JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

J. Agric. Food Chem. **2005,** *53,* 4637−4642 **4637**

Ochratoxin A in Korean Food Commodities: Occurrence and Safety Evaluation

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To evaluate the exposure of Koreans to ochratoxin A, we conducted a survey in 2003 for ochratoxin A in various domestic food commodities: 60 polished rices, 22 barleys, 35 wheat flours, 46 beers, and 14 unstrained rice wine (makkolli) samples. They were analyzed for ochratoxin A using immunoaffinity column and high-performance liquid chromatography (HPLC)−fluorescence detection, and the positive samples were confirmed using HPLC−tandem mass spectrometry. By combining results from different surveys on the levels of ochratoxin A in selected foods and the consumption patterns, we obtained the Korean probable daily intakes (PDI) of ochratoxin A. The polished rice commodity had the highest mean levels of ochratoxin A, which ranged from 0.2 (not detected, i.e., ND = 0) to 1.0 ng/g (ND = limit of detection, i.e., LOD). The estimated PDI for all Koreans fell into the range of 0.8−4.1 ng/kg bw/day, while for heavy consumers the estimates ranged from 1.7 to 9.1 ng/kg bw/day, which did not exceed the PTDI value (14 ng/kg bw/day). Staple rice is the major contributor (>90%) to the Korean dietary intake of ochratoxin A. On the basis of these estimates, it may be concluded that there is at present no considerable risk of ochratoxin A exposure for the average Korean consumer.

KEYWORDS: Ochratoxin A; cereals; polished rice; Korea; estimated daily intakes

INTRODUCTION

Since the chlorinated isocoumarin mycotoxin ochratoxin A (**Figure 1**) was discovered in 1965 by South African scientists as a toxic metabolite of *Aspergillus ochraceus*, other species of the *A. ochraceus* group and *Penicillium verrucosum* also have shown to produce ochratoxin A (*1*−*3*). These fungi may frequently occur in various cereals, e.g., barley, corn, and wheat, and produce this secondary metabolite in the fields or during storage. It is mainly found as a natural contaminant of cereals (*4*). However, there is evidence that it can occur in a wide range of foods such as cocoa products, beer, coffee, wine, as well as in edible pork tissues (*5*−*9*) as a result of carryover from animal feed. Previous surveys of food grains and food products conducted in Korea have shown that about 10% out of 88 samples of polished rice, a dietary staple accounting for 16% of the Korean total diet, and more than 70% of cereals and grain products in the Korean diet in 2002 were contaminated with ochratoxin A (*10*, *11*). From experimental toxicosis in animal species and epidemiological studies, it is nephrotoxic in small concentrations to vertebrates including humans and livestock when introduced via a natural route and is suspected to be a possible determinant of the chronic human disease Balkan endemic nephropathy (BEN) (*12*, *13*). On the basis of the above information, the International Agency for Research on Cancer concluded in 1993 that ochratoxin A is a "possible human carcinogen" (*14*). In 2001, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable daily intake (PTDI) for ochratoxin A, the daily amounts of ochratoxin A that can be consumed without noticeable risk over an entire lifetime, of 14 ng/kg of body weight per day (*15*).

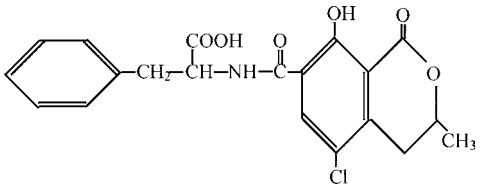

Figure 1. Structure of ochratoxin A.

Thirty-one countries have set regulatory or guideline limits for ochratoxin A in the range of 3−5 ng/g in cereals and/or cereal products (*16*). In Korea, however, there is no residue limit established for mycotoxins except aflatoxins, and an action limit for ochratoxin A has not been discussed yet. Furthermore, there are very few surveys on actual levels of ochratoxin A in Korean food products (*10*, *11*). Earlier, we estimated daily exposure of Koreans to AFB_1 from various commodities and noted that rice turns out to be the major contributor to the AFB_1 intake by Koreans, because of its high daily consumption (*17*). Thus, Koreans may be exposed to the threat of AFB_1. According to

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10.1021/jf050227j CCC: $30.25
Published on Web 04/21/2005

the latest study, levels of ochratoxin A in Korean rice were relatively high as compared to those reported in other countries (*11*). Therefore, considering the high amount of rice as a staple food in this country and the significant levels of ochratoxin A contamination, the consumption of rice contaminated with ochratoxin A may pose a hazard to public health.

In the present study, we determined the natural occurrence of ochratoxin A in Korean cereals or cereal-derived foods such as polished rice, barley, wheat flour, beer, and unstrained rice wine (makkolli) by using high-performance liquid chromatography (HPLC) with fluorescence detection (FD) after cleanup with immunoaffinity columns (IAC). Positive samples were confirmed by HPLC with electrospray ionization (ESI) tandem mass spectrometry (MS/MS). We also estimated Korean probable daily intakes (PDIs) of ochratoxin A from the level of ochratoxin A in selected foods combined with the consumption patterns, obtained by dietary recall for different ages and sexes of the Korean population (*18*). To evaluate ochratoxin A-related risk in Koreans, the data on exposure assessment (PDIs) were compared with the risk assessment such as the PTDI for ochratoxin A recommended by the JECFA (*15*).

MATERIALS AND METHODS

Safety. Ochratoxin A is a powerful experimental nephrotoxin as well as a carcinogen and should be handled with care.

Chemicals and Analytical Standard. HPLC grade solvents and analytical grade reagents were used for all purposes. Ochratoxin A standard was purchased from Sigma (St. Louis, MO), and a stock solution was prepared in toluene/acetic acid (99:1), which was stored in an amber vial in a freezer (ca −18 °C). Standard solutions for HPLC were prepared by appropriate dilution in the mobile phase, acetonitrile/water/acetic acid (57:43:2).

Samples. From February to April 2003, a total of 177 samples comprising polished rice ($n = 60$), beer ($n = 46$), wheat flour ($n = 35$), unstrained rice wine (makkolli, $n = 14$), and barley ($n = 22$) were obtained for analysis. These were selected from 108 foods on a typical food list in Korea (*18*). All specimens originating in Korea were obtained at the retail level in Seoul, Korea, and at least 0.5 kg or 0.5 L (for beer and makkolli) of each sample was collected. The samples of beer and makkolli were obtained by stratified random sampling based on market share information; half of the samples in each beverage were from the companies in the upper 25% of the market share, while 30% and the remaining 20% of the samples were from the companies in the middle 50% and in the lower 25% of the market share, respectively. All of the solid samples were ground using a commercial blender (KitchenAid, St. Joseph, MI) for 3 min to pass at least a US #20 sieve and then kept in a refrigerator (4 °C) until analysis.

Ochratoxin A Determination. The method employed was based on reversed-phase HPLC with FD and IAC cleanup, according to the modified procedure of Entwisle et al. (*19*). Ten grams of ground samples was extracted with 50 mL of methanol/3% aqueous sodium bicarbonate (50:50) by shaking for 1 h using a horizontal shaker, centrifuged for 10 min at 3000*g*, and filtered through a Whatman #41 paper filter, and then, the filtrate was collected. Ten milliliters of filtrate was mixed with 10 mL of phosphate-buffered saline (PBS, 0.2 g of potassium chloride, 0.2 g of potassium dihydrogen phosphate, 1.16 g of disodium hydrogen phosphate, 8 g of sodium chloride, and 1 g of sodium azide in 1 L of distilled water, adjusted to pH 7.0 with 1 N HCl); from this, an aliquot of 10 mL was passed through an OchraTest IAC (Vicam, Watertown, MA) attached onto a Visiprep vacuum manifold (Supelco, Bellefonte, PA). The IAC was washed with 10 mL of PBS followed by 10 mL of water and then dried with air for about 30 s. Ochratoxin A was eluted with 2 mL of methanol at a flow of 1−1.5 mL/min. The methanol eluate was evaporated to dryness under a stream of nitrogen at 35 °C and reconstituted in 100 μL of mobile phase. In the case of beverage samples such as beer and makkolli, the modified procedure of Visconti et al. (*20*) was used. Briefly, 10 mL portions of beverage samples were diluted with 90 mL of PBS and blended for 3 min at 10000 rpm using a benchtop homogenizer (Polytron, Kinematica AG, Littau, Switzerland). The mixture was centrifuged for 10 min at 5000*g* and filtered through a Whatman #41 paper filter. A 20 mL volume of filtrate was cleaned up as described above with OchraTest IAC.

A HPLC−FD system equipped with a model 616 pump, a model 717 plus injection module, and a model 474 fluorescence detector with excitation at 330 nm and emission cutoff at 440 nm (Waters, Milford, MA) was used. Separation was done on a 150 mm × 3.9 mm i.d., 5 μm, column (Nova-Pack C_{18}, Waters). The mobile phase was acetonitrile/water/acetic acid (57:43:2) pumped at a constant flow rate of 0.5 mL/min. The limit of detection (LOD) of ochratoxin A (signal/noise = 5) for cereals and cereal products obtained in this study was 0.5 ng/g, while that of beverage was about 0.2 ng/mL. For recovery tests, uncontaminated samples of each food were spiked with ochratoxin A corresponding to 10 ng/g (barley, rice, and wheat flour) or 2 ng/mL (beer and makkolli) and analyzed in triplicate using the same procedure as described for these foods.

To confirm the presence of ochratoxin A in the positive samples by HPLC−MS/MS, each cleaned-up extract found to contain ochratoxin A by HPLC was reevaporated and then dissolved in a mobile phase of acetonitrile/methanol/water (1:1:1) with 40 mM formic acid. HPLC−MS/MS analysis was performed by a minor modification of a method described by Scott et al. (*21*) with a VG Biotech platform MS (VG Biotech., Cheshire, United Kingdom) with ESI in positive ion mode: the cone voltage (90 eV) was applied, and the flow rate of ESI nebulizing gas (N_2) was 25 L/h. The MS platform interfaced with a HP 1100 HPLC system (Agilent Technologies, Palo Alto, CA) was equipped with a 250 mm × 2 mm i.d., 5 μm, column (UltraCarb ODS 30, Phenomenex, Torrance, CA). The molecular and major daughter ions equivalent to m/z 404 $[M + H]^+$ and m/z 358 $[M + H - H_2O - CO]^+$ were monitored. The flow rate was 0.2 mL/min.

Exposure Assessment. The daily intake of ochratoxin A through food depends on both the concentration in the food and the amount consumed. In addition to data from this survey, ochratoxin A occurrence data from previous surveys carried out in Korea were also used in order to estimate ochratoxin A risk assessment. In determining the true mean ochratoxin A content, the level of ochratoxin A in samples below LOD was assumed as either zero (free of ochratoxin A) or LOD (not detectable ochratoxin A). Food consumption data for each food item were obtained from the Korean National Health and Nutrition Survey, conducted from November to December 2001 (*18*). This survey included a quantitative description of the daily consumption estimated by a 24 h recall method and a recording of sex, age, and body weight of 9968 individuals belonging to 3398 households. For the dietary ochratoxin A estimates of average and heavy consumers in Korea, consumption rates for all Koreans and for 95th percentile of consumer were used, respectively. In particular, dietary estimates of ochratoxin A for the heavy consumer were summed up to achieve a worst case scenario. In addition to intake estimates based on a 55 kg body weight for all Koreans, estimates were also made by sex (female and male) and by residential district (urban and rural population), as the consumption rates of some foods in each category are highly variable because of different dietary habits; beer is consumed more by the Korean male, while rice and makkolli are typically consumed more in rural areas. Because exposure assessment of dietary chemicals should address vulnerable subpopulations such as children, pregnant women, or the elderly, as well as the heavy consumer (95th percentile), we evaluated the mean dietary intakes of ochratoxin A, which were estimated by using both individual food intake data and mean body weights for each age group of concern, as a function of age.

Statistics. Analysis of variance ($P < 0.05$) for PDI values estimated for both average Koreans and the heavy consumer (95th percentile) was performed by using SigmaStat (Jandel Scientific., Version 3.0, San Rafael, CA.), while the regression curves (exponential linear combination model) predicting the dietary ochratoxin A intakes against age were carried out by using SigmaPlot (Jandel Scientific, Version 8.0).

RESULTS AND DISCUSSION

Recoveries of Ochratoxin A from Food Commodites. IAC cleanup for ochratoxin A was initially developed by Sharman

Table 1. Number of Contaminated Samples and Levels of Ochratoxin A in Various Domestic Food Commodities Marketed in Korea

	contaminated samples				mean[b]	
commodity	1998–1999	2002	2003[a]	range (ng/g or mL)	ND = 0	ND = LOD
polished rice		8/88[c]	5/60	0.9–6.0	0.2	1.0
barley	0/30[d]		5/22	0.6–0.9	< 0.1	0.8
wheat flour			0/35	<0.5	0	0.5
beer			2/46	0.2–0.3	< 0.1	0.2
makkolli			0/14	<0.2	0	0.2
total	0/30	8/88	12[e]/177	<0.2–6.0		

[a] Present survey. [b] Samples below the level of detection (ND) were taken as either 0 or the LOD. [c] Survey data of Park et al. (*11*). [d] Survey data of Park et al. (*10*). [e] All of the positive samples detected by HPLC–FD were confirmed by HPLC-MS/MS for the presence of ochratoxin A.

et al. (*22*) and applied to ochratoxin A determination in cereals and animal-derived products. The OchraTest column was evaluated for beer analysis by Scott and Kanhere and has been applied to the determination of ochratoxin A in wheat and wine (*20*, *23*, *24*). We found the IAC performed well for analysis of polished rice, beer, barley, and wheat flour, all giving good recoveries (>80%) of added ochratoxin A with low relative standard deviations for within-day repeatability (RSD) ranging from 5 to 8%. These results are in agreement with those obtained by others from collaborative studies (*19*, *24*). In particular, recoveries from polished rice and barley spiked with ochratoxin A were consistently higher than those reported in our previous studies, in which liquid−liquid partition and Sep-Pak C_{18} cleanup were employed (*10*, *11*). However, there appeared to be lower recoveries (<60%) with makkolli than with other commodities. Several experiments were tried to improve recoveries of ochratoxin A from the makkolli samples by modifying the extraction solvent and the ratios of sample to extraction solvent: methanol/3% aqueous sodium bicarbonate (50:50), a solvent that has recently come into favor for extraction of ochratoxin A from solid samples, was attempted instead of PBS; different ratios (1:1−1:5) were tested; instead, a 1:9 ratio was used. Even extraction with chloroform followed by partition with 3% aqueous sodium bicarbonate, which was used in previous reports, did not enhance the recoveries of ochratoxin A (data not shown) (*10*, *11*). Recoveries of ochratoxin A added to a blank extract at the same spiking level were more than 90%, indicating that the losses did not occur in the IAC cleanup procedure. These results led us to assume that some substances in unstrained rice wine may react with ochratoxin A, so giving low recoveries. Further studies on makkolli for ochratoxin A are desirable to solve the recovery problem and enable routine analysis.

Occurrence Data on Ochratoxin A in Food Commodities. The results of surveys including the previous ones done on barley samples and polished rice are shown in **Table 1**, which indicates the range of the ochratoxin A concentrations obtained for each commodity and the overall means (*10*, *11*). Overall mean levels of ochratoxin A in Korean food commodities varied from levels below LOD (<0.5 ng/g or <0.2 ng/mL) to 1.0 ng ochratoxin A/g. The highest level of ochratoxin A found was detected in a polished rice sample (6.0 ng/g) (*11*). The mean ochratoxin A content was calculated by assuming that the level of ochratoxin A in samples below the LOD was either equal to zero (not detected, i.e., ND = 0) or equal to LOD (ND = LOD). Therefore, the true mean was somewhere between these two estimates, which depends on the LOD of the analytical method employed, the number of samples below the LOD, as well the distribution of ochratoxin A content. For polished rice, incidences and levels of ochratoxin A present in the samples analyzed in this study were very consistent with those analyzed in a previous survey (*11*). The polished rice commodity had the highest levels of ochratoxin A, which ranged from 0.9 to 6.0 ng/g, while the wheat flour samples did not contain detectable ochratoxin A (<0.5 ng/g). In particular, ochratoxin A levels in nine (six from 2002, three from this 2003 survey) of the polished rice samples were above the European Union tolerable limit (3 ng/g) established for cereal grains destined to human consumption (*16*). There are some recent surveys on the natural occurrence of ochratoxin A in rice and rice products available: rice flour in Italy and rice-based baby cereals in Canada and Italy (*25*, *26*). The levels of this mycotoxin in these rice commodities were quite low (<1 ng/g) as compared to our results, except for a rice-based infant cereal sample (2.4 ng/g) found in Canada (*26*). This would suggest that Korean rice is susceptible to ochratoxin A contamination and may be supported by the latest studies on the occurrence in Korean polished rice of *Penicillium verrucosum*, known as an ochratoxin A producer in temperate climates (*11*). On the other hand, studies on the effect of milling on ochratoxin A in wheat indicated that it is significantly removed by scouring because a high proportion exists in the bran fraction (*27*). Thus, levels of ochratoxin A found in wheat flour are usually low, at levels below 1 ng/g, and also comparable to our findings. Experiments on the effect of milling on rice grains should be made because the presence of ochratoxin A in polished rice samples could indicate the existence of much higher levels in rice grains.

Relatively high ochratoxin A concentrations were found in the barley samples analyzed in this survey, the average concentration being between <0.1 and 0.8 ng/g for ND = 0 and ND = LOD, respectively. However, because barley is less frequently consumed in Korea than rice, the contribution of barley grains to the total ochratoxin A intake is relatively low (approximately less than 4%) (**Table 2**). This is the first report on the detection of ochratoxin A in Korean domestic beer. The incidence was low (4.3%), and of the 46 samples analyzed, two samples contained detectable amounts of ochratoxin A, whereas the limited number of makkollli (n = 14) did not have a detectable level (<0.2 ng/mL). In comparison, more than 50% of beer samples in Canada, Denmark, and Italy were contaminated with ochratoxin A (*23*, *28*, *29*). However, occurrence levels in beer in these countries were as low (<1 ng/mL) as we analyzed in Korean domestic beer.

Dietary Intake of Ochratoxin A. On the basis of data on Korean surveys for cereals and cereal-derived products, we estimated dietary intakes of ochratoxin A from the consumption of individual food commodities by the average Korean and the heavy consumers (95th percentile), respectively (**Table 2**). Assuming an average Korean with body weight of 55 kg and no difference in body weight within both categories, the estimated PDI for all Koreans ranged from 0.8 to 4.1 ng/kg bw/day, while for heavy consumers the estimates ranged from 1.7 to 9.1 ng/kg bw/day. These results indicate that the presence of ochratoxin A in a polished rice contributes more than 90% to the total intake, because polished rice contained the highest levels among the foods analyzed; also, its consumption rate by Koreans is much higher than that of any other Korean commodities. Other sources of ochratoxin A intake in Korea are from the intake of barley and beer commodities. Foods that contribute most to intakes of ochratoxin A would be expected to vary because of the large national and regional differences in the intakes of food commodities. The major dietary sources

Table 2. Estimated Korean Daily Intakes of Ochratoxin A by Average Persons and Heavy Consumers (95th Percentile)

	all persons[a]			heavy consumers[a]		
		ochratoxin A intake			ochratoxin A intake	
commodity	food intake (g/day)	ND = 0[b]	ND = LOD[b]	food intake (g/day)	ND = 0[b]	ND = LOD[b]
polished rice	215.9	0.8	3.9	452.5	1.6	8.2
barley	4.3	>0.1	0.1	24.7	>01	0.4
wheat flour	5.1	0	>0.1	27.2	0	0.2
beer	24.9	>0.1	0.1	54.9	>0.1	0.2
makkolli	4.9	0	>0.1	24.7	0	>0.1
PDI (ng/kg bw/day)		0.8	4.1		1.7	9.1

[a] Korean average body weight is 55 kg. [b] Samples below the level of detection (ND) were taken as either 0 or the LOD.

Table 3. Comparison of Korean Daily Intakes of Ochratoxin A by Separate Groups Divided by Sex

	female[a]			male[a]		
		ochratoxin A intake			ochratoxin A intake	
commodity	food intake (g/day)	ND = 0[b]	ND = LOD[b]	food intake (g/day)	ND = 0[b]	ND = LOD[b]
polished rice	190.5	38.1	190.5	244.1	48.8	244.1
barley	3.9	0.2	3.1	4.8	0.3	3.8
wheat flour	5.4	0	2.7	4.7	0	2.4
beer	15.7	0.2	3.1	35.2	0.4	7.0
makkolli	2.6	0	0.5	7.4	0	1.5
total intakes (ng/person/day)		38.5	200.0		49.5	258.8

[a] Body weights are 51.2 and 57.4 kg for Korean females and males, respectively. [b] Samples below the level of detection (ND) were taken as either 0 or the LOD.

Table 4. Comparison of Korean Daily Intakes of Ochratoxin A by Separate Groups Divided by Residential District

	urban populations			rural populations		
		ochratoxin A intake			ochratoxin A intake	
commodity	food intake (g/day)	ND = 0[a]	ND = LOD[a]	food intake (g/day)	ND = 0[a]	ND = LOD[a]
polished rice	209.2	41.8	209.2	237.6	47.5	237.6
barley	4.3	0.2	3.4	3.8	0.2	3.0
wheat flour	5.1	0	2.6	3.7	0	1.8
beer	27.0	0.3	5.4	16.0	0.2	3.2
makkolli	4.9	0	1	7.0	0	1.4
total intakes (ng/person/day)		42.4	221.6		47.9	247.1

[a] Samples below the level of detection (ND) were taken as either 0 or the LOD.

of ochratoxin A in Europeans and North American areas are cereals (i.e., flour-based foods) and wine, with minor quantities from grape juice, coffee, and dried vine fruits (*15*, *30*). In Korea, most of the above-mentioned commodities are imported from other countries, and furthermore, they are not listed in the representative food list in this country due to their relatively low daily consumption rates; coffee beverage, wine, and dried vine fruits are consumed only at 7.1, 0.3, and 0.1 g/person/day, respectively, from the 2001 National Health and Nutrition Survey (*18*). As is usual, the PDI of dietary chemicals for all populations is made to address possible concerns about a chronic exposure, while that for extreme consumers (95th percentile) is useful not only to predict the acute exposure to humans if it happens but to assess the chemical-related risk threatening the highly vulnerable subgroups such as infants and the elderly. Because the summed PDI for heavy consumers is based on the worst scenario that specific subgroups will consume more in all food commodities, this figure may be an overestimate. The PDI of ochratoxin A for heavy consumers in Korea estimated in this study is significantly higher than that for all Koreans ($P < 0.05$), but it appears to be well below the PTDI recently set by JECFA (100 ng ochratoxin A/kg bw/week, corresponding to 14 ng ochratoxin A/kg bw/day).

Dietary intakes of ochratoxin A in different groups according to sex or residential district were also estimated to find out which groups are more exposed to the health risk caused by dietary ochratoxin A and are summarized in **Tables 3** and **4**. The Korean male appears to consume more ochratoxin A than the Korean female, but considering that Korean males (57.4 kg) are slightly heavier than females (51.2 kg), there may be no marked difference in dietary ochratoxin A estimates between them (**Table 3**) (*18*). No trend emerged in the average consumption of ochratoxin A by sex. For rural dwellers, the estimates ranged from 47.9 to 247.1 ng ochratoxin A/person/day, with urban dwellers consuming somewhat less than this (**Table 4**); the higher consumption rate of staple rice in rural districts seems to cause this difference. Studies on Korean standards by residential district conducted in 1993 demonstrated that the average body weight of rural populations was lower than that of urban populations, and it is supposed that this trend will become intensified gradually (*31*). The rural population's light weight seems to be caused by low caloric intake because

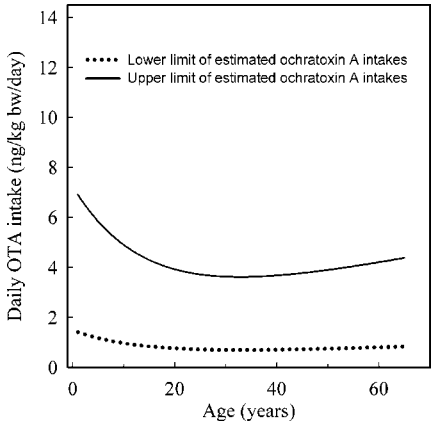

Figure 2. Distribution of Korean daily intakes of ochratoxin A as a function of age. The solid and dotted lines obtained by nonlinear regression represent the upper and lower limits of estimated intakes as a function of age, respectively.

of the lower income. Thus, the higher intake of ochratoxin A and the lower body weight of rural dwellers could make the difference in daily intake of ochratoxin A per kg body weight between both groups wider. Furthermore, in farming communities, where locally harvested food may be consumed, acute exposure to ochratoxin A combined with chronic exposure could be encountered. Detailed studies on rural populations will be needed to realize whether this subpopulation is made at risk.

In general, dietary exposure to mycotoxins occurs during the lifespan of humans. Therefore, if mean consumption data as well as mean body weight of people in the same age bracket are available, the daily intakes of ochratoxin A within a lifespan could be plotted as a function of age. Fitting these data to the regression curves ($r^2 > 0.84$) yields the results presented in **Figure 2**, showing that the relative intake tends to decrease with age. Toddlers (1−2 year old children) appear to be the most susceptible group in Korea, with the other age groups consuming less than this; the highest consumption of polished rice relative to body weight is noted in this group. The "true Korean exposure to dietary ochratoxin A" lies somewhere between both regression curves shown in **Figure 2**, and it is unlikely to approach the PTDI (14 ng/kg bw/day). It has been estimated that the intakes of ochratoxin A were 5.0 ng/kg bw/day for the highest exposure group in Canada and about 6.4 ng/kg bw/day (corresponding to 45 ng/kg bw/week) for all Europeans (*15*, *30*). In comparison with other countries, the intake of ochratoxin A in Korean seems to be comparable with those in certain other European and North American areas, even though the contributors to ochratoxin A intake were different. On the other hand, recent exposure assessments done in areas with a high incidence of BEN demonstrated that the weekly intake of ochratoxin A (92.7 ng/kg bw/week) was near the TDI value (*32*). On the basis of some estimates done in the present studies, it may be concluded that there is no considerable risk for the average Korean consumer. For the most vulnerable group in Korea, the margin between PDI of ochratoxin A and the PTDI was rather small, especially for toddlers with a high consumption of staple rice, indicating that an action level for ochratoxin A in polished rice needs to be considered. Additional surveys in other commodities marketed in Korea should be carried out not only to estimate more precisely the Korean daily intake of ochratoxin A but to know about other contributors of ochratoxin A in Korea.

ACKNOWLEDGMENT

We thank the staff in the Hazardous Substance Research Division in Seoul Branch, the Korea Basic Science Institute, for the confirmation of ochratoxin A present in all HPLC-FD positive samples by using HPLC-MS/MS.

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Received for review January 31, 2005. Revised manuscript received March 29, 2005. Accepted March 30, 2005. We thank the Postdoctoral Fellow Program of Korea Science and Engineering Foundation (KOSEF) for supporting J.W.P.'s research.

JF050227J