-nutritional factors in legumes seeds. Wageningen. The Netherlands: Wageningen Pers, pp.76.

Khokhar S. and Apenten, R.K.O. (2003) Antinutritional Factors in Food Legumes and Effects of processing, The role of food, agriculture, forestry and fisheries in human nutrition, Encyclopedia of Life support systems, Publishers CO Ltd, Oxford, UK

Lajolo, F. M., Finardi-Filho, F., Menezes, E. W. (1995) Amylase inhibitors in Phaseolus Vulgaris beans. *Food Technol*. 45, pp.119-121.

Lajolo, F.M. and Genovese, M.S. (2002) Nutritional Significance of Lectins and Enzyme Inhibitors from Legumes, *J. Agric. Food Chem.* 50, pp.6592−6598

Lestienne, I., C.M. Rivier, C.I. Verniere, I. Rochette, and S. Treche. (2005) The effects of soaking of whole, dehulled and ground millet and soybean seeds on phytate degradation and Phy/Fe and Phy/Zn molar ratios. *Int. J. Food Sci. Tech*. 40(4): pp.391-399.

Lioi L., Sparvoli F., Galasso I., Lanave C., Bollini R. (2003). Lectin-related resistance factors against bruchids evolved through a number of duplication events. Theor. Appl. Genet. 107, 814–822. 10.1007/s00122-003-1343-8

Mubarak, A. E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (Phaseolus aureus) as affected by some home traditional processes. *Food Chemistry* 89: pp.489-495.

Nadeem, M. Anjum, F.M., Amir, R.M.A., Khan, M.R., Hussain, S. and Javedistan M.S. (2010), An overview of anti-nutritional factors in cereal grains with special reference to wheat-A review, *Journal of Food Sciences,* 20, pp. 54-61

Comment [U57]: Not cited

Comment [U58]: Not cited

158 Oghbaei & Prakash, Cogent Food & Agriculture (2016), Effect of primary processing of
159 cereals and legumes on its nutritional quality: A comprehensive review, Cogent Food &
160 Agriculture 2: 1136015, http://dx.doi.org/10.1080/23311932.2015.1136015

161 Pawar, V.D. and U.M. Ingle. (1988) Investigations on phytate protein mineral complexes in
162 whey fractions of moth bean (*Phaseolus aconitifolius Jacq*) flour. *J.Food Sci. Techn*. 25
163 pp.190-195.

164 Pereira, M.A., D.R. Jacobs, J.J. Pins, S.K. Raatz , M.D.Gross, J.L. Slavin and E.R. Seaquist.
165 2002. Effect of whole grains on insulin sensitivity in overweight hyper insulinemic adults.
166 *Am. J. Clin. Nutr*. 7: 848-855

167 Potter J.D., Illman R.J., Calvert G.D., Oakenfull D.G. and Topping D.L. (1980) Soya
168 saponins, plasma lipids, lipoproteins and fecal bile acids: a double blind cross-over study.
169 *Nutr Rep Intl* 22: pp.521-528
170 Pusztai, A., Watt, W. B., Stewart, J. C. (1991) A comprehensive scheme for the isolation of
171 trypsin inhibitors and the agglutinin from soybean seeds. *J. Agric. Food Chem*., 39, pp.862-
172 866

173 Savelkoul, F., H., M., G., Van der poel, A., F., B. and Tamminga S. (1992) The presence
174 and inactivation of trypsin inhibitors, tannins, lectins and amylase inhibitors in legume seeds
175 during germination. A review *Plant Foods for Human Nutrition*, 42, pp. 71-85,

176 Sgarbieri, V. C. and Whitaker, J. R. (1982) Physical, chemical, and nutritional properties of
177 common bean (Phaseolus) proteins. *AdV. Food Res*., 28, pp. 93-166

178 Shimelis, E.A. and Rakshit, S.K. (2017) Effect of processing on antinutrients and in vitro
179 protein digestibility of kidney bean (*Phaseolus vulgaris L*.) varieties grown in East Africa,
180 *Food Chemistry*, 103, pp.161–172

181 Sidhu, G. S. & Oekenfull, D. G. (1986). A mechanism for the hypocholesterolaemic activity
182 of saponins. *Br. J. Nutr*. 55: pp. 643- 649.

183 Weaver, C.M. and S. Kanna. (2002) Phytate and mineral bioavailability In: N.R. Reddy and
184 S.K. Sathe, editors food phytates. CRC press boca raton. pp. 211-224.

185 Wu,P., Tian, J.C., Walker, C.E. & Wang, F.C. (2009) Review article Determination of phytic
186 acid in cereals – a brief review *International Journal of Food Science and Technology,* pp.
187 44, 1671–1676

188 Zucoloto, S., Scaramello, A. C., Lajolo, F. M., Muccillo, G. (1991) Effect of oral
189 hytohemagglutinin intake on cell adaptation in the epithelium of the small intestine of the rat.
190 *Int. J. Exp. Pathol*., 72 , pp. 41-45.