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Evaluation of Residual Pesticides in Fresh Ginseng Collected in Seoul

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Abstract This study was performed to analyze 48 kinds of pesticide residues using gas chromatography (GC)/nitrogen phosphorous detector, GC/micro electron capture detector, GC/mass selective detector, and high performance liquid chromatograph/diode array detector in 186 fresh ginseng samples collected in the Seoul area from 2010 to 2011. Fresh ginseng dietary intakes were estimated using the data from the 2009 Korea National Health and Nutrition examination survey. Residual pesticides were detected in 79 samples (42.5%) with eight different fungicides. Only 20 samples (10.8%) exceeded the maximum residue limits (MRLs) for pesticides registered by the Korea Food & Drug Administration. Among them, tolclofos-methyl residues (10.2%) exceeded the MRL for fresh ginseng in 18 ginseng seedlings and one of the two-year old fresh ginseng plants, and the residual level in just one ginseng seedling violated the MRL for pyrimethanil. The results showed that residual pesticides levels in marketable fresh ginseng around Seoul were relatively safe. The percent acceptable daily intake (%ADI) was calculated using pesticide residues in fresh ginseng and dietary intakes of fresh ginseng. The risk caused by pesticide residues in fresh ginseng was very low.

Keywords % acceptable daily intake · fresh ginseng · multi residual pesticide · tolclofos-methyl

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Introduction

Ginseng is classified based on several Latin names, including *Panax ginseng* C. A. Meyer (Korean ginseng), *Panax notoginseng* Burkill (Chinese ginseng), *Panax quinuefoloum* L. (American ginseng), and *Panax L. japonicum* (Japanese ginseng). Among them, *Panax ginseng* C. A. Meyer is in the Acanthopanax family of perennial herbaceous plants and is categorized as fresh ginseng (not dried), red ginseng (steamed and dried), white ginseng (not cooked and dried), and Taegeuksam (boiled and dried with fresh ginseng). In 2009, the share of ginseng to Korea's agricultural products was 2.0% and the production of fresh ginseng was increased by 198% compared to 1990. Quality, production, and supply and demand adjustment are absolute elements for the ginseng industry. Ginseng growing fields encompassed 19,010 ha with production of 26,944 tons, and of which 6,350 tons were exported in 2010. The per capita consumption of ginseng was 0.43 kg in 2010, and fresh ginseng occupied the highest percentage of 45.7% in ginseng industry (Ministry for Food, Agriculture, Forestry and Fisheries, 2011).

The consumption of ginseng has increased steadily with its positive health effects such as physical strength, liver protection, blood pressure control, anticancer, antidiabetic, and anti-aging effects (Nam, 2002). However, ginseng may be damaged by disease and insects during growing for 4–6 years on the same land. The most common pest injuries are Alternaria blight, damping-off, gray mold rot, and anthracnose. Also, there is high incidence of damage out of insect-slowpoke, scale bug, and snails. Ginseng-related pest injuries are known to be 38 kinds, and accordingly ginseng is reported to be the most vulnerable among crops cultivated in Korea (Kang, et al., 2007; Kim, 2007; Lee et al., 2009; Park and Kim, 2010). Therefore, various chemicals and cultivation methods are being used to control numerous pests, but pesticides are being applied more and more for the sake of effectiveness. However, the inconsistent use of pesticides has lead to overuse or misuse of pesticides in recent years. According to

the Ministry of Food, Agriculture, Forestry, and Fisheries (2011), the violation rate of maximum residue limits (MRLs) for pesticide residues has increased annually from 5.6% in 2005 to 11.4% in 2008. The accumulation levels of pesticide residues depend on the pesticide formulation type and form, the timing of its use, the concentration in spraying, the number of usage, crop varieties, cultivation methods, and time between harvesting and consumption after spraying.

The pesticides registered for ginseng at the Rural Development Administration are sorted into four categories and included 189 pesticides, 150 fungicides, 37 insecticides, and two herbicides in 2011 (KCPA, 2011). Maximum residue limits (MRLs) for ginseng and its extracts have been established for 67 pesticides by the Korea Food and Drug Administration (KFDA, 2008).

Pesticides do not degrade well under ginseng growing conditions, which include 4–6 years of cultivation under artificial shade. A total of 44.1% of farmers responded that they continuously used pesticides for 2–5 years, and 50.2% of the farmers applied pesticides for longer than 5 years (Kang et al., 2007). Analytical method studies on ginseng have been reported, but there are few systematic studies on Pesticide Residues of *Panax Ginseng*.

This study was performed to analyze 48 kinds of pesticide residues which were available for simultaneous multiresidue analysis in fresh ginseng marketed in Seoul, to assess the safety of fresh ginseng. Additionally, the dietary intake of fresh ginseng was estimated by Korea National Health and Nutrition examination survey of 2009 and the exposure levels to the pesticides were evaluated based on fresh ginseng consumption.

Materials and Methods

Materials. Pesticide residues were analyzed in 186 fresh ginseng samples, including 69 1-year-root ginseng plants, six 2-year-root ginseng plants, 40 3-year-root ginseng plants, 54 4-year-root ginseng plants and 17 5-year-root ginseng plants. All samples were purchased from retail stores, department stores, The Kyundong traditional market and Karak wholesale markets around Seoul.

Reagents and Apparatus. Pesticide standards were purchased from Dr. Ethrenstorfer GmbH (Germany). Acetonitrile and methanol (J.T. Baker, USA) were used for extraction and purification, and acetone, hexane, and dichloromethane (Kanto, Japan) were of analytical reagent grade and high performance liquid chromatography (HPLC) grade (Tedia, USA). Stock solutions of each pesticide were dissolved in acetone at a concentration of 100–300 mg/L and stored at −18°C. Gas chromatography/nitrogen phosphorous detector (GC/NPD) with blos bead and GC/micro electron capture detector (GC/μECD) with a 7890A instrument (Agilent Technologies, USA) were used to determine pesticide residues levels, and HPLC/diode array detector (Agilent Technologies) was applied, and the detected pesticides were confirmed by gas chromatography/mass selective detector (GC/MSD, 5975i, Agilent Technologies). This study focused on pesticide residue limits and investigated the residue conditions of 48 pesticides. Among them, 30 were fungicides and 18 were insecticides. The analyzed pesticides are shown in Table 1.

Method. The sample preparation procedure was carried out by slightly modifying the multiresidue method proposed by Cho et al. (2009) and KFDA (2008). Sampling was conducted according to the official methods specified in notices from the KFDA. Ground samples (20 g) were extracted with 100 mL acetonitrile for 2 min with a homogenizer (Marriet, USA) and filtered with 10–15 g sodium chloride. The extract was vigorously shaken and allowed to stand for 30 min and then centrifuged at 3000 rpm for 3 min. The upper phase (10 mL) was transferred to a 100 mL beaker and evaporated to dryness in a steam bath at 60°C under a stream of air. The dried residue was loaded onto a Sep-Pak Florisil cartridge (Phenomenex, USA) and an NH_2 cartridge (Varian Technologies, USA) for cleanup. The eluate was evaporated and redissolved in 20% acetone in hexane (2 mL) for GC/NPD and GC/μECD and in methanol (2 mL) for HPLC/DAD. The eluate was filtered through a 0.2 mm nylon syringe filter (Whatman, USA) prior to injection. Finally, 11 pesticides were assessed by GC/NPD, 26 pesticides were analyzed by GC/μECD, and 11 pesticides were applied to HPLC/DAD. Confirmation of targeted pesticide to identify was performed by GC/MSD with pesticide library. The analytical conditions of the instruments are shown in Tables 2 and 3.

Limit of detection (LOD) and recovery. The LOD and LOQ were determined by considering a signal to noise ratio of 3 and 10, respectively. They were based on the standard deviation of the response and on the slope of the analytical curve. Recovery tests of the detected pesticides were performed after adding a range of pesticides to uncontaminated fresh ginseng at a concentration of 0.1–1.5 mg/L for GC/μECD and 0.5–3.0 mg/L for GC/NPD along with the analysis of samples by the same procedure. In calculating the recovery, the spiked samples from ginseng were prepared triplicate, and the unspiked samples were also investigated.

Exposure assessment. Human exposure to pesticide residues was determined with fresh ginseng residues, food consumption data of the target population, and the exposure parameters including body weight. General human exposure assessments to hazardous substances can be divided into acute dietary exposure and chronic dietary exposure assessment. In this study, a chronic dietary exposure assessment was conducted to assess lifetime exposure to the pesticide residues, because pesticide residues in fresh ginseng will be continued for the life time.

Percent acceptable daily intake (%ADI) was calculated by the pesticide residue database in comparison with estimated daily intake (EDI)

Thus, pesticide residue safety was assessed based on this %ADI. We used a Japanese database for pesticides that did not have an ADI value in the KFDA database

$$\text{Accepatble daily intake} = \text{ADI (mg/kg/day)} \times \text{Body weight (kg)} \quad (1)$$

Table 1 Pesticides analyzed in fresh ginseng

Pesticide	Use	Molecular Formula	MRLs (mg/kg)	LOD (mg/kg)	ADI (mg/kg/day)
The pesticides analyzed by GC/NPD					
Cadusafos	insecticide	$C_{10}H_{23}O_2PS_2$	0.05	0.002	0.0005
Tebupirimfos	insecticide	$C_{13}H_{23}N_2O_3PS$	0.01	0.001	0.0002
Cyprodinil	fungicide	$C_{14}H_{15}N_3$	2.0	0.019	0.03
Diethofencarb	fungicide	$C_{14}H_{21}NO_4$	0.3	0.009	0.43
Fluazinam	fungicide	$C_{13}H_4Cl_2F_6N_4O_4$	0.7	0.011	0.01
Fludioxonil	fungicide	$C_{12}H_6F_2N_2O_2$	0.5	0.020	0.4
Flusilazole	fungicide	$C_{16}H_{15}F_2N_3Si$	0.07	0.019	0.007
Kresoxim-methyl	fungicide	$C_{18}H_{19}NO_4$	0.2	0.003	0.4
Metconazole	fungicide	$C_{17}H_{22}ClN_3O$	1.0	0029	0.01
Pencycuron	fungicide	$C_{19}H_{21}ClN_2O$	0.7	0.041	0.02
Pyrimethanil	fungicide	$C_{12}H_{13}N_3$	1.0	0.010	0.2
The pesticides analyzed by GC/ECD					
Aldrin	insecticide	$C_{12}H_8Cl_6$	0.01	0.001	0.0001
BHC-α	insecticide	$C_6H_6Cl_6$	0.01	0.001	0.0125[1)]
BHC-β				0.004	
BHC-γ				0.001	
BHC-δ				0.001	
Bifenthrin	insecticide	$C_{23}H_{22}ClF_3O_2$	0.5	0.001	0.01
Chlorfenapyr	insecticide	$C_{15}H_{11}BrClF_3N_2O$	0.1	0.002	0.026
Cyfluthrin	insecticide	$C_{22}H_{18}Cl_2FNO_3$	0.1	0.008	0.04
Cyhalothrin	insecticide	$C_{23}H_{19}ClF_3NO_3$	0.05	0.006	0.02
Cypermethrin	insecticide	$C_{22}H_{19}Cl_2NO_3$	0.1	0.003	0.02
2,4-DDT	insecticide	$C_{14}H_9Cl_5$	0.01	0.001	0.005[1)]
4,4-DDT				0.001	
4,4-DDE				0.001	
4,4-DDD				0.001	
Dieldrin	insecticide	$C_{12}H_8Cl_6O$	0.01	0.001	0.0001
Endrin	insecticide	$C_{12}H_8Cl_6O$	0.01	0.001	0.0002
Tefluthrin	insecticide	$C_{17}H_{14}ClF_7O_2$	0.1	0.001	0.005
Amisulbrom	fungicide	$C_{13}H_{13}BrFN_5O_4S_2$	0.3	0.018	0.1
Azoxystrobin	fungicide	$C_{22}H_{17}N_3O_5$	0.5	0.010	0.2
Boscalid	fungicide	$C_{18}H_{12}Cl_2N_2O$	0.3	0.021	0.04
Cyazofamid	fungicide	$C_{13}H_{13}ClN_4O_2S$	0.3	0.041	0.17
Cymoxanil	fungicide	$C_7H_{10}N_4O_3$	0.2	0.027	0.013
Chlorothalonil	fungicide	$C_8Cl_4N_2$	0.1	0.002	0.02
Dimethomorph	fungicide	$C_{21}H_{22}ClNO_4$	3.0	0.019	0.2
Flutolanil	fungicide	$C_{17}H_{16}F_3NO_2$	1.0	0.044	0.09
Prochloraz	fungicide	$C_{15}H_{16}Cl_3N_3O_2$	0.3	0.010	0.01
Quintozene	fungicide	$C_6Cl_5NO_2$	0.1	0.001	0.01
Thifluzamide	fungicide	$C_{13}H_6Br_2F_6N_2O_2S$	1.0	0.001	0.02[1)]
Tolclofos-methyl	fungicide	$C_9H_{11}Cl_2O_3PS$	1.0	0.006	0.07
Tolylfluanid	fungicide	$C_{10}H_{13}Cl_2FN_2O_2S_2$	0.2	0.001	0.08
Triflumizole	fungicide	$C_{15}H_{15}ClF_3N_3O$	0.1	0.015	0.05
Procymidone	fungicide	$C_{13}H_{11}Cl_2NO_2$	-	0.006	0.1
The pesticides analyzed by HPLC/DAD					
Acetamiprid	insecticide	$C_{10}H_{11}ClN_4$	0.1	0.015	0.071
Clothianidin	insecticide	$C_6H_8ClN_5O_2S$	0.2	0.025	0.097
Methoxyfenozide	insecticide	$C_{22}H_{28}N_2O_3$	0.2	0.033	0.1
Thiacloprid	insecticide	$C_{10}H_9ClN_4S$	0.1	0.047	0.01
Thiamethoxam	insecticide	$C_8H_{10}ClN_5O_3S$	0.1	0.017	0.012
Ethaboxam	fungicide	$C_{14}H_{16}N_4OS_2$	0.2	0.044	0.055
Fenhexamid	fungicide	$C_{14}H_{17}Cl_2NO_2$	0.3	0.020	0.2
Fluquinconazole	fungicide	$C_{16}H_8Cl_2FN_5O$	0.2	0.019	0.005
Pyraclostrobin	fungicide	$C_{19}H_{18}ClN_3O_4$	2.0	0.017	0.03
Simeconazole	fungicide	$C_{14}H_{20}FN_3OSi$	0.7	0.023	0.0085
Trifloxystrobin	fungicide	$C_{20}H_{19}F_3N_2O_4$	0.1	0.021	0.04

[1)]Japan

Table 2 Analytical conditions of GC/μECD, GC/NPD and GC/MSD

Instrument	GC-μECD	GC-NPD	GC-MSD
Column	DB-1701 (30 m×0.32 mm×0.25 μm) DB-5 (30 m×0.32 mm×0.25 μm)		HP-5MS (30 m×0.25 mm×0.25 μm)
Gas flow	N_2 (1 mL/min)	N_2 (1.4 mL/min) Air (60 mL/min) H_2 (3.5 mL/min)	He (1 mL/min)
Injection mode	Temp.: 230°C Vol.: 1 μL (splitless)	Temp.: 210°C Vol.: 1 μL (splitless)	Temp.: 230°C Vol.: 1 μL (splitless)
Detector temp.	320°C	320°C	280°C (Interface temperature)
Oven temp.	150°C (1 min)-12°C/min- 240°C (2 min)-10°C/min- 280°C (13 min)	110°C (1 min)-15°C/min- 200°C (8 min)-10°C/min- 260°C (8 min)	100°C (2 min)-10°C/min- 280°C (15 min)
Ionization			Electron impact at 70 eV
Scan range			50–550 m/z (2.91 scan/s)

Table 3 Analytical conditions of HPLC/DAD

Instrument	Agilent 1200 series		
Column	Eclipse XDB-C18 (4.6 mm ×150 mm × 5.0 μm,)		
Detector	Diode arrary detector (λ: 254 nm, scan λ: 190–400 nm)		
Flow rate	1.0 mL/min		
Column oven	30°C		
Injection vol.	10 μL		
Mobile phase Gradient Condition	Time(min)	Water (%)	Methanol (%)
	0.00	70	30
	5.00	50	50
	10.00	20	80
	15.00	5	95
	20.00	0	100
	23.00	50	50
	25.00	70	30

EDI of fresh ginseng can be expressed as:

$$\text{Estimated daily intake (mg/day/person)} = \sum_{i=1}^{n}\sum_{j=1}^{k}\left[\begin{array}{l}(\text{Pesticide average conc. (mg/kg)})_i \\ \times(\text{Daily food intake (kg/day/person)})_j\end{array}\right]$$

Daily intake of fresh ginseng was calculated by taking advantage of Korean National Health and Nutrition Examination Survey (2009) from the Centers for Disease Control and Prevention.

Results and Discussion

Distribution of residual pesticides in fresh ginseng. The distribution of residual pesticides determined in the 186 fresh ginseng samples collected in Seoul from 2010 to 2011 is shown Table 4. Residual pesticides were detected in 79 samples (42.5%). Among those, two pesticides were detected in 14 samples, and one sample was contaminated with three pesticides at the same time. Eight of the pesticides were fungicides.

Tolclofos-methyl was detected 72 times (38.7%), and was the most frequently detected pesticide. Tolclofos-methyl is an organophosphorus pesticide to prevent damping off and has a long residual period. It is applied as a soil in corporation treatment immediately after planting in a powder form or is utilized just prior to planting as a seed dressing in a water dispersible powder (Shin et al., 2010). The mean content was 1.05±2.21 mg/kg, and the distribution ranged from 0.01 to 13.32 mg/kg. Fludioxonil is applied to prevent damping-off and was found at a mean level of 0.29 mg/kg in 11 samples (5.9%). The MRL for fresh ginseng is 0.5 mg/kg. Flutolanil (MRLs: 1.0 mg/kg) was detected in 2.7% of all ginseng samples at a level of 0.48±0.28 mg/kg. Thifluzamide, tolylfluanid, and pencycuron were also present. Pyrimethanil was detected at a level of 17 times the MRLs for ginseng (1.0 mg/kg). These pesticides are mostly utilized to prevent damping-off, gray mold rot, and anthracnose. Procymidone was present in the range of 0.07–0.13 mg/kg. It has been disallowed for ginseng production. It seemed that the residues were due to imprudent spraying during growth or that ginseng growers did not obey safety guidelines. Also, the contamination of plants may be caused by absorbing residual pesticides from soil (Kim and Lee, 2002; Kang et al., 2007).

Residual pesticides in fresh ginseng by growth year are shown in Table 5. Of the 186 fresh ginseng samples, pesticides exceeded the MRLs in 20 fresh ginseng samples (10.8%). Tolclofos-methyl and pyrimethanil residues exceeded the MRLs (<1.0 mg/kg) in 19 and one fresh ginseng sample, respectively. The majority of the number of pesticide ginseng violations was found in seedlings. Nineteen (27.5%) of 69 ginseng seedlings and one 2-year-old ginseng were contaminated in excess of the MRLs. The rate of detection was relatively higher in ginseng seedlings (76.8%) and 2-year-old ginseng roots and that of 3-year-old ginseng roots was similar to that of 4 and 5-year-old samples. But, a greater number of samples are needed for further inspection to verify our results.

Table 4 Mean, detection range, and recovery of the detected pesticide residues

Pesticides	No. of detected frequencies	Mean ± SD[1)] (mg/kg)	Detection range (mg/kg)	Recovery (%)	RSD (%)
Tolclofos-methyl	72	1.05±2.21	0.01-13.32	101.6	5.4
Fludioxonil	11	0.29±0.11	0.15-0.44	99.4	6.3
Flutolanil	5	0.48±0.28	0.22-0.93	89.9	8.6
Procymidone	3	0.09±0.03	0.07-0.13	105.4	4.3
Thifluzamide	2	0.74±0.04	0.71-0.74	80.9	10.1
Pencycuron	1	0.07	-	96.7	5.6
Pyrimethanil	1	17.12	-	98.5	4.5
Tolylfluanid	1	0.12	-	115.2	9.6

[1)]Pesticide concentration

Table 5 Distribution of residual pesticides in fresh ginseng by year

Pesticides	ginseng seedling	2 year old ginseng	3 year old ginseng	4 year old ginseng	5 year old ginseng
Tolclofos-methyl	40(18)[1)]	3(1)	11	13	5
Fludioxonil	6	1	2	2	-
Flutolanil	4	1	-	-	-
Procymidone	1	-	1	-	1
Thifluzamide	1	1	-	-	-
Tolylfluanid	-	-	1	-	-
Pencycuron	-	-	-	1	-
Pyrimethanil	1(1)	-	-	-	-
Total	53(19)	6(1)	15	16	6
Detection rate (%)	76.8	100.0	37.5	29.6	35.3
Violation rate (%)	27.5	16.7	-	-	-

( )[1)] No. of samples violating maximum residues limits

Some studies on residual pesticides detected in contaminated ginseng and its production are shown in Table 6. Kim (2007) reported that the tolclofos-methyl concentration in fresh ginseng collected in Sangju was 0.054 mg/kg. According to Ministry for Food, Agriculture, Forestry, and Fisheries, tolclofos-methyl, procymidone, cypermethrin, endosulfan, and diethofencarb were present in ginseng in 2008. Additionally, Hong (2004) reported that tolclofos-methyl, procymidone, and quintozene were detected in 30 domestic fresh ginseng plants cultivated for more than 4 years, and that tolclofos-methyl was present at a concentration of 0.102–1.480 ppm. This was a lower level than that of our study, but the detection rate was somewhat higher. Procymidone was present at a rate of 40% (0.035–1.383 ppm). Park and Kim (2010) discovered that residual organochlorine pesticides do not remain in ginseng cultivated in Yeungju and Sangju of North Gyeongbuk. Our results were very different for the kinds of pesticides. The Gyeonggi-do Institute of Health and Environment (2012) reported that among 412 fresh ginseng samples collected in Gyeonggi-do from 2006–2010, the rate of detection was 23.1% for tolclofos-methyl and 22.1% for fludioxonil, boscalid, and quintozene were present. However, the amount of tolclofos-methyl detected in two ginsengs and fludioxonil residue in one sample violated the MRLs, it occurred in only 0.3% of the samples. Thus, the violation level appeared to be somewhat lower. In the first half of the year 2010, pesticides were detected in nine samples (24.3%), exceeded the MRLs in two samples (5.4%), and tolclofos-methyl was detected in 37 fresh ginseng samples collected in Busan (Park et al., 2011). Oh (2009) suggested that 10 *baeksam* (two Chinese ginsengs, eight Korean ginsengs) samples were not contaminated with pesticides. Meanwhile, quintozene and benzene hexachloride (BHC) have been detected in imported ginseng from China (Hong, 2004; Park and Oh, 2004). Quintozene was detected in the range of 0.0701–2.0452 ppm but organochlorine pesticides such as dichloro-diphenyl-trichloroethane (DDT), aldrin, dieldrin and endrin were not detected (Leung et al., 2005).

Durgnat et al. (2005) reported that 43% of 30 samples contained residual pesticides, and that the MRL was exceeded for quintozene, BHC, lindane, and folpet in Asian and American ginseng extracts purchased in Europe, USA, and China. Organochlorine pesticides (α, β-BHC, aldrin, and dieldrin) were detected in 31.7% of 60 *P. quinuefoloum* L. samples (Wu et al., 2011). Organochlorine pesticides such as quintozene, DDT, aldrin, and dieldrin were detected in 75.0 and 69.2% of the liquid and solid ginseng samples consumed in the USA, Europe, and Asia, respectively (Khan et al., 2001). These results were similar to those of Wu et al. (2011).

Kim et al. (2008) reported that tolclofos-methyl, treated by dressing ginseng seeds, was at a concentration of 0.13 mg/kg, which was below the Korean MRL. But, pesticide residues were detected in both ginseng and ginseng field soil, and many ginseng

Table 6 Examples of residual pesticides detected in ginseng and its production

Samples	Detected Pesticides	References
Fresh ginseng	Tolclofos-methyl	Park et al., 2011
Fresh ginseng	Tolclofos-methyl, Fludioxonil, Boscalid, Quintozene	GIHE[1)], 2012
Korean ginseng	Tolclofos-methyl, Procymidone, Diazinon, Parathion, Quintozene, Cypermethrin, Deltamethrin	Hong, 2004
Korean ginseng	Tolclofos-methyl	Kim, 2007
Korean ginseng	Tolclofos-methyl	Kim et al., 2008
Chinese ginseng	BHC, Deltamethrin, Quintozene	Hong, 2004
Chinese ginseng	Quintozene, BHC	Park and Oh, 2004
Chinese ginseng	Quintozene, BHC, Lindane	Leung et al., 2005
Ginseng production	Quintozene, DDT, β-BHC, Lindane, Chlorothalonil, Aldrin, Dieldrin, Dicofol, Chlordane	Khan, 2001
Asian and American ginseng extracts	Quintozene, BHC, Lindane, chlorpyrifos, Folpet	Durgnat et al., 2005
American ginseng	α,β-BHC, Aldrin, Dieldrin	Wu et al., 2011

[1)]Gyeonggi-do Institute of Health and Environment

Table 7 Estimated daily intake (EDI) and percent acceptable daily intake (%ADI) for pesticides in fresh ginseng

Pesticides	EDI (mg/day/person)		% ADI	
	Mean	95th	Mean	95th
Tolclofos-methyl	1.07E-02	3.57E-02	2.79E-01	9.27E-01
Fludioxonil	2.97E-03	9.86E-03	1.35E-02	4.48E-02
Flutolanil	4.91E-03	1.63E-02	9.92E-02	3.30E-01
Procymidone	9.21E-04	3.06E-03	1.67E-02	5.56E-02

growers mostly spray tolclofos-methyl as a disinfectant, unlike guidelines for safe use of pesticides. In our study, tolclofos-methyl was being used mostly on ginseng roots. Thus, ginseng growers must be educated on the guidelines for the safe use of pesticides and be banned from using unregistered compounds.

Exposure assessment. Pesticides detected more than three times in the residue analysis became the target pesticides for an exposure assessment. It is important to evaluate safety in groups who consume the greatest quantities of fresh ginseng the reason why the consumption of fresh ginseng can vary greatly depending on preference.

Dietary intakes for fresh ginseng were estimated using the data from the Korea National Health and Nutrition examination survey in 2009 to avoid underestimating consumer intakes. Fresh ginseng intakes were identified as 200 people from the Korea National Health and Nutrition examination survey in 2009.

Mean intake was 10.23 g/day and the 95th percentile intake of the high-consumption group was 34.00 g/day, (range: 0.22–127.42 g/day). The estimated daily intake and % ADI in the mean intake group and the high-consumption group are shown in Table 6. The worst case scenario, or the group who consumed fresh ginseng with pesticide residues was assumed, and the mean intake group and the high-consumption group had % ADIs of 2.79×10^{-1} and 9.27×10^{-1} tolclofos-methyl, respectively.

However, these % ADI were very low and the risk from fresh ginseng intakes was insignificant.

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