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Seed Quality of Soybean Produced from Upland and Drained-Paddy Field

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ABSTRACT : This study was carried out to evaluate the seed quality of soybeans produced from upland and drained-paddy fields. Soybeans from drained-paddy field showed significantly higher in the 100 seeds weight and greater in the size of seed length than those from upland fields. However, there are no significant differences in seed width and thickness between upland and paddy fields. In case of Hunter's color value, the lightness (L) was significantly higher in the upland soybeans, but the a (redness) and b (yellowness) values were higher in the drained-paddy field soybeans. Seed appearance of drained-paddy field was poor than that of upland field. Soybeans produced from the drained-paddy field showed higher protein content, whereas, lipid and ash contents were higher in the upland field. Soybeans from upland field had lower contents of total amino acids compared to drained-paddy fields. No statistical differences were found in palmitic, linoleic, and linolenic, but stearic, oleic, saturated fatty acids (SFA), and unsaturated fatty acids (USFA) showed significant differences between soybean seeds from upland and drained-paddy fields. Genistein content was higher in the drained-paddy fields, while daidzein and glycitein contents were higher in the upland fields. This result suggested that the soil condition of drained-paddy field is more favorable to synthesis genistein than daidzein and glycitein.

***Keywords*:** soybean, upland, drained-paddy, amino acid, fatty acid, isoflavone

In Korea, rice is one of the major crops and during the past few decades most of rice research projects were focused on the high yielding rice varieties for the purpose of self sufficient in rice.

In recent years, however, rice consumption has been decreased because traditional dietary habit has been gradually replaced with western-style meals, and this trend resulted in a surplus rice and a decline of rice cultivation. Futhermore, intensive monoculture of rice does not seem to be sustainable in the long term, so it is encouraged to produce upland crops from drained-paddy fields and began to provide an information about the profitable ways and intensive use of paddy fields.

Crop diversification in the drained-paddy field is an important research topic in Korea. However, the main problems are the difficulty of integrating such crops with rice, and the lack of varieties with a stable yield which are suitable for drained-paddy field and have disease and insect resistance.

In Korea, soybeans are traditionally grown in upland fields but are now also grown in drained-paddy fields, and over 1,905 ha (2002) of paddy fields have been converted into upland fields for soybean and other crops cultivation, and this will be increased about 7,000 ha until 2004 (NICS, RDA, 2004).

Soybean is a promising crop because there is good demand for soybean as a vegetable protein sources, and it has been utilized traditionally in many ways in Korea. For this reason, farmers are encouraged to cultivate soybean rather than leave their land fallow.

On the other hand, soybean researchers are now looking for varieties which give better performance, pest and disease resistance, tolerant to excess water, and suitable for mechanized farming in the drained-paddy field. However, soybean yield and quality produced in the drained-paddy fields are still unstable and a suppling system for homogeneous and stable production are not fully established yet To improve this situation, it is necessary to establish the basic techniques for soybean cultivation in the drained-paddy field to develop varieties reflecting consumers' needs and to stabilize yield and quality.

This study was carried out to evaluate the seed quality of soybeans produced from upland and drained-paddy fields.

MATERIALS ANDMETHODS

Soybean cultivation

Eight soybean varieties such as 'Daewonkong', 'Geomjoungkong 1', 'Hwangkeumkong', 'Pungsannamulkong', 'Sinpaldalkong 2', 'Somyeongkong', 'Sowonkong', and 'Taekwangkong' were simultaneously grown and harvested at the upland field of National Institute of Crop Science, Suwon, Korea, and at the drained paddy field in Paltan located at near Suwon, in 2002. The chemical characteristics

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of upland soil was pH 6.7, O.M. 1.5%, available P_2O_5 338 ppm, exchangeable cation K, Ca, and Mg were 0.49, 2.3, and 1 2 me/100g, respectively The paddy soil was pH 5 4, O.M 2.6%, available P_2O_5 130 ppm, exchangeable cation K, Ca, and Mg were 0 26, 3 5, and 1 2 me/100g, respectively

Composition Analyses

Soybean seeds were ground by using laboratory test mill (Brabender, Germany) about 100 mesh flour for the analyses of proteins. lipids. amino acids, and fatty acids. Protein content of seed samples was determined according to the Kjeldahl procedure using a Tecator Kjeltec Auto Analyzer, model 2400 (Foss Tecator, Sweden). Lipid content was measured by Soxtherm automatic system (Gerhardt, Germany). The extraction beakers were filled with a few boiling stones and then dried at 105 °C. The 5.0 g of homogenized sample was put into extraction thimble and add 140 m*l* of n-hexane After boiling for 30 min at 180°C, extraction was performed for 80 min with 5 times of solvent reduction After extraction, the beakers were dried at 105°C for 1 hour, then cooled down to room temperature in a desiccator and weighed. Total lipid contents were represented on a dry basis of soybean seeds

Hunter's color value

The Hunter's color value such as L (lightness), a (redness) and b (yellowness) was measured by using color & color difference meter (Minolta Chromameter CR-200, Japan) which had adjusted with a standard white plate (L = 97.38, a = –0 02, and b = 1.66).

Amino acid analysis

The 0.3 g of each sample was weighed and 5 m*l* of 6 N-HCl was added. The hydrolysis was maintained for 24 h at 110°C in test tubes with nitrogen gas flushing. Afterwards, the samples were diluted to the 100 m*l* of Milli-Q water and filtered with Millipore 0.45 μm syringe filters (Milford, USA). The 1 m*l* of each hydrolysate was put into an autosampler bottle and injected into an amino acid autoanalyzer (Hitachi L-8800, Japan) The amount of each amino acid present in the samples was calculated with reference to the standard amino acids (Ajnomoto-Takara Co., Japan).

Fatty acid analysis

The fatty acids were analyzed by Rafael and Mancha's method (1993). The procedure was as follows. The 0.5 g of soybean flour was heated with a reagent containing methanol : heptane : benzene · 2,2-dimethoxypropane . H_2SO_4 = 37 : 36 · 20 : 5 : 2 (v/v). The simultaneous digestion and lipid transmethylation was taken place in a single phase at 80°C. After cooling at room temperature, the upper phase containing the fatty acid methyl ester (FAME) was prepared for the capillary GC analysis The GC analysis was performed on a Agilent 6890 system (HP Co , U S.A.) equipped with a FID by using a HP-Innowax capillary 30 m×0.25 mm×0.25 μm film (Cross-linked polyethylene glycol) column. The initial temperature of 150 °C was increased to the final temperature of 280 °C at the rate of 4 °C/min. Carrier gas was nitrogen at the flow rate of 10 m*l*/min. During the analysis, the temperatures of inlet and detector were maintained to 250 and 300 °C, respectively. The standard FAME Mix (C14-C22) was purchased from Supelco (USA)

Isoflavone analysis

Three grams of defatted soybean flour was weighted into a round-bottom flask. suspended with 30 m*l* of 1 N HCl, and heated for 2 hr at 100 °C with a reflux condenser in water bath. After digestion, the extract was volume up to 100 m*l* with methanol and then the supernatant was filtered through a PTFE 0.45 μm syringe filter (Waters, Milford, MA, USA) The filterate was injected for the HPLC analysis Analysis of isoflavone was conducted by reverse-phase HPLC (Waters 2690 Alliance System, USA) equppied with YMC-Pack ODS-AM303 (250×4.6 mm) connecting a guard column packed with Bonda C_{18} Waters guard-Pak pre column, (Waters, Milford, MA, USA). The 0 1% acetic acid in 35% acetonitrile was employed for analysis of isoflavone mobile phase. The solvent flow rate was 1 m*l*/min and following the injection of 20 μ*l* of sample, the eluted isoflavone were detected at 254 nm. All HPLC analysis were performed at ambient temperature. The standard isoflavone was purchased from Sigma (St. Louis, MO, USA).

Statistical analysis

There were three replicates for all measurements. The data obtained from the analysis were statistically analyzed using SAS release ver. 6.12 for Windows (Statistical Analysis Systems Institute Inc., Raleigh, NC, USA).

RESULT AND DISCUSSIONS

Seed characteristics and chemical compositions

Seed characteristics and chemical compositions of soybeans produced from the upland and drained-paddy fields

Table 1. Comparison on seed characteristics, color value, and chemical compositions in soybeans produced in the upland and drained-paddy fields.

	†Varieties	Seed characteristics				Hunter's color value			Chemical compositions		
		‡100 SW (g)	Length (mm)	Width (mm)	Thick-ness (mm)	L	a	b	Protein (%)	Lipid (%)	Ash (%)
Upland field	DW	26.3	7.9	7.6	6.9	51.5	4.71	33.0	38.6	18.5	4.94
	GJ	28.2	8.4	7.8	6.5	10.2	0.11	1.1	37.4	18.2	5.10
	HK	26.0	8.3	8.0	7.1	46.2	5.25	31.4	37.6	18.7	5.05
	PS	10.4	4.8	5.3	4.7	55.6	6.69	32.4	36.3	17.4	4.95
	SP	21.5	7.9	7.1	6.1	43.4	6.81	27.9	39.4	17.1	5.17
	SM	9.5	5.7	5.4	4.9	48.7	3.76	34.1	37.4	16.3	4.97
	SW	9.5	5.5	5.6	5.1	50.5	2.12	32.8	35.9	18.2	4.93
	TK	21.4	8.0	7.4	6.0	46.4	4.17	32.9	36.6	18.1	5.22
	Mean	19.1	7.1	6.8	5.9	44.1	4.20	28.2	37.4	18.2	5.10
Drained-paddy field	DW	28.9	8.8	7.7	7.3	42.9	3.97	34.3	40.8	17.7	4.62
	GJ	31.5	8.9	8.3	6.8	5.1	0.12	1.7	40.0	17.1	4.78
	HK	30.4	8.4	7.6	6.7	40.4	5.09	31.1	39.5	17.6	4.78
	PS	12.8	6.8	5.9	5.2	53.6	4.82	35.8	41.0	16.3	4.65
	SP	23.3	8.8	7.4	6.4	45.4	6.20	30.1	41.2	17.4	4.93
	SM	10.4	6.6	5.6	5.0	45.8	3.12	33.7	39.9	15.5	4.81
	SW	12.8	6.4	5.8	5.3	41.6	1.39	32.9	37.9	17.1	4.93
	TK	29.3	8.7	7.6	6.8	45.9	5.60	33.5	39.8	17.1	4.66
	Mean	22.4	7.9	6.9	6.2	40.1	3.79	29.1	40.0	17.1	4.78
LSD(0.05)§		1.8	0.4	NS	NS	3.2	0.8	1.1	0.8	0.4	0.13

†DW: Daewonkong, GJ: Geomjoungkong 1; HK: Hwangkeumkong; PS: Pungsannamulkong; SP: Sinpaldalkong 2; SM: Somyeongkong, SW: Sowonkong, TK: Taekwangkong, ‡100 seeds weight §Between upland and drained-paddy field.

are presented in Table 1. Soybeans from drained-paddy field showed significantly higher in the 100 seeds weight and greater in the size of seed length than those from upland fields. However, there were no significant differences in seed width and thickness between upland and paddy fields.

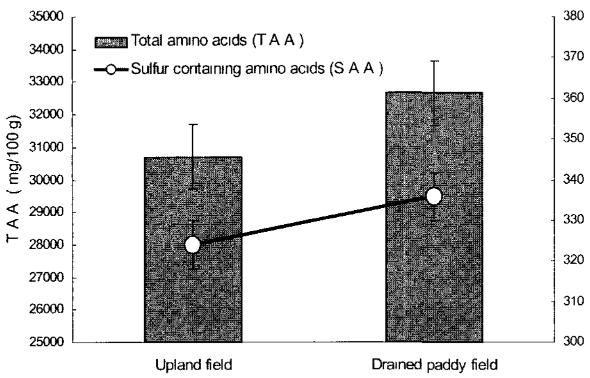
Differences in Hunter's color values [L (lightness), a (redness), and b (yellowness)] were detected between soybeans from upland and paddy fields. The lightness (L) was significantly higher in the upland soybeans than those of drained-paddy field, but the a (redness) and b (yellowness) values were higher in the seeds of drained-paddy fields. The soybean seed coat determine the important quality traits, such as lustre, permeability, and nutritional value, and also seed coat color affects visual appearance of soyfoods. Soybean seed color showed its diversity and soybeans which have bright colors are usually being sold a premium price in the market (Kim *et al.*, 2004). On this point of view, the seed appearances from drained-paddy field is not favourable than those from upland field.

Protein content was significantly affected by cultivation field types. Protein content varied from 35.9% ('Sowonkong', upland) to 41.2% ('Sinpaldalkong', drained-paddy). The soybeans produced from the drained-paddy field showed the higher protein content (40.0%) than those of upland field (37.4%). Whereas, lipid content varied from 15.5 to 18.7%, and lipid and ash contents were significantly higher in the upland field (18.2 and 5.1%) than those of drained-paddy field (17.1 and 4.78%).

Soybean is the most important source of dietary protein and it is also one of the highest quality protein sources with the least variability. Some variation, however, may occur because of differences in varieties of soybeans, growing conditions, storage conditions, and processing variation. Before this research works, we have expected that the drained-paddy field will be maintained the slightly wet condition because of paddy soil characteristics will prevent the full drainage, and this facts will affect the soybean growth negatively. However, obtained results slightly differ from our hypothesis and the previous research works of Dwivedi *et al.* (1996) who reported protein content was sensitive for

Table 2. Compaпson of amıno acıd contents ın soybeans produced ın the upland and draıned-paddy fields (Unıt . mg/100 g)

	Amıno acıds[†]	Amıno acıd contents of eıght soybean varıetıes								
		DW[‡]	GJ	HK	PS	SP	SM	SW	TK	Mean
Upland field	Asp	2446 3	2231 1	2021 8	2203.4	2387 0	2309.8	2162.2	2197 5	2244.9
	Thr	2699.2	2455 9	2224 1	2495.7	2621.0	2559 2	2478 5	2488 0	2502 7
	Ser	1739.8	1593 9	1445 3	1568.4	1708 3	1614 2	1571 1	1590.7	1604 0
	Glu	4986 8	4641.0	4183.3	4506.9	4976.4	4792 5	4443.9	4538 0	4633 6
	Gly	2911 6	2692.2	2373 5	2727 2	2796.5	2784 9	2683 0	2626.0	2699.4
	Ala	1942 1	1798 6	1587 8	1834 0	1855.7	1857 5	1786 5	1757 0	1802 4
	Cys	162 3	143 2	123 3	147 0	134 6	125 5	134.6	143 4	139.2
	Val	1430 8	1317 0	1242.6	1388 1	1472 0	1586.1	1312 6	1336 1	1385.7
	Met	207 9	238 0	121.7	176 8	166 9	202.7	213 3	150.6	184.7
	Ile	943 0	901 2	933 4	940 7	1135 0	1286 5	872 2	931 8	993.0
	Leu	1872 8	1797 7	1900 8	1803 2	2331 5	2517.9	1739 8	1857.9	1977 7
	Tyr	244 3	245 4	276 3	252.1	327 9	351 0	248 4	252 5	274 7
	Phe	296 9	307.0	388 1	317 9	406.3	389 3	289 1	321 4	339 5
	Lys	260 3	231 5	214 0	242 7	252.5	249 8	237 9	236 5	240 7
	NH_3	4430 0	8251 5	4389 8	4389 1	4676 0	4643 0	4195.9	3904 0	4859 9
	Hıs	847 5	782.5	717.5	809 5	848.9	850 4	785.2	768.2	801.2
	Arg	2522.0	2352.4	2081 0	2304 3	2442.7	2509 4	2151 3	2241.3	2325 6
	Pro	1800 6	1662 5	1585.2	1647 5	1842 2	1733.3	1682 3	1653 7	1700 9
Draıned-paddy field	Asp	2558.8	2460 0	2463.7	2212.7	2563 2	2367.0	2186 1	2567 4	2422.4
	Thr	2778.4	2673 8	2668.3	2445.4	2752 9	2627.7	2479 1	2802 3	2653.5
	Ser	1814.1	1738 4	1713 0	1581.4	1765 0	1693.2	1572.1	1787 9	1708 1
	Glu	5252.6	5088 0	5069 4	4603.7	5359 8	4945 3	4580 3	5332 2	5028.9
	Gly	3002.6	2940 6	2870 0	2664.8	2992 7	2829.4	2669.0	3003 7	2871.6
	Ala	1995 5	1959 1	1908 6	1762.3	1965 8	1886.1	1780 0	1974 7	1904 0
	Cys	162 3	152 8	150 6	141 4	131 5	132 2	135 9	156 1	145.4
	Val	1538 1	1415 7	1506 1	1423 5	1599 4	1465 8	1427 6	1573 6	1493 7
	Met	324 1	164.6	108 4	213.0	191 6	155 8	160.6	205 9	190 5
	Ile	1119 3	949 6	1007 1	1448 9	1073 6	1023.7	1040 5	1034 0	1087 1
	Leu	2228 3	1904 4	1980 2	3014 1	2076 6	2079 0	2052 8	1969 5	2163 1
	Tyr	305 6	254 7	247 4	513 2	272 3	290 4	264 8	251 2	300 0
	Phe	374 1	321 4	312 9	664 9	328.9	365 3	291.4	306 4	370 7
	Lys	258 3	261.0	259 6	237 1	263.5	257 7	239.9	261 0	254 8
	NH_3	4608 1	4577.8	4736 1	4612 9	5459.5	4320 3	4496.0	5079 6	4736 3
	Hıs	885 1	850.1	860.8	805 8	911 0	871 4	802 0	898 4	860 6
	Arg	2736.4	2608.6	2580 7	2563 6	2703 7	2732 3	2211 0	2772 2	2613 6
	Pro	1971 6	1812.7	1905 8	1724.9	1982 8	1776.4	1720 0	1987.4	1860 2



Thıs figure showed the mean values of total amıno acıd (T.A.A) and sulfur contaınıng amıno acıd (S A A ; methıonıne +cysteıne) contents of eıght varıetıes

[†]Asp aspartıc acıd, Thr threonıne, Ser serıne, Glu glutamıc acıd, Gly glycıne, Ala alanıne; Cys cysteıne, Val: valıne Met methıonıne, Ile: ısoleucıne, Leu leucıne; Tyr tyrosıne Phe phenylalanıne, Lys lysıne, Hıs hıstıdıne, Arg argınine, Pro: prolıne

[‡]DW. Daewonkong, GJ Geomȷoungkong 1, HK : Hwangkeumkong, PS Pungsannamulkong, SP Sınpaldalkong 2, SM Somyeongkong, SW Sowonkong, TK Taekwangkong

soil moisture.

Amino acids

Amino acid compositions of soybean seeds produced from the upland and drained-paddy field are presented in Table 2. Differences were detected in the contents of all amino acids including sulfur containing amino acids, methionine and cystine. Soybeans from upland field had lower contents of total amino acids compared to soybeans from drained-paddy field, with the exception of NH_3 which we presumed as an intermediate products. Nutritional and functional qualities of protein are generally determined by its amino acid content and nitrogen solubility. It is well known that soybeans are deficient in the sulfur containing amino acids, so the sulfur containing amino acids are considered as the first limiting amino acid in nutrition (Peter *et al.*, 1998).

Fatty acids

The fatty acid compositions in the soybeans produced from upland and paddy fields are shown in Table 3. Linoleic (C18 : 2), oleic (C18 : 1), palmitic (C16 : 0), linolenic (C18 : 3), and stearic acids (C18 : 0) are the principal fatty acids. The proportion of linoleic acid varied from 50.6% ('Sowonkong', drained-paddy field) to 58.8% ('Sinpaldalkong 1', drained-paddy field), whereas palmitic acid ranged from 10.8 to 12.8%, oleic acid ranged from 14.4 to 25.5% and linolenic acid ranged from 5.4 to 10.2%, respectively. No statistical differences were found in palmitic, linoleic, and linolenic, but stearic acid, oleic, saturated fatty acids (SFA), and unsaturated fatty acids (USFA) were significantly differed between the seeds from upland and drained-paddy fields. Stearic acid and SFA were significantly higher in the seeds from upland fields, while oleic and USFA were significantly higher in the seeds from drained-paddy fields. This results suggested that drained-paddy filed cultivation is more favorable to increase the USFA in the soybean seeds than upland field cultivation

It was reported that the fatty acid composition of soybean and vegetable oils varies depending on seed genealogy, planting date, and meteorological factors during the growing season (Gibson & Mullen, 1990; May *et al.*, 1993; Wolf *et al.*, 1982; Cherry *et al.*, 1985; Howell *et al.*, 1957). Furthermore, soybeans grown in cooler climates have higher contents of the polyunsaturated linoleic and linolenic acids, while monounsaturated oleic acid prevails in warmer climates (Wolf *et al.*, 1982; Cherry *et al.*, 1985; Howell *et al.*, 1957). Judging from our study results and pervious reports,

Table 3. Comparison of fatty acid composition in soybeans produced in the upland and drained-paddy fields. (Unit : %)

	Varieties	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	†SFA	‡USFA
Upland field	Daewonkong	11.6	4.9	17.9	57.2	8.4	16.5	83.5
	Geomjoungkong 1	12.0	4.2	23.9	52.6	7.3	16.2	83.8
	Hwangkeumkong	12.0	4.3	20.8	54.6	8.3	16.3	83.7
	Pungsannamulkong	12.8	5.0	21.5	55.3	5.4	17.8	82.2
	Sinpaldalkong 2	12.2	4.7	19.2	55.1	8.9	16.8	83.2
	Somyeongkong	12.3	4.8	14.6	58.3	10.1	17.1	82.9
	Sowonkong	12.7	4.9	16.2	57.5	8.8	17.5	82.5
	Taekwangkong	11.4	5.2	23.7	52.1	7.6	16.6	83.4
	Mean	12.1	4.7	19.7	55.3	8.1	16.9	83.1
Drained-paddy field	Daewonkong	12.1	3.9	25.5	51.0	7.5	16.0	84.0
	Geomjoungkong 1	11.4	3.8	23.1	53.9	7.9	15.1	84.9
	Hwangkeumkong	12.0	4.6	21.2	53.9	8.4	16.5	83.5
	Pungsannamulkong	12.1	4.3	20.1	55.1	8.4	16.5	83.5
	Sinpaldalkong 2	11.8	4.8	14.4	58.8	10.2	16.5	83.5
	Somyeongkong	12.1	4.5	16.4	58.4	8.6	16.6	83.4
	Sowonkong	10.8	4.5	26.6	50.6	7.5	15.3	84.7
	Taekwangkong	11.4	4.1	18.0	58.1	8.4	15.4	84.6
	Mean	11.7	4.3	20.7	55.0	8.4	16.0	84.0
	§LSD(0.05)	NS	0.4	0.5	NS	NS	0.6	0.6

†Saturated fatty acids, ‡Unsaturated fatty acids. §Between upland and drained-paddy fields

Table 4. Comparison of isoflavone contents in soybeans produced in the upland and drained-paddy fields. (Unit : mg/g)

Soybean varieties	Upland field				Drained-paddy field			
	Daidzein	Glycitein	Genistein	Total	Daidzein	Glycitein	Genistein	Total
Daewonkong	259.3	122.1	1433.7	1815.1	224.9	23.6	1705.3	1953.8
Geomjoungkong 1	153.0	27.9	969.1	1150.0	89.0	16.8	674.0	779.8
Hwangkeumkong	154.2	29.8	1227.1	1411.1	137.4	22.1	1937.0	2096.5
Pungsannamulkong	160.2	23.2	1071.0	1254.4	112.3	26.1	954.8	1093.2
Sinpaldalkong 2	220.4	26.6	1206.0	1453.0	180.1	18.6	1395.6	1594.3
Somyeongkong	198.1	22.6	1468.7	1689.4	206.6	25.0	1749.7	1981.3
Sowonkong	257.8	22.9	1584.3	1865.0	245.9	23.5	1721.8	1991.2
Taekwangkong	137.6	27.8	791.3	956.7	67.4	18.8	1175.2	1261.4

we suggested as possible causes that the soil condition of upland field is more aerial than drained-paddy field, and this conditions may work for increasing the SFA levels in soybeans.

Isoflavones

Isoflavone content for the soybean varieties produced from upland and drained-paddy fields shown in Table 4. The results showed that total isoflavone contents were higher in the soybeans from drained-paddy field than those of upland field, with a predominance of genistein.

The genistein contents of tested soybean varieties were higher in the soybeans from drained-paddy fields, but the contents of 'Geomjoungkong 1' which have black seed-coat and 'Pungsannamulkong' which was developed for soybean sprouts were higher in the soybeans of paddy field. This results suggested that soybean isoflavone contents are varied by cultivation methods and their physiological responses are different according to soybean varieties.

It was reported that the content of isoflavones in soybean seeds is quite variable and is affected by both genetics and environmental conditions such as growing location, temperature during seed fill (Dixon *et al.*, 1995; Lee *et al.*, 2003), and they can be stress-induced by pathogenic attack, wounding, high UV light exposure and pollution (Dixon & Paiva, 1995)

As shown in Table 4, genistein content was higher in the drained-paddy field, however, daidzein and glycitein contents were higher in the upland field. It was suggested that soil condition of drained-paddy field is more favorable to synthesis genistein than daidzein and glycitein. Because the biosynthesis of genistein has a different branch pathway from daidzein and glycitein, the availability of the substrate for certain isoflavone synthase relies on the activity level of a branch of the phenylpropanoid pathway, and isoflavones are produced under certain environmental conditions where this branch pathway is active (Jung *et al.*, 2003).

Soy isoflavones are referred to as phytoestrogens, and they appear to weakly bind to estrogen binding sites in cells and have either weak estrogen-like or antiestrogenic activity (Dixon & Ferreira, 2002, Molteni *et al.*, 1995). Isoflavones were reported to reduce risk of breast cancer and heart disease through several mechanisms, and they also reduce total cholesterol levels and show some antioxidant activity, and appear to be beneficial to arterial function as well (Fotsis *et al.*, 1993; Wei *et al.*, 1993; Molteni *et al.*, 1995). From the obtained results, we suggested that soybean cultivation in the drained-paddy field will be the one of profitable strategies for the production of high isoflavone soybeans.

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