Seed Protein Content and Fatty Acid Composition of Soybeans collected from Southwestern Islands in Korea

Byung Sun Kwon[1] Jeong Sik Shin[2] and Seong-kyu Choi[3]

[1] Dept. of Resources Plant Development, Sunchon Nat'l Univ. Sunchon 540-742, Korea

[2]Dept. of Biology Sunchon Nat'l Univ. Sunchon 540-742, Korea

[3] Dept. of Oriental Medicine Resources, Sunchon Nat'l Univ. Sunchon 540-742, Korea

ABSTRACT

The 129 soybean genotypes were collected in 43 island locations from January to May 2001. Seeds of 129 genotypes collected were analyzed for crude protein and fatty acid composition contents. The crude protein content was averaged to 41.1% and ranged from 37.4% to 44.4%.

The average palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid content were 12.0%, 4.0%, 23.2%, 55.5%, and 7.9%, and the ranges of those were 10.0% to 15.0%, 3.0% to 4.8%, 21.7% to 25.5%, 50.2% to 58.3% and 7.0% to 12.0%, respectively.

Heritabiliries of palmitic acid, oleic acid, linoleic acid, and crude protein were higher, but that of stearic acid and linolenic acid were relatively lower.

The genotypic correlation coefficients between crude protein and oleic acid showed highly positive correlation, but that of linoleic acid showed highly opsitive correlation, but that of linoleic acid showed highly negative correlation and also palmitic acid, stearic acid and linolenic acid showed negative correlation.

Key Words : Soybeans, crude protein fatty acid composition

INTRODUCTION

Bean contains the protein of 40% or so, which has the highest content of protein among edible crops. It also produces the maximum protein per unit area and is considered as an important protein source of foods or fodders. Bean contains about 20% of fat and it is used for obtaining soybean oil in the West and soybean chaff after oil expression is used for protein fodder. Asian countries including Korea use it for foods as well as fodder and it is also an important source of fat and plant protein (Hong et al. 1990).

About 80% of soybean protein are Globulines, which is a very good protein because it has little problems except amino acid (methionine, cystine) of protein (Hong et al. 1990).

Processing technique of soybean has been developed, it is easy to use it for strengthening protein added to other foods and its value as food processing material has been enhanced (Hong et. al. 1990).

According to the analysis of chemical ingredients of soybean, the contents of protein, fat and sugar in about 60 kinds of soybeans harvested by maturity period

Corresponding author : Byung Sun Kwon, Tel : +82-61-750-3282, E-mail : kbs@sunchon.ac.kr

showed 33.1~49.2%, 14.5~23% and 5.6~10.9% (Hymowitz et al. 1974), cultivated soybeans have higher total sugar contents than wild soybeans (Hymowitz et al. 1972) and when different sowing seasons are applied, the variation of ingredient contents of seeds are varied by ecotype of soybean, but while the shorter ripening period is, the more the content of protein is and the shorter the growth period is, the less the content of fat is(Weiss et al. 1952), the content of fat is greatly governed by genotype of variety (Singh et al. 1968).

As a result of analyzing the contents of soybean seeds harvested in six regions of Korea, content of crude protein was 44.99% in Jeju and 42.67% in Mokpo. Content of crude fat was 22.22% in Mokpo and 18.02~18.94% in other regions. Crude protein had the negative correlation with the fat in it. In hereditability, the crude protein was 39.15% and the crude fat was 69.66% (Kim et al. 1993).

Quality of black soybean is governed by physical and chemical properties of seed and characteristics of black soybean related to taste include size of seed in its appearance and biting, tenderness, lumpy-tasting, chewing, disgusting taste and sweet in its property (Guh et al. 1983).

Black pigment content extracted in mixing black soybean with rice and barley is an important factor in variety of choice beans (Kim et al. 1993), pigment deciding a testa color of black soybean is anthocyanin and it is delphinidin-3-monoglucoside and cyanidin-3-monoglucoside according to Yoshi Kura and Hamaguchi (1969).

The mean fatty acid of five types including Suwon 155 is composed of 22% of oleic acid, 55% of linoleic acid and 7% of linolenic acid and the content ratio of unsaturated fatty acid of the whole fatty acid was 84% (Kim et al. 1993).

This study examines and analyzes the composition of crude protein and fatty acid with black soybean collected from 45 island regions in the southern part of Korea and obtains some results from the experiment for quality improvement.

Table 1. Varieties of black seeded soybean used as material

No. Varieties	No. Varieties	No. Varieties
1. Bigeum loca	16. Palgeum local	31. Guneue local
2. Gasan local	17. Haeu local	32. Geumdang local
3. Gulim local	18. Heuksan local	33. Bogil local
4. Gwangde local	19. Gagu local	34. Saengil local
5. Dogo local	20. Wando local	35. Soan local
6. Yongso local	21. Geumil local	36. Chungsan local
7. Jadang local	22. Dekwoo local	37. Jindo local
8. Sinye local	23. Hwangje local	38. Gogun local
9. Anja local	24. Chungdo local	39. Gunnae local
10. Ante local	25. Jangwon local	40. Yeusin local
11. Aphae local	26. Nowha local	41. Inhae local
12. Imja local	27. Uryong local	42. Jodo local
13. Jaeun local	28. Gogeum local	43. Jisan local
14. Jangsan local	29. Dekdong loal	
15. Jengdo local	30. Chowan local	

Table 2. Mean, minimum and maximum of fatty acid composition and crude protein of soybean varieties

Characters / Item	Saturation fatty acid		Unsaturated fatty acid			Crude protein
	※PAL.(16:0)	STE.(18:0)	OLE.(18:1)	LIN.(18:2)	LIN.(18:3)	
Mean	12.0	4.0	23.2	55.5	7.9	41.1
Minimum	10.0	3.0	21.7	50.2	7.0	37.4
Maximum	15.0	4.8	25.5	58.3	10.0	44.4
SD	1.80	0.51	2.21	1.88	0.67	2.12

※ PAL. : Palmitic OLE. : Oleic LNI. : Linolenic
STE. : Stearic LIN. : Linoleic

Table 3. Analysis of variance for fatty acid composition and crude protein of soybean varieties

Item / Characters	Varieties	Error
PAL.	2.4521**	0.4731
STE.	0.4134**	0.1624
OLE.	15.5024**	1.2321
LIN.	7.2563**	1.5324
LNL.	1.3012**	0.4856
Crude protein	9.5321**	1.6178

** Significant at 1% (level)

MATERIALS AND METHOD

This experiment was conducted from June to October of 2001 with school research subsidy. Published variety was the native species of soybean cultivated in 43 island regions on the south coast (Table 1).

Cultivation method used the whole quantity of base manure of N-P2O5-K20=4-7-6 Kg/10a, sowed 5～6 grains at the planting distance of 70 × 20cm and kept one bundle after thinning out them twice or three times. The packing arrangement was conducted through three repetitions by randomized block design.

Soybean to be used for analysis should be the complete grain and after drying it with 60℃ hot-air drier for 24 hours, it was made 60 mesh of powder. Analysis of crude protein used kjeldahl method (AOAC, 1970), quantified the total nitrogen of it and multiplied it by nitrogen coefficient 6.25. For analyzing the fatty acid, acetylchloride and methanol are processed in 20mg of bean powder, shaken in water bath of 70℃ for 3 hours, add to hexane and separated hexane layer by centrifuge (2,000rpm, 5min.).

Oil without hexane is infused into gaschromatography and the composition of fatty acid is analyzed and classified into palmitic (PAL.16:0), stearic (STE.18:0), oleic (OLE18:1), linoleic (LIN18:2) and linolenic (LAN.18:3).

Variance analysis was done by multiplying the measurement of each character by the mean value and genetic correlation, phenotype correlation and heritability were measured by variance analysis of Grafius et al (1952) and Robinson et al. (1949, 1951).

RESULTS AND DISCUSSION

1. Composition of Fatty Acid and Variation among Varieties of Crude Protein

Table 4. Heritabilities (h^2), genotypic variances(σ^2G) and environmental variances(σ^2E) of fatty acid composition and crude protein of soybean varieties

Item / Characters	h^2(%)	σ^2G	σ^2E
PAL.	54.9031	0.5824	0.4321
STE.	37.2151	0.0941	0.1613
OLE.	81.0201	4.4526	0.2011
LIN.	53.2114	1.8346	0.4211
LNL.	25.3721	0.1850	0.4431
Crude protein	63.3145	2.8138	1.6120

The results of examining the mean, minimum and maximum values of measurements from variety groups to investigate the width of variation of composition of fatty acid and crude protein are shown in Table 2 and the results of variance analysis of measurements among varieties are in Table 3. According to these results, the variation of character of the native species of soybean was great and the variation among varieties was clear. The character of the greatest variation among characters examined was oleic acid, followed by linoleic acid, linolenic acid and crude protein. Most of these characters have high significance among varieties and the characteristics of published varieties were clear.

As a result of analyzing the composition of fatty acid of Suwon-155, -156 and -157 which are cultivated for choice bean at National Crop Experiment Station, Kyundong-3, small black soybean, and Danpaheuk, large black soybean, the mean content of linoleic acid was 54.84%, that of linolenic acid 6.92% and that of oleic acid 22.0%. Therefore the mean content of unsaturated fatty acid was 84%, which was similar to composition of fatty acid of other soybeans and that of black soybeans has no difference from that of other soybeans (Kim et al. 1993).

This trend was shown in the mean value of 43 varieties of the native species of black soybeans used in this research as 55.5% of linoleic acid, 7.9% of lenolenic acid and 23.2% of oleic acid with 86.6% of the mean unsaturated fatty acid.

2. Estimation of Hereditability

Variance of a specific character by varieties is composed of hereditary variance from the hereditary difference and environmental variance ; the former is adjustable through the selection of breeding and the percentage of the whole variance is expressed as hereditability (Robinson et al. 1949). This hereditability is the index of selection efficiency and genetic gain and the estimation of each character is very important. The estimated hereditability of composition of fatty acid and protein character of the native sp ecies of black soybean is shown in Table 4. According to Table 4, oleic acid has 82% of hereditability, palmictic acid 54%, linoleic acid 53%, crude protein 63%, stearic acid 37% and linolenic acid 25%. Therefore, oleic acid and crude protein has a great variation width as 81～63% and will achieve a great selection effect.

Research of local variations of contents of high protein in soybeans showed that the hereditability of crude protein in three kinds of soybeans such as Hwangkenm kong, Suwon-158 and -159 was 39% (Kim et al. 1993) and it is because the number of published varieties is small and Suwon-158 and -159 have the similar ecotype, which cannot represent general soybeans (Kim et al. 1993). Therefore, the content of other ingredients should be lowered to enhance the

Table 5. Phenotypic(γPh), genotypic(γG) and environmental(γE) correlation coefficients in black seeded soybeans

Characters		2)	3)	4)	5)	6)
1) PAL.	γPh	0.2121	-5214**	-0.0313	0.557	-0.3416*
	γG	0.6363**	-0.7191**	0.2214	0.5542**	-0.6765**
	γE	0.0712	-0.2012	-0.2818*	0.0518	-0.0415
2) STE.	γPh		-0.4912**	0.2121	0.0261	-0.4175**
	γG		-0.7555**	0.4731**	0.5151**	-0.6827**
	γE		-0.2338	0.0238	0.1036	-0.1762
3) OLE.	γPh			-0.7575**	-0.3417**	0.8989**
	γG			-0.8383**	-0.6226**	0.9595**
	γE			-0.6518**	-0.838	0.7475**
4) LIN.	γPh				-0.1121	-0.7612**
	γG				-0.3011*	-0.8413**
	γE				-0.4336**	-0.6672**
5) LNL.	γPh					-0.1814
	γG					-0.4321**
	γE					-0.0170
6) Crude protein	γPh					-
	γG					-
	γE					-

content of protein and it will be an important task to breeding specialists and for this, exploration of variety of genes and the induction of variation are urgent.

3. Correlations among major characters

Results of calculating phenotype, hereditary and environmental correlations to examine the degree of correlations among characters using covariance analysis are shown in Table 5. Correlations have a higher hereditary correlation value than phenotype correlation value and hereditability is somewhat higher as shown in Table 4. From the correlation coefficients among characters, the content of crude protein showed a high positive correlation with oleic acid and a high negative correlation with linoleic acid palmitic acid, stearic acid and linolenic acid. Then the content of oleic acid should be high and that of linoleic acid, palmitic acid, stearic acid and linolenic acid should be low in order to enhance the content of crude protein.

The research of local variations of content of high protein in soybeans by Kim et al. (1993) showed the negative correlation between crude protein and fat, positive correlation between crude protein and its quantity and negative correlation between crude fat and its quantity. Also the content of protein has been influenced by environment, but effects of interaction between variety and environment were not shown and it is found that the breeding of high protein is possible regardless of environment.

Therefore, environmental factors affecting the composition of fatty acid include temperature (Collins et al. 1957) and the formation of fatty acid is not necessarily based on hereditary characteristics (Brim et al. 1958), (Howell et al. 1972) and more profound research of it should be followed.

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