Oil Contents and Fatty Acid Composition of Korean Perilla (*Perilla ocimoides* L.) Collections

Seong-Taek Hong*, Suk-Yeong Son[1], Seung-keun Jong[1]
Chang Woo Rho, and Jong Sun Yun
Chungbuk Agricultural Research and Extension Services, Cheongwon, 363-880, Korea
[1]Dept. of Agronomy, Chungbuk National University, Cheongju, 361-763, Korea

ABSTRACT

This study was carried out to obtain informations on the variations of oil content and fatty acid composition among 90 Korean perilla collections. Average oil content of 90 perilla collections was 44.2% with a range from 29.7% to 61.9%. Perilla collections with late-maturing, super-large seed and gray seed coat showed higher oil content than other types in general. Average saturated fatty acid content in perilla oil was 9.0% with a range from 8.2% to 10.7%, while average unsaturated fatty acid content varied from 89.3% to 91.8% with a mean of 91.0%. Contents of saturated and unsaturated fatty acids were not related to maturity. There were no differences in the contents of saturated and unsaturated fatty acids according to maturity. Linoleic acid and linolenic acid contents were the highest in the super large-sized group(15.5%) and in the large-sized seed group(61.4%), respectively, while contents of fatty acids among the perilla collections were variable with different seed coat colors. Most of the traits studied were not significantly correlated with oil content, but linoleic acid(ω-6) content was negatively correlated (r=-0.217*) with linolenic acid(ω-3) content.

Keywords **:** Fatty acid composition, Oil content, Perilla.

INTRODUCTION

Perilla(*Perilla ocimoides* L.), an annual herbaceous oilseed crop native to the eastern Asia, has been cultivated in India, Korea and the north-eastern China from the ancient times. Currently, perilla is the fourth most important oil crop in the world.

Perilla is highly regarded as nutritive source with its organic nutrients, vitamins and minerals. Perilla seeds are used as raw materials to produce tea, gruel and cake, while perilla oil is used for the production of food, paint, printing ink, water-proof materials and so on. Recently, the perilla leaves are used as important fresh vegetable as well as pickle, can, medicine and forage. Perilla has received much attention for its various biological activities

Varietal differences in oil content and fatty acid composition of perilla were reported. Oil content of perilla seeds ranged from 40.3% to 45.3%(Lee *et al.*, 1991; Kwak, 1994; Park, 1996; Ryu *et al.*, 1993), while

*Corresponding author : **Seong-Taek Hong**, E-mail : hongst2000@yahoo.co.kr

linolenic acid content ranged from 60.0% to 63.7%(Lee *et al.*, 1986; Kwak, 1994, Okuyama, 1992; Ryu *et al.*, 1993). Oil content was positively correlation with linolenic acid(Ryu *et al.*, 1993).

Ethyl acetate isolated from the roasted perilla seeds exhibited strong antioxidant activity(Jung *et al.*, 2001). Nagatsu *et al.*(1995) also reported the isolation of novel antioxidants from roasted perilla seeds.

In this study, we analyzed the oil content and the fatty acid composition of Korean perilla collections to provide basic informations useful in breeding of perilla with high quality oil.

MATERIALS AND METHODS

Total of 90 perilla collections were grown at the experimental field of Eumsung Greenhouse Agricultural Experiment Station, Chungbuk Agricultural Research & Extension Service in 2002. 90 perilla collections were randomly selected among the Korean local perilla collections made by Plant genetic Resources Division, Rural Development Administration and Chungbuk Agricultural Research & Extension Service during the last several years.

Seeds were sown in 72-cell plug trays on May 20, 2002 and 15-day old young seedlings were transplanted to field by hand on June 5. One seedling per hill was planted with a space of 20cm between hills in a row of 60cm width on June 5. Experimental field was consisted of single row plot with 7 hills per row and randomized complete block design with two replications was used.

The early maturity was flowering before august 30, the medium maturity was flowering september 1 to 10 and the late maturity was flowering after september 11.

Based on soil analysis, basal application of fertilizers, i.e., nitrogen, phosphorus, potassium, lime and compost at the rates of 4kg, 1kg, 2kg, 100kg and 1,000kg per 10a, was made before transplanting. The other cultural methods based on the standard cultural methods for Agricultural Experiments (R.D.A., 1995) were followed through out the experiment.

Oil content of perilla seeds was determined by soxtec method using hexane as a solvent. Fatty acid contents were measured by GLC(varian CP-8400 Netherland) after fatty acids of seed oil were analyzed by one step extraction/ methylation method.

RESULTS AND DISCUSSION

Oil content and fatty acid composition of 90 perilla collections of perilla groups classified based on maturity, seed size and seed coat color were presented in Table 1~6.

The average oil content of 90 perilla collections was 44.2% with a range of 29.7~61.9% (Table 1). Oil content of most of the perilla collections ranged from 36.0% to 50%, while oil content of 6 collections was higher than 50.0%. These results were similar to those of the previous reports (Lee *et al.*, 1991; Kwak, 1994; Park, 1996; Ryu *et al.*, 1993). Perilla collections from Kimcheon, Sooncheon, Namwon and Keumrung might be promising gene source in the perilla improvement

Table 1. Oil content of the 90 perilla collections of different maturity groups

Maturity group	Oil content(%)						No. of var.	Mean (%)	Min. (%)	Max. (%)
	<35	36~40	41~45	46~50	51~55	56<				
Early	2	6	15	13	1	1	23	42.6	31.3	52.1
Medium	0	4	5	5	1	0	54	44.5	29.7	61.9
Late	2	10	7	15	3	0	13	45.7	39.6	52.4
Total	4	20	27	33	5	1	90	44.2	29.7	61.9

Table 2. Oil content of the 90 perilla collections of different 1000 seed weight

1.000 seed	Oil content(%)						No. of	Mean	Min.	Max.
weight(g)	<35	36~40	41~45	46~50	51~55	56<	vars	(%)	(%)	(%)
>3.00	1	2	4	7	2	0	16	45.3	34.4	54.4
3.01~4.00	2	11	16	20	3	0	52	44.2	29.7	61.9
4.01~5.00	1	5	7	4	0	1	18	43.1	36.9	49.4
5.01~6.00	0	2	0	1	0	0	3	41.5	39.7	48.6
6.01<	0	0	0	1	0	0	1	49.7	49.7	49.7
Total	4	20	27	33	5	1	90	44.2	29.7	61.9

Table 3. Oil content in the 90 perilla collections of different seed coat color

Seed coat	Oil content(%)						No. of	Mean	Min.	Max.
color	<35	36~40	41~45	46~50	51~55	56<	var.	(%)	(%)	(%)
Dark brown	1	1	4	7	0	0	13	44.4	34.5	49.8
Brown	2	16	10	16	4	0	48	43.7	29.7	54.4
Gray brown	1	2	8	6	1	0	18	44.1	31.3	52.0
Gray	0	0	3	1	0	1	5	47.6	42.2	61.9
Light gray	0	1	2	3	0	0	6	44.8	39.9	47.8
Total	4	20	27	33	5	1	90	44.2	29.7	61.9

program for high oil content.

Oil contents were higher in the oder of late, medium and early maturing groups (Table 1). Oil contents of late, medium and early maturing groups were 45.5%, 44.5% and 42.6%, respectively. The similar results were reported in rape (Lee *et al.*, 1984; Lee *et al.*, 1991).

The oil contents of perilla collections classified based on 1,000-seed weight were as shown in Table 2. The average oil contents were higher in perilla collection groups with lower seed weight. Oil content of small (3.01~4.00g/1000 seeds), medium (4.01~5.00g/1,000 seeds), and large (5.01~6.00g of 1,000 seeds) seed collections were 44.2%, 43.1% and 41.5%, respectively. Although oil content was, in general, inversely proportional to seed size, 1 super large seed collections (larger than 6.01g/1,000 seeds) from Jincheon showed high oil content with 49.7%.

Oil content of gray seed coat was the highest with 47.6%, while that of brown seed coat was the lowest with 43.7% (Table 3). This result was different from Lee *et al.*'s(1991), but was similar to that of Park *et al.* (1996). Varietal difference and the number of varieties which belong to the same seed coat might influence oil content of perilla seeds.

The contents of the saturated and the unsaturated fatty acids were not different among maturity groups of perilla collections (Table 4). But there were a large variations in oleic and linolenic acid contents among perilla collections. The content of linolenic acid, the major fatty acid, ranged from 59.9% to 61.5% with a mean of 60.4%. Such results were similar to those of Lee *et al.* (1986), Kwak (1994), Okuyama *et al.* (1992) and Ryu *et al.* (1993). The later the maturity group was the higher the content of linoleic acid and the lower the content of linolenic acid, linoleic acid and linolenic acid was respectively significant at the 1%. This results was similar to that of Park (1996).

Table 4. Contents of fatty acids of the 90 perilla collections of different maturity groups

Maturity group	No. of varieties	Fatty acid composition(%)				
		Palmitic	Stearic	Oleic	Linoleic	Linolenic
Early	23	6.8	2.3	16.0	13.4	61.5
Medium	54	6.7	2.3	16.9	14.1	60.0
Late	13	6.7	2.5	16.0	14.9	59.9
Mean	90	6.7	2.3	16.6	14.0	60.4

Table 5. Fatty acid composition of the 90 perilla collections of different 1,000 seed weight

1,000 seed wt.(g)	No. of varieties	Fatty acid composition(%)				
		Palmitic	Stearic	Oleic	Linoleic	Linolenic
>3.00	16	6.8	2.3	16.0	14.2	60.7
3.01~4.00	52	6.7	2.3	16.4	14.0	60.6
4.01~5.00	18	6.5	2.4	17.6	14.0	59.5
5.01~6.00	3	6.6	2.1	16.7	13.1	61.4
6.01<	1	6.6	2.1	15.9	15.5	59.9
Total	90	6.7	2.3	16.6	14.0	60.4

Table 6. Fatty acid composition of the 90 perilla collections of different seed coat color

Seed coat color	No. of varieties	Fatty acid composition				
		Palmitic	Stearic	Oleic	Linoleic	Linolenic
Dark brown	13	6.8	2.4	15.1	13.5	62.2
Brown	48	6.7	2.2	16.8	14.2	60.0
Gray brown	18	6.7	2.5	17.3	14.1	59.4
Gray	5	6.7	2.4	16.0	13.8	61.2
Light gray	6	6.6	2.2	16.1	13.2	61.8
Mean	90	6.7	2.3	16.6	14.0	60.4

The palmitic acid composition of perilla collections of extremely small seeds (less than 3.0g/1,000 seeds) with 6.8% was higher than that of others, while stearic acid content of medium size seeds with 2.4% was higher than that others but not significant (Table 5). The oleic acid content was higher in the perilla collections of medium seeds with 17.6% than in others, while the linoleic acid content was higher in the perilla collections of super large seeds with 15.5%. Linolenic acid content was higher in the perilla collections of large seeds with 61.4%.

The fatty acid composition was different among perilla collections of 5 groups of seed coat colors (Table 6). The perilla collection with dark brown seeds and light gray seeds showed the highest and the lowest palmitic acid contents with 6.8% and with 6.6%, respectively. The stearic acid content was the highest (2.5%) in the perilla collections with gray brown seeds, and lowest (2.2%) in the perilla collections with brown and light gray seeds. The oleic acid content was the highest in the gray brown group with 17.3%, and the lowest in the dark brown group with 15.1%. The

Table 7. Correlation coefficients among oil content, five fatty acids, ω-6/ω-3 fatty acid ratio, SFA and UFA in the 90 perilla collections

Variable	Oil content	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	ω6/ω3 acid ratio	SFA
Palmitic acid	-.043							
Stearic acid	.035	-.113						
Oleic acid(ω-9)	.076	-.245*	.242*					
Linoleic acid(ω-6)	-.127	.090	-.187	-.352*				
Linolenic acid(ω-3)	.144	-.055	-.278**	-.815**	-.217*			
ω-6/ω-3 acid ratio	.172	.085	-.069	-.061	.945**	-.501**		
SFA	-.052	.663**	.662**	.008	-.098	-.174	.010	
UFA	.092	-.674**	-.562**	-.094	.079	.184	-.012	-.982**

SFA : Saturated fatty acid, UFA : Unsaturated fatty acid, ω-6/ω-3 ratio : ω-6 fatty acid/ω-3 fatty acid ratio
*,** : significant at the 5% and 1% level, respectively.

linoleic acid was the highest in the brown group with 14.2%, and the lowest in the light gray group with 13.2%. And, the linolenic acid was the highest in the dark brown group with 62.2%, and the lowest in the gray brown group with 59.4%. These results were different from Lee *et al.*(1991) who reported that the fatty acid contents was not related with seed coat color in perilla. Stearic acid and linolenic acid was respectively significant at the 1%.

The correlation coefficients among oil content, five fatty acids, ω-6/ω-3 fatty acid ratio, SFA(saturated fatty acids) and UFA(unsaturated fatty acids) in the 90 perilla collections are shown in Table 7. There was no significant correlation coefficients between the oil content and the other characters. This result did not correspond with the those of Lee *et al.*(1991) and Ryu *et al.*(1993).

The palmitic acid content was positively correlated with the SFA (r=+0.663**), but was negatively correlated with oleic acid content and UFA. The stearic acid content was positively correlated with the oleic acid content and SFA, but it was negatively correlated with the linolenic acid content and the UFA.

The oleic acid content was negatively correlated with the contents of linoleic and linolenic acids, and it corresponded with the result of Park(1996). The linoleic acid(ω-6) content was negatively correlated with the linolenic acid(ω-3) content (r=-0.217*), but was positively correlated with the ω-6/ω-3 acid ratio (r=+0.945**). These results were similar to those of Ryu *et al.*(1993) and Kwak(1994).

There was highly negative correlation between linolenic acid content and ω-6/ω-3 acid ratio. The SFA showed negative correlation with UFA (r=-0.982). These results were similar to those of Ryu *et al.*(1993) and Park(1996).

In peanut, one of the important oilseed crops, oil content was positively correlated with stearic acid content, and oleic acid content was negatively correlated with linolenic acid content (Park *et al.*,1991). On the other hand, in rape, oil content was positively correlated with palmitic, stearic and oleic acid contents. Oleic acid was positively correlated with linoleic acid(ω-6), and linoleic acid(ω-6) was positively correlated with linolenic acid(ω-3) (Bang *et al.*, 1991).

Oil of perilla seed is easily oxidized because of its high degree of unsaturation. Linolenic acid(ω-3) has received much attention for its various biological

activities, and is the most important fatty acid determining oil quality of perilla seeds (Ryu *et al.* 1993). Several perilla collections(Gyeonggi Pyeongtaek and Gyeongbuk Goryeong) with high linolenic acid contents might be useful as gene source to improve high oil quality lines of perilla in future.

LITERATURES CITED

Bang J.K., J.I. Lee, K.J. Kim and R.K. Park. 1991. Oil content and fatty acid composition of rapeseed. Korean J. Crop Sci. 36: 62-78.

Kwak T.S. 1994. Major growth characters and fatty acid composition of Korean native perilla collections. Korean J. Breed. 26(2): 148-154.

Lee J.I., E.D. Han, S.T. Lee and H.W. Park. 1986. Study on the Evaluation of oil quality and the differnces of fatty acid composition between varieties in perilla (*Perilla frutescens* Britton var. *Japonica* Hara) Korean J. Breed. 18(3): 226-233.

Lee J.I., J.K. Bang, B.H. Lee and K.H. Kim. 1991. Quality improvement in perilla I. Varietal differences of oil content and fatty acid composition. Korean J. Crop Sci. 36: 48-61.

Nagatsu A., K. Tenmaru, H. Matsuura, N. Murakami, T. Kobayashi, H. Okuyama and J. Sakakibara. 1995. Novel antioxidants from roasted perilla seed. Chem. Pharm. Bull. 43: 887-998.

Okuyama, H. 1992. Polyunsaturated fatty acids in human nutrition. Nestle nutrition workshop series 28: 169-178. Verey/Raven Praven Press, Ltd., New York, U.S.A.

Park C.B. 1996. Studies on quality improvement in Perilla(*Perilla ocimoides* L.). Thesis for the degree of Doctor. Chungbuk National Univ. pp.1-58.

Park H. W., J.I. Lee, J.K. Bang, B.H. Lee and K.H. Kang. 1991. Variations of Oil Content and Fatty Acid Composition in Groundnut Germplasm. Korean J. Crop Sci. 36: 33-47.

R. D. A. 1995. The standard for culture and measurment in agricultural experiment. pp. 487-573.

Ryu S.N., J.I. Lee, H.S. Lee, C.B. Park and B.R. Sung. 1993. Varietal differnce of oil content and omega fatty acid composition in Korea Local Perilla. Korean J. Crop Sci. 38(6): 560-565.

(Received Oct. 5, 2003)
(Accepted Oct. 30, 2003)