DEVELOPMENT OF NON-OILSEED LEGUMES AS SOURCE OF PROTEIN TO STRENGTHEN FOOD SECURITY IN MARGINAL AREAS

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INTRODUCTION

The number of population growth has forced Indonesia to strengthen the country food security as soon as possible, whereas protein-calorie malnutrition occurred in Flores and Lombok Islands with more than 2000 victims in the middle of 2005. This datum shows that some problems still exist in accessibility of source of protein by community, because of the high price. Moreover, Indonesia still imports the protein foods, such as meat and soybean. For those reasons, it is necessary to explore alternative local resources as protein foods, such as non-oil seed legumes.

Indonesia is rich in non-oilseed legumes, which have not been exploited well. Generally, these plant seeds contain a high concentration of protein by 18 – 25% of the seed, considering as a suitable source of protein (Roberts, 1985). And these plants can grow with a high productivity even in a marginal land. Therefore, a comprehensive study, from production to processing technology is required to explore the plant potency as source of protein. Moreover, in the viewpoint of processing technology, non-oilseed legumes contain some antinutritional factors and poisons, such as: trypsin inhibitor, hemagglutinin, polyphenol (tannin), phytic acid and cyanide acid, in which attention should be greatly focused on elimination of the compounds.

Accordingly, this study deals with development of processing technology of non-oilseed legumes, in where the seed superiority would be urged, while their inferiority would be eliminated, resulting in the increase of protein supply, added value of the seeds, and strengthen the economic condition of the community, especially, in marginal area.

MATERIALS AND METHODS

Materials
One batch of hyacinth bean (*Lablab purpureous* (L.) Sweet), lima bean (*Phaseolus lunatus* (L.)) and jack bean (*Canavalia ensiformis* (L.)) used for this study was collected from a farm in Bondowoso City, East Java, Indonesia. The lima beans consisted of two subgroups named lima bean 1 and lima bean 2. The lima bean 1 had various colors of seed, whereas the lima bean 2 had only one type of color. After arrival in laboratory, the seeds were sorted to remove immature and defected bean. The sorted beans were divided into portions for the various analyses, and stored in cold room (4-6 ^{o}C) until used. The chemicals and solvents used were of guaranteed grade.

Physical Measurements
The seed length, width, and thickness were measured with a vernier calliper. Weight of seed and cake was measured by analytical balance. To evaluate the color of the seeds and the protein isolate, Chromameter CR-100 (Minolta) was used (Subagio, 2006).

Chemical analysis

Proximate analysis, hydrogen cyanide (HCN), and phytate were done using AOAC methods (1990). Trypsin inhibitor fraction was extracted from the seeds according to Akpapunam and Sefa-Dedeh (1997), and then the fraction was used to determine the trypsin inhibitor activities using casein as substrate. Fractination of the proteins was done using the classical Osborne protein fractionation procedure (Hamada,1997). Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) of the proteins was carried out using a Mini-Protean II Electrophoresis System (Bio-Rad, Richmond, CA, USA) based on the instruction manual supplied.

RESULTS AND DISSCUSION

Seed characterization

The investigation asertained that there are many species of non-oilseed legumes in Indonesia. But in this study, three species of non-oilseed bean was used. i.e. hyacinth bean, lima bean and jack bean. However, in the case of lima bean, two subgroups were studied, named lima bean 1 and lima bean 2. Physically, the jack beans were white in color the biggest seed among others. The hyacinth beans were brownish white in color and the smalest bean. The colors of lima bean 1 were varied from white, red, brown and black. These colors suggested the present of many cultivars of the lima bean. However, it was no significant difference of size and shape among cultivars of the lima bean 1. Meanwhile, the seed colors of lima bean 2 was brownish red, and comparing with lima bean 1, that of subgroup 2 was more well rounded as shown by lesser length and width, but thicker (data not shown) .

The non-oilseed legumes contain a middle concentration of protein by 12 – 22% of the dry seed, which were lower values comparing with that of soybean (39.2%) (Table 1). Among the non-oilseed legumes analyzed, jack bean has the higher concentration of crude protein by 21.7%, followed by hycinth bean and lima bean 2, and lima bean 1 by 17.1, 17.1and 14.8%, respectively. Furthermore, no significant difference was found in the concentration of crude protein among cultivars of lima bean 1.

Table 1. Chemical composition of seeds of some non-oilseed legumes[a]

Components	Jack Bean	Hyacinth Bean	Lima 1 Bean	Lima 2 Bean
Moisture (%)	8.4 ± 0.1	9.3 ± 0.5	9.0 ± 1.0	14.3 ± 0.2
Protein (%)	21.7 ± 2.1	17.1 ± 1.5	14.8 ± 1.4	17.1 ± 0.1
Lipid (%)	4.0 ± 0.3	1.1 ± 0.4	2.2 ± 0.6	0.5 ± 0.1
Ash (%)	2.9 ± 0.1	3.6 ± 0.1	2.9 ± 0.1	3.0 ± 0.1
Carbohydrate (%) [b]	64.0 ± 5.2	67.9 ± 4.2	70.2 ± 4.2	65.1 ± 0.2
HCN (mg/100g)	0.5 ± 0.1	1.1 ± 0.1	111.8 ± 5.3	1.2 ± 0.2
Phytate (mg/g)	13.2 ± 1.2	18.9 ± 0.2	13.0 ± 1.3	15.0 ± 1.5
Trypsin inhibitor (TIU/mg)	0.15 ± 0.02	0.15 ± 0.02	35.90 ± 2.5	1.25 ± 0.22

[a] Calculated as wet basis

[b] Calculated using *by different method* from moisture, protein, lipid and ash.

The jack, hyacinth and lima bean subgroup 2 contained low concentrations of HCN (Table 1), suggesting that this seeds could be consumed without any doubt of HCN poisoning. However, lima bean subgroup 1 contained a high HCN concentration of 111.8 mg/100 g. Moreover, the phytate and trypsin inhibitor content were high enough in all beans. These results suggested that any treatment should be applied to reduce these anti nutritional factors before the seeds will be consumed, such as steeping, and cooking (Table 2).

Table 2. Effect of some treatments on the antinutrional factors and poisons in some non-oilseed legumes

Treatment	Hyacinth bean	Lima bean 1	Jack bean
HCN (mg/100g)			
Steeping 12 h	nd	102.9	nd
Steeping 12 h + pressure cooking 30 min	nd	0.39	nd
Fitat (mg/g)			
Steeping 12 h	11.34	12.4	10.56
Steeping 12 h + pressure cooking 30 min	11.34	6.5	9.9
Inhibitor Trypsin (TIU/mg)			
Steeping 12 h	0.44	3.60	0.14
Steeping 12 h + pressure cooking 30 min	0.12	0.36	0.11

Table 3. Ratio of 7S/11S globulin of soybean and some non-oilseed legumes

Legumes	Ratio of 7S/11S Globulin
Soy bean	0.65
Jack bean	3.57
Hyacinth bean	3.25
Lima bean 1	3.64
Lima bean 2	2.79

By the fractionation analyses using Osborne method, all beans have high content of albumins, promising a good potency of the seed protein on functional properties. Moreover, analysis of 7S/11S globulin showed that lima bean 2, hyacinth bean, lima bean 1, and jack bean have the ratio of 2.79, 3.25, 3.64 and 3.57, respectively (Table 3). The lower amount of 11S globulin suggests that the protein of the seeds could not form a strong gel, since there were not enough sulfhydryl groups, which are needed to form the disulfide bond in the gel. Accordingly, this seed protein is not recommended as a raw material for gel-like products, such as tofu (Mori, *et al*., 1986). Hyacinth bean 7S globulin contained 4 fractions with molecular weight ranged from 21.6 kD and 42.9 kD, by SDS-PAGE electrophoresis. Whereas, lima bean 7S globulin consisted of 5 fractions (18.2 – 45.2 kD) and jack bean 2 fractions i.e. 21.6 and 39.9 kD. Furthermore, the 11S globulin of hyacinth bean has 9 subunits (19.6 -80.4 kD), that of lima bean 1 has 7 subunits (22.4-49.8 kD) and that of jack bean has 9 subunits (19.6-66.2kD).

Protein Isolate

Using isoelectric method, protein isolate could be prepared from the milk of the non-oilseed legumes. The yield of protein isolates from jack bean, hyacinth bean and lima bean 2 were low with the total protein recovery ranged from 23% to 40%. But the protein isolate had good color, neutral odor, high protein content, and low ash. The protein isolate had also good functional properties such as solubility, foaming capacity, and emulsifying activity. However, the foaming and emulsifying stabilities were low.

Further advanced studies showed that the addition of the protein isolate from jack and hyacinth bean seeds up to 1% could improve the properties of the cake by increasing loaf volume, increasing specific volume, softening the texture and improving overall preference (Figure 1). When the protein isolate was added more than 1%, the cake tended to decrease those qualities of the cake comparing with 1%. However, the more protein isolate was added, the more vivid the color and the more slowly the rate of staling (data not shown).

Protein Rich Flour

With high content of carbohydrate and protein, non-oilseed legumes are potentially processed to be Protein Rich Flour (PRF). Hyacinth bean gave a higher yield of PRF (41.8%) than that of lima bean (34.0%). The produced PRF had a high content of protein by 58.4±4.5 and 40.9±3.6 % for hyacinth and lima beans, respectively (Table 4). Moreover these PRF from hyacinth and lima beans had high oil holding capacity (83.2±3.7 and 72.7±2.8%, respectively), and emulsion activity (1090.3±67 and 926.4±25.7 m2/g, respectively). Further advanced study showed that these PRF could be used as food ingredient to replace protein concentrate that are commonly produced from soy bean, such as in sausage and nugget.

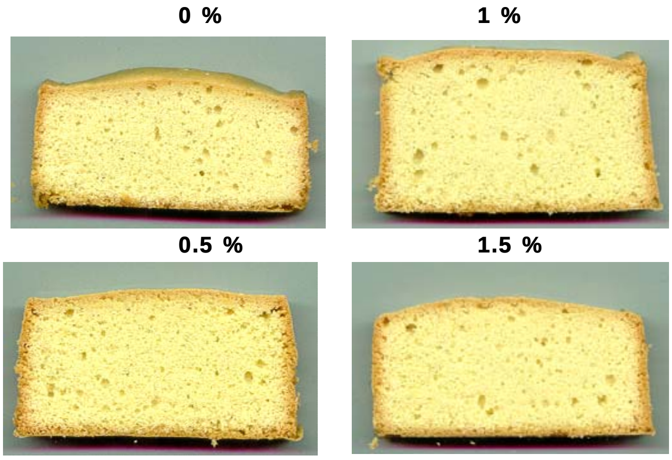

Figure 1. Cross section of cakes added by various concentration of protein isolate from jack bean seeds.

Table 4. Chemical composition of PRF from hyacinth and lima beans (%)

Component	Hyacinth bean	Lima bean 1
Moisture	6.4±0.2	4.1±0.1
Protein	58.4±4.5	40.9±3.6
Fat	0.3±0.1	1.6±0.2
Carbohydrate		
- Starch	26.9±0.6	49.6±4.9
- Total sugar	0.2±0.1	1.0±0.0
- Crude fiber	0.8±0.1	0.4±0.0
Ash	3.5±0.2	2.7±0.0

Other derivative products

Regarding to results of characterization of non-oil seed legumes, and elimination methods of their antinutritional factors and poisons, recently, some products based on protein of non-oil seed legumes are developed. As the results, some products, such as processed seed beans, fremented flour, and tempeh have been produced from the non-oil seed legumes.

CONCLUSIONS

In conclusion, non-oil seed legumes could be enhanced to be source of protein for human, by simple technologies. The implementation of this technology would, if successful, provide the cheap protein source, and would strengthen food security, especially in marginal areas.

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