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The Diversity of Four Anti-nutritional Factors in Common Bean

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Abstract

Anti-nutritional factors such as lectins, saponin, trypsin inhibitor and phytic acid are endogenous substances in the common bean (*Phaseolus vulgaris* L.). In this study, the contents or activities of these anti-nutritional factors in fresh pods were detected in 56 selected cultivars. The results revealed significant difference within each factor in the tested cultivar population. The mean value of lectin content and the activity of trypsin inhibitor were 1.743 mg · g^{-1} and 1.680 mg · g^{-1} respectively. Their coefficients of variation (*CV*) were both more than 100% and each of the cultivar frequency distribution curve showed a main peak, but the discontinuous distributions in the extremely high and low areas indicate hierarchic cultivars. However, the mean contents of saponin and phytic acid were 3.730 mg · g^{-1} and 3.102 mg · g^{-1}, respectively, with *CV* less than 41%. Each showed a main peak in its normal distribution curve and low frequency continuous distribution in dual tails. Meanwhile, statistic analysis demonstrated a positive correlation between the lectin content and trypsin inhibitor activity in fresh pods. Furthermore, all 56 tested cultivars were clustered into three groups based on their four anti-nutritional factor levels: 80% of them into medium level group, and 12% of them into low level group. The endogenous edible toxic compounds, such as lectin and trypsin inhibitor, are closely related to insect resistance in the field. This study suggests that it is possible to screen the cultivars containing less lectin and other factors but with reduced pest resistance in the field.

Keywords: common bean; *Phaseolus vulgaris*; lectin; saponin; trypsin inhibitor; phytic acid; genetic variation

1. Introduction

Common bean (*Phaseolus vulgaris* L.) can be classified into snap bean (*P.* var. *chinensis* Hort.) and kidney bean. As one of the important crops worldwide, common bean is a kind of nutritious food that is low in fat, high in protein and rich in minerals and multiplex vitamins. However, due to its endogenous toxins, intoxication accidents still happen, even though the toxins are deactivated by high-temperature in cooking process (Zhang et al., 2010). The toxins can cause neurological symptoms such as limb numbness, headache, chest tightness, and even severe coma, multiple organ damage or sudden death (Li et al., 1998).

Studies have shown that special chemical ingredients of common bean are anti-nutritional factors, such as phytic acid (O'Deli and Savage, 1960), lectins (Weder et al., 1997; Vasconcelos and Oliveira, 2004), trypsin inhibitor (Angela and Domenico, 2003), saponin (Yao et al., 2006), etc. These factors are the main substances of the endogenous toxins in common bean, but their levels and genetic variations in germplasm have seldom been reported. Only a few studies were conducted in analysis of a small number of indicators in several cultivars (Lou and Wang, 2008; Li and Zhang, 2009). Scientific approach for detoxification of common bean germplasm should be extensively performed to eliminate cases of food poisoning due to its consumption.

In this study, the contents or activities of lectin, saponin, trypsin inhibitor and phytic acid in fresh pods of 56 selected common bean cultivars were detected, and their population level distribution and genetic variation provide a unique metric to screen for low or non-toxic common bean cultivars. It can also help breed new cultivars with no endogenous toxins to promote food safety.

2. Materials and methods

2.1. Plant material

The comparative test of common bean germplasm resources was carried out in the spring of 2012 and 2013, respectively, at the experimental plot of Hubei Province Engineering Research Center for Legume Plants, Jianghan University (Yongan Town, Caidian District, Wuhan City, Hubei Province, latitude of 30°30′N

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Table 1 Sources and main characteristics of 56 cultivars of common bean

Accession	Name	Source	Characteristics
1	Xinshuangqingwang snap bean	Jixian, Tianjin	Early maturity, trailing, green pod
2	Baizi snap bean	Nanning, Guangxi	Medium maturity, trailing, green pod
3	Chunqiu Dazipao	Liaoyang, Liaoning	Medium maturity, trailing, purple pod
4	97-5 Jiadouwang	Liaoyang, Liaoning	Early maturity, trailing, green pod
5	Jinlongwang	Xinji, Hebei	Early maturity, trailing, green pod
6	Kangre Jiadou	Shijiazhuang, Hebei	Early maturity, trailing, white pod
7	Honghua snap bean	Wuhan, Hubei	Medium maturity, trailing, light green pod
8	Baibulao	Yangyuan, Hebei	Early maturity, trailing, white pod
9	Jiulibai	Wuhan, Hubei	Early maturity, trailing, white pod
10	Jingdian Baifengwang	Huairou, Beijing	Early maturity, trailing, light green pod
11	Jinshulu 97-5	Xinji, Hebei	Early maturity, trailing, light green pod
12	Jingxuan 97-5	Liaoyang, Liaoning	Early maturity, trailing, light green pod
13	Lüningbaiyun	Jinzhou, Liaoning	Early maturity, trailing, white pod
14	Thailand Jiangdouwang 1	Wuhan, Hubei	Early maturity, trailing, green pod
15	Jiulihong	Shenyang, Liaoning	Medium maturity, trailing, purple pod
16	Chaoji Baidajia	Liaoyang, Liaoning	Medium maturity, trailing, white pod
17	Teji Shilichang	Liaoyang, Liaoning	Early maturity, trailing, purple pod
18	WS5	Wuhan, Hubei	Medium maturity, trailing, light green pod
19	WS11	Wuhan, Hubei	Medium maturity, trailing, light green pod
20	WS20	Wuhan, Hubei	Medium maturity, trailing, white pod
21	WS21	Wuhan, Hubei	Medium maturity, trailing, light green pod
22	WS22	Wuhan, Hubei	Medium maturity, trailing, light green pod
23	WS23	Wuhan, Hubei	Medium maturity, trailing, white pod
24	WS24	Wuhan, Hubei	Medium maturity, trailing, purple pod
25	WS25	Wuhan, Hubei	Medium maturity, trailing, white pod
26	Gailiang Jiulibai	Wuhan, Hubei	Medium maturity, trailing, white pod
27	Chunqiu Wujia snap bean	Wuhan, Hubei	Medium maturity, erection, green pod
28	Xinxuan Lülong Jiadou	Wuhan, Hubei	Medium maturity, trailing, green pod
29	Yuanzhong Didouwang	Wuhan, Hubei	Medium maturity, erection, white pod
30	Thailand Jiadouwang 2	Wuhan, Hubei	Medium maturity, trailing, green pod
31	Jiadouwang 6	Wuhan, Hubei	Medium maturity, trailing, green pod
32	Garden Bean Gold Rush	America	Early maturity, erection, light green pod
33	Garden Bean Blue Lake 274	America	Early maturity, erection, light green pod
34	Garden Bean Blue Lake Stringless	America	Late maturity, trailing, green pod
35	Garden Bean Improved Tendergreen	America	Early maturity, erection, light green pod
36	Garden Bean Kentucky Wonder	America	Late maturity, trailing, green pod
37	Bean State Half Runner	America	Early maturity, trailing, green pod
38	Bean White Rice	America	Medium maturity, erection, light green pod
39	Bean Mayflower	America	Late maturity, trailing, light green pod
40	Bean Saint Esprit a Oeil Rouge	America	Medium maturity, erection, light green pod
41	Bean Contender	America	Medium maturity, erection, light green pod
42	Bean Royalty Purple Pods	America	Medium maturity, erection, purple pod
43	Cobra	England	Medium maturity, erection, light green pod
44	Cobra	America	Medium maturity, erection, light green pod
45	97-5 Jiadou	Wuhan, Hubei	Late maturity, trailing, green pod
46	923	Shenyang, Liaoning	Late maturity, trailing, light green pod
47	Dazipao	Shenyang, Liaoning	Medium maturity, trailing, green pod
48	Baizi snap bean	Shenyang, Liaoning	Early maturity, trailing, light green pod
49	Honghua snap bean	Shenyang, Liaoning	Early maturity, trailing, light green pod
50	Zijiadouwang	Shenyang, Liaoning	Early maturity, trailing, purple pod
51	Ziyu	Shenyang, Liaoning	Early maturity, trailing, purple pod
52	Yundou	Shenyang, Liaoning	Early maturity, trailing, light green pod
53	Qiangfeng 15	Kunming, Yunnan	Medium maturity, trailing, light green pod
54	Thailand Jiangdouwang 3	Kunming, Yunnan	Late maturity, trailing, light green pod
55	Thailand Wujindou	Kunming, Yunnan	Late maturity, trailing, light green pod
56	Honghua snap bean	Kunming, Yunnan	Early maturity, trailing, light green pod

and longitude of 113°47′E). A total of 56 cultivars of edible pods were used in this experiment (Table 1).

2.2. Sample preparation

The soil fertility in the experimental plot was uniform, and common bean was sowed annually on 23rd March by the plastic film mulching. Randomized block design with three replications was conducted. The length and width of each plot was 10 m × 1.6 m, respectively, and planting seedlings at the spacing of 0.25 m × 0.85 m. Cultivation management was in accordance with local conventional techniques. Agronomic traits, such as flowering and fruiting, were observed since 1st May. In each plot, some fresh pods of 15 days after flowering were