Condensed tannin: a major anti-nutritional constituent of faba bean (Vicia faba L.)

Abstract

Nutritionally, faba bean (Vicia faba L.) is one of the important legume crops cultivated for both food and feed purposes. However, in some parts of the world, it has not gained the status of a commercial legume crop, and it is cultivated in marginal agricultural fields with almost no agricultural inputs. Despite having nutritional as well as medicinal properties, it is not being cultivated in large scale because of one or other anti-nutritional constituents present in its edible parts. Condensed tannins are one of the major anti-nutritional factors found in edible parts of this crop which confers noticeable astringency and inhibition in digestion process. Molecular breeding and genetic engineering approaches may provide a suitable way to reduce the content of condensed tannin in the seed coat. Germplasm characterization for identification of best parents and identification of crucial genes/QTLs are some of the initial steps for improvement of this crop. Genomic information available in model and other legume crops will also serve as important resources for taking a suitable approach.

Keywords: Proanthocyanidins, anti-nutritional factors, food legumes, phenolics, flavan-3-ols

Introduction

Faba bean (Vicia faba L.) is one of the oldest crops grown by man to supply high-protein seeds for human and animal nutrition, which is known by various common names such as field bean, broad bean, horse bean, tick bean, windsor bean, hava feve, baakla shime. This legume crop is an important food legume in China, Egypt, Italy, Brazil and Ethiopia, whereas in some of the countries like India it is one of the underutilized pulse crops which is mainly cultivated in the fields with almost no agricultural inputs. Despite its nutritional advantages, faba beans have not gained the status of a commercial legume crop and it is grown in marginal agricultural fields with almost no agricultural inputs. Condensed tannins are one of the major anti-nutritional factors found in edible parts of this crop which confers noticeable astringency and inhibition in digestion process. Molecular breeding and genetic engineering approaches may provide a suitable way to reduce the content of condensed tannin in the seed coat. Germplasm characterization for identification of best parents and identification of crucial genes/QTLs are some of the initial steps for improvement of this crop. Genomic information available in model and other legume crops will also serve as important resources for taking a suitable approach.

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the flavan-3-ols catechin and epicatechin, whose last common biosynthetic intermediate is leucoanthocyanidin (an intermediate in anthocyanin biosynthesis also referred to as flavan 3,4-dioli), which results from the reduction of flavonols by dihydrodihydroquino-4-reductase (DFR).\(^1\) Subsequently, catechin is derived from the reduction of leucoanthocyanidin through the activity of leucoanthocyanidin reductase (LAR). Epicatechin formation occurs via anthocyanidin synthesis and reduction, two steps catalyzed by anthocyanidin synthase (ANS) and anthocyanidin reductase (ANR), encoded by leucoanthocyanidin dioxygenase (LDOX)/ANS and BANYULS (BAN)/ANR genes, respectively. Anthocyanidins are consequently essential for PA biosynthesis in species that accumulate only epicathechin-based PAs. Chemical characterization of the reaction products of ANR identified two isomers of flavan-3-ol, namely 2R, 3R-2, 3-cis-and 2S, 3R-2, 3-trans. With cyanidin as substrate, these products are (+)-epicatechin and (-)-catechin, respectively. The 2R, 3R-2, 3-cis-flavan-3-ol, which was the major reaction product, is the common building block of CTs in many plants including Arabidopsis and alfalfa (Medicago sativa).

**Way forward for improvement**

Characterization of the genetic variation in the available germplasms is important for further crop improvement which facilitates the transfer of useful genes among cultivated species and to improve yield parameters to impart resistance to biotic and abiotic stresses.\(^6\) Our work demonstrated that different faba bean cultivars have different levels of extractable phenol and proanthocyanidin\(^1\) in seed extract (Figure 1A). The whole tissue or histo-chemical localization of CTs may serve the purpose to determine its content in different germplasms for selection of better parent for conventional and molecular breeding to address this nutritional problem of the pulse crop. We used CT specific reagent known as DMACA (p-dimethylaminocinamaldehyde) reagent in concentration of 2% w/v DMACA in 3 M HCl for different time period for staining CTs in seed coat of whole seed and its localization (Figure 1B) (Figure 1C). Plants exhibit both carbon and nitrogen based defense system depending on environmental and their growth conditions.\(^4\) Probably because of this reason the amount of PAs are regulated in various tissues to better adapt in different external conditions (Figure 1D). A considerable amount of PA may be removed simply by soaking in water. Our results show 30 hrs of soaking resulted around 45% of decrease in PA content in seed and there after no considerable decrease was observed (Figure 1E). As far as genetic engineering approaches are concerned, down regulation of ANR gene in seed by RNA interference techniques may facilitate silencing of its expression and hence modulate amount of condensed tannins in the end product of faba bean to improve its nutritional quality.

**Conclusion**

Considering the nutritional aspects and minimal requirement of agricultural inputs of faba bean, this pulse crop has potential to be used as commercial pulse crop provided the content of anti-nutritional constituents specifically in economically important plant parts is reduced. The current genomic and marker-assisted breeding technologies and basic understanding about secondary metabolic pathway will serve the potential ways to improve the nutritional quality of this pulse crop.

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**Conflict of interest**

Authors declare no conflict of interest.

**References**


**Figure 1**: A: Different faba bean germplasms showing diverse seed coat color at maturity; B: whole seed; C: seed coat stained with DMACA; D: % PA content in different parts of faba bean; E: % decrease in PA content in water leachate.

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