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Risk Assessment of Chemical Pollution in Organic Food

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Food safety is an important factor affecting people's health and quality of life. As a key means ensuring food safety, the chemical pollution assessment of food has also become the research focus in the current food safety field. In recent years, all countries in the world have paid more attention to food safety, and China is no exception. Taking Daxing District of Beijing as the research object, this paper conducts the risk assessment of chemical pollution in organic foods. According to the research results, through detecting metal contaminants (lead, cadmium, mercury), organophosphorus pesticides, and food additives etc. of the selected organic foods, it's found that the heavy metal pollution in organic foods was not serious, and all the detection results of organophosphorus pesticides were below the minimum detection limit and the content of food additives did not exceed the national standard. The single-factor pollution index indicates that organic foods have a low degree of pollution, and the comprehensive pollution index indicate that all organic foods are safe and clean except that the comprehensive pollution index of cucumbers shows mild pollution.

1. Introduction

Food safety is an important factor that affects the people's health and quality of life. If food safety is not effectively guaranteed, it will not only affect the people's physical and mental health, cause economic losses, but even influence the government's credibility (Fisk et al., 2001). In recent years, food safety issue has become the focus of governments around the world. Governments of all countries have made it an important task to ensure food safety, and controls of harmful chemical pollution in food has become their important goal (Kelly and Gobas, 2001). With Chinese economy developing and people's living standards improving, people's demand for food is getting higher and higher, thus, strengthening food safety is conducive to the health of the people and the development of the food industry in China (And and Ihm, 2001). Besides, frequent food safety incidents in China have further attracted the attention of the government and the public. Assessment of chemical pollutant in food, as one key means of ensuring food safety, has also become the major issue in the current food safety field (Lohmann et al., 2004).

At present, many scholars and experts at home and abroad have conducted extensive research on food safety risk assessment. Many countries have set up specialized research centres to conduct specialized research (Hwang et al., 2002; Mchugh et al., 2007); others have formulated relevant laws and regulations as well as developed relatively mature assessments techniques and standards (Nizzetto et al., 2008; Demare and Regla, 2012). Besides, some scholars, taking regions as research objects, analysed food safety issues of different groups (Debruyn and Gobas, 2004). This paper, mainly taking Daxing District of Beijing as the research object, evaluates the chemical pollution risk of organic food, which is of important significance for practical guidance.

2. Related theories

2.1 Chemical pollution

There are many reasons for organic food pollution, and chemical pollution is the important one (Bellos and Sawidis, 2005). Food pollution resulted from chemical processing and artificial addition, etc., is easily discerned and prevented. However, natural toxins in the form of natural components of foods are not easily identified and are more harmful to the human body (Baun et al., 2000). This natural toxin includes two kinds: endotoxins and exogenous toxins. The endotoxins are mainly produced by the food materials themselves and brought into the final foods. They mainly contain toxic amino acids, toxic proteins, and wood pyrrolidone toxins etc. The exogenous toxins are mainly produced by other natural methods rather than food materials, which contaminate the food, and be accumulated by foods. This is not inherent in food materials, so it is more difficult to prevent. It mainly includes food-borne bacterial toxins and mycotoxins etc. (Zala and Penn, 2004).

2.2 Pollution assessment methods

1) Single-factor pollution index method
At present, this method is commonly used in China to assess the heavy metal pollution; its calculation formula is given as:

$$P_i = \frac{C_i}{S_i} \quad (1)$$

where, P_i is the pollution index of the chemical pollutant i, C_i is the measured mass fraction of chemical pollutant i (mg/kg), and S_i is the assessment standard of chemical pollutant i (mg/kg). Normally, the second standard is adopted (Nikolov and Zeller, 2006). The greater the value of P_i, the higher the degree of contamination. The range of P_i values and the degree of pollution represented are shown in Table 1.

Table 1: The degree of pollution represented by the Pi value

Range of value	≤0.7	(0.7,1.0]	(1.0,2.0]	(2.0,3.0]	>3.0
Degree of pollution	Excellent	Security	Mild pollution	Moderate pollution	Severe pollution

This method mainly reflects the main pollution factors in the environment, but the current environmental situation is an increasingly complex system. Under normal circumstances, environmental pollution is formed by the combination of multiple factors, so the application of this method has certain limitations (Szatrowski, 1990).
2) Nemero comprehensive pollution index
This method can comprehensively reflect the degree of pollution (Liebetrau et al., 2015). Its calculation formula is given as:

$$\mathrm{P} = \sqrt{\frac{(\frac{C_i}{S_i})_{\max} + (\frac{C_i}{S_i})_{av}}{2}} \quad (2)$$

where, $(\frac{C_i}{S_i})_{av}$ is the average value of single factor pollution index for food, and $(\frac{C_i}{S_i})_{\max}$ is the maximum value of each individual food pollution index. The greater the value of P, the higher the degree of pollution (Ren et al., 2015). The range of P values and the degree of pollution represented are shown in Table 2.

Table 2: The degree of pollution represented by the P value

Range of value	≤0.7	(0.7,1.0]	(1.0,2.0]	(2.0,3.0]	>3.0
Degree of pollution	Security	Cordon	Mild pollution	Moderate pollution	Severe pollution

3) Gas chromatography
Gas chromatography is mainly based on the analysis of the dissolution, adsorption, distribution, ion exchange, or other affinity between the fixed and mobile phases of the sample components. It's mainly used to detect the content of organophosphorus pesticides in the organic food. The key features of this method are high sensitivity, wide application range, and fast analysis speed. The formula is given as:

$$\mathrm{X} = \frac{A}{m \times 1000} \quad (3)$$

where, X is the content of organic phosphorus pesticides in organic foods, in mg/kg; A is the mass of organophosphorus pesticides mentioned in the sample injection, in ng; m is the mass of the sample equivalent to the injection volume (μL), in g.

3. Chemical pollution risk assessment of organic food

In the paper, the chemical pollution of organic food in Daxing District of Beijing was mainly analysed and studied by selecting the representative organic foods in different regions of Daxing District for testing. The detection of chemical pollutants is mainly made for metal contaminants (lead, cadmium, mercury), organophosphorus pesticides, and food additives etc. The percentage of sample sizes for different food detecting items is shown in Fig.1.

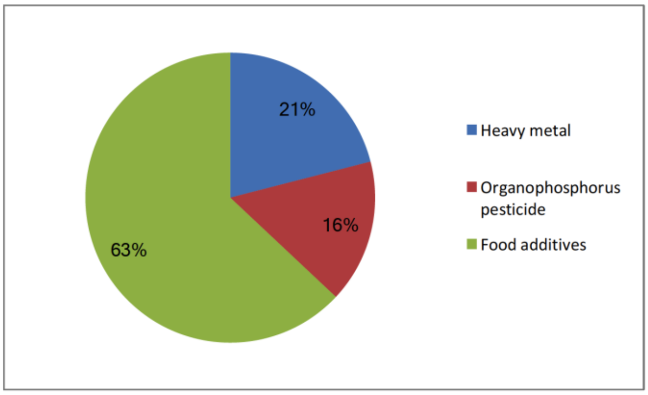

Figure 1: Percentage of sample size for different food detection items

The organic foods detected included rice, green pepper, cucumber, eggplant, shiitake, Flammulina velutipes, fruit juice drink, white pumpkin seed, and grass carp, etc. The total number was 110. The specific detection samples and items are shown in Table 3.

Table 3: Chemical contaminants in organic food

Name of the sample	Sampling quantity	Detection item
Rice	10	Metal contaminants
Green peppers	10	Organophosphorus pesticide
Cucumbers	10	Metal contaminants and Organophosphorus pesticide
Eggplants	10	Metal contaminants and Organophosphorus pesticide
Letinous edodes	10	Metal contaminants
Flammulina velutipes	10	Metal contaminants
Juice drinks	20	Organophosphorus pesticide
White melon seeds	20	Sulfur dioxide
Grass Carp	10	Metal contaminants
Total	110	

3.1 Analysis of heavy metal detection

The detection of heavy metals mainly involves the pollution of lead, cadmium, and mercury. The pollution of lead, cadmium, and mercury in foods is shown in Fig. 2, 3, and 4.

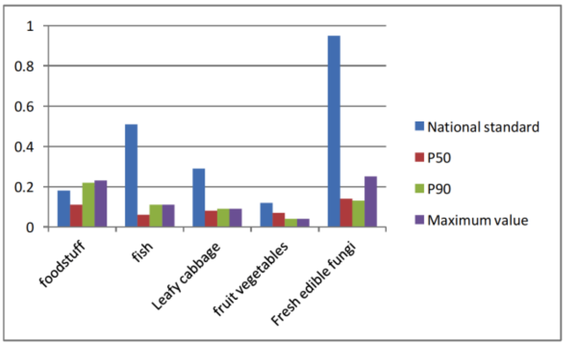

Figure 2: Lead pollution in various kinds of food

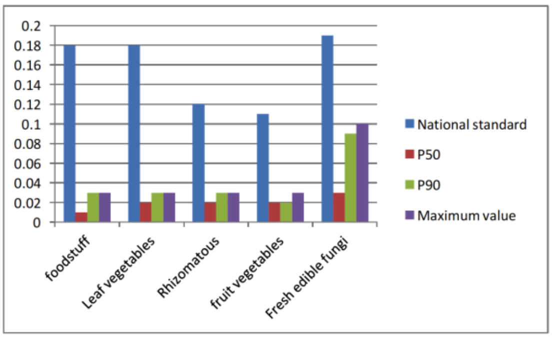

Figure 3: Cadmium pollution in various kinds of food

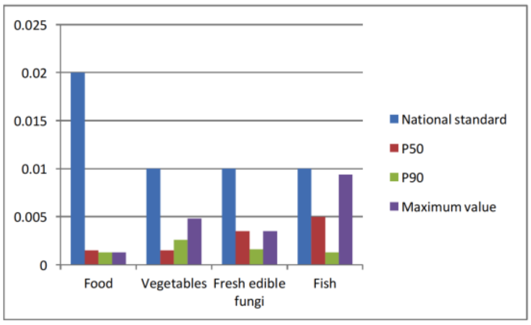

Figure 4: Mercury pollution in various kinds of food

Lead is a harmful metal contaminant in food, which can damage the body's digestive system and kidneys. It can be seen from the detection results in Fig.2 that the highest level of lead pollution is fresh edible fungus, with the maximum value reaching 0.25mg/kg, while the level of lead pollution in other foods is low.
According to the detection results of cadmium and mercury pollution in Fig.3 and 4, it can be seen that the detection values of different types of organic foods are much lower than the standard values, indicating that neither the heavy metal cadmium pollution nor the mercury pollution is serious.

Table 4: Single factor pollution index of organic food

Name of organic food	Single factor pollution index		
	Lead	Cadmium	Mercury
Rice	0.05	0.02	0.003
Green peppers	0.07	0.07	0.13
Cucumbers	0.12	0.25	-
Eggplants	0.01	0.09	0.04
Letinous edodes	0.11	0.16	0.32
Flammulina velutipes	0.10	0.14	0.29
Juice drinks	0.08	0.23	0.47
White melon seeds	0.13	0.44	-
Grass Carp	0.09	0.23	0.05

Table 4 shows the single-factor pollution index of each metal contaminant in each organic food. According to the data in the table, the pollution degree of all organic foods is excellent.

3.2 Analysis of organophosphorus pesticides detection

For the detection of organophosphorus pesticides, 12 organophosphorus and 2 organochlorine pesticides were detected in green peppers, cucumbers, eggplants, and fruit juice beverages. All detection results were below the minimum detection limit (where, the minimum detection limit of organophosphorus was 0.03-0.14 mg/kg). This shows that the pollution level of pesticide residues in organic foods such as vegetables, fruits, and drinks in Daxing District of Beijing is relatively low. In this paper, only one residue was selected for analysis. Table 5 shows the detection results of omethoate.

Table 5: Detection results of Omethoate in organic food

Name of organic food	Range of measured values(mg/kg)	Average value(mg/kg)	Limit value (mg/kg)	Exceeding standard rate (%)	Single factor pollution index
Rice	<0.02	0.006	0.008	0	0.24
Green peppers	<0.02	0.006	0.008	0	0.23
Cucumbers	<0.02	0.006	0.008	0	0.26
Eggplants	<0.02	0.006	0.008	0	0.31
Letinous edodes	<0.02	0.006	0.008	0	0.26
Flammulina velutipes	<0.02	0.006	0.008	0	0.69
Juice drinks	<0.02-1.00	0.0476	0.008	0	0.18
White melon seeds	<0.02	0.006	0.008	0	0.43
Grass Carp	<0.02	0.006	0.008	0	0.06

3.3 Analysis of food additive detection

For the detection of food additives, it was mainly performed on white pumpkin seeds and fruit juice drinks. The detection of sulfur dioxide in white pumpkin seeds is shown in Table 6.

Table 6: Residue of sulfur dioxide in while pumpkin seeds

Food name	National standard	P50	Q_L-Q_U	P90	Maximum value	Exceeding standard rate(%)	Single factor pollution index
White melon seeds	-	0.062	0.004-0.230	1.12	1.41	-	0.2

It can be seen from the data in Table 6 that the sulfur dioxide had a higher residual amount in the white pumpkin seeds, but currently there is no specific standard for this item in China. It is expected that based on the detected data, the limit standard in accordance with actual situation in China can be formulated as soon as possible.
The content of cyclamate and sorbic acid in 20 juice drinks was detected. The specific results are shown in Table 7.

Table 7: Content of sodium cyclamate and sorbic acid in juice drinks

Food name	National standard	P50	QL-QU	P90	Maximum value	Exceeding standard rate(%)	Single factor pollution index
Sodium cyclamate	0.58	0.120	0.004-0.250	0.270	0.420	0	0.2
Sorbic acid	0.60	0.074	0.017-0.170	0.210	0.240	0	0.4

According to the detection results in Table 7, it can be seen that the content of cyclamate and sorbic acid in fruit juice drinks didn't not exceed the national standard.
Table 8 shows the comprehensive pollution index of various organic foods. According to the data in the table, only the comprehensive pollution index of cucumbers shows mild pollution, while other organic foods belong to the level of safety and cleanliness.

Table 8: Comprehensive pollution index of all kinds of food

Name of organic food	P_{max}	P_{av}	P	Degree of pollution and evaluation
Rice	0.31	0.15	0.24	Safety and cleanliness
Green peppers	0.12	0.06	0.09	Safety and cleanliness
Cucumbers	1.97	0.16	1.40	Mild pollution
Eggplants	0.37	0.37	0.37	Safety and cleanliness
Letinous edodes	0.46	0.20	0.35	Safety and cleanliness
Flammulina velutipes	0.41	0.26	0.34	Safety and cleanliness
Juice drinks	0.20	0.03	0.14	Safety and cleanliness
White melon seeds	0.17	0.06	0.13	Safety and cleanliness
Grass Carp	0.002	0.0014	0.002	Safety and cleanliness

4. Conclusion

(1) Through detecting metal contaminants (lead, cadmium, mercury), organophosphorus pesticides, and food additives in the selected organic foods, it was found that heavy metal contamination in organic foods wasn't serious, and all detection results for organophosphorus pesticides were below the minimum detection limit, and the content of food additives didn't exceed the national standard.
(2) Data analysis shows that the safety degree of organic food in Daxing District of Beijing is generally satisfactory. The single-factor pollution index indicates that organic foods have a low degree of pollution; the comprehensive pollution index indicates that all organic foods are safe and clean except that the comprehensive pollution index of cucumbers shows mild pollution.

References

And D.C.K., Ihm S.K., 2001, Application of spinel-type cobalt chromite as a novel catalyst for combustion of chlorinated organic pollutants, Environmental Science & Technology, 35(1), 222-226, DOI: 10.1021/es001098k

Baun A., Jensen S.D., Bjerg P.L., 2000, Toxicity of organic chemical pollution in groundwater downgradient of a landfill (grindsted, Denmark), Environmental Science & Technology, 34(9), 1647-1652, DOI: 10.1021/es9902524

Bellos D., Sawidis T., 2005, Chemical pollution monitoring of the river pinios (thessalia-greece), Journal of Environmental Management, 76(4), 282-292, DOI: 10.1016/j.jenvman.2005.01.027

Debruyn A.M.H., Gobas F.A.P.C., 2004, Modelling the diagenetic fate of persistent organic pollutants in organically enriched sediments, Ecological Modelling, 179(3), 405-416, DOI: 10.1016/j.ecolmodel.2004.05.009

Demare P., Regla I., 2012, Synthesis of two local anesthetics from toluene: an organic multistep synthesis in a project-oriented laboratory course, Journal of Chemical Education, 89(1), 147-149, DOI: 10.1021/ed100838a

Fisk A.T, Hobson K.A., Norstrom R.J., 2001, Influence of chemical and biological factors on trophic transfer of persistent organic pollutants in the northwater polynya marine food web, Environmental Science & Technology, 35(4), 732-738, DOI: 10.1021/es001459w

Hwang Y.L., Keller G.E, Olson J.D., 2002, Steam stripping for removal of organic pollutants from water. 1. stripping effectiveness and stripper design, Industrial & Engineering Chemistry Research, 31(7), 1753-1759, DOI: 10.1021/ie00007a021

Kelly B.C., Gobas., F.A.P.C., 2001, Bioaccumulation of persistent organic pollutants in lichen-caribou-wolf food chains of Canada's central and western arctic, Environmental Science & Technology, 35(2), 325-334, DOI: 10.1021/es0011966

Liebetrau C., Hoffmann J., Nef H., Mãlimann H., 2015, Response to letter regarding article, "revisiting the role of scd40l as an inflammatory biomarker in a clinical model of acute myocardial infarction", Circulation Research, 116(4), e27, DOI: 10.1161/circresaha.115.305972

Lohmann R., Durham L., Ockenden W., 2004, Potential contamination of shipboard air samples by diffusive emissions of pcbs and other organic pollutants: implications and solutions, Environmental Science & Technology, 38(14), 3965-3970, DOI: 10.1021/es035005l

Mchugh B., Law R.J., Allchin C.R., Rogan E., Murphy S., Foley M.B., 2007, Bioaccumulation and enantiomeric profiling of organochlorine pesticides and persistent organic pollutants in the killer whale (orcinus orca) from british and irish waters, Marine Pollution Bulletin, 54(11), 1724-1731, DOI: 10.1016/j.marpolbul.2007.07.004

Nikolov N., Zeller K., 2006, Efficient retrieval of vegetation leaf area index and canopy clumping factor from satellite data to support pollutant deposition assessments, Environmental Pollution, 141(3), 539-549, DOI: 10.1016/j.envpol.2005.08.059

Nizzetto L., Jarvis A., Brivio P.A., Jones K.C., Guardo A.D., 2008, Seasonality of the air−forest canopy exchange of persistent organic pollutants, Environmental Science & Technology, 42(23), 8778-8783, DOI: 10.1021/es802019g

Ren B., Wang Q., Chen Y., Ding W., Zheng X., 2015, Analysis of the metals in soil-water interface in a manganese mine, Journal of Analytical Methods in Chemistry, 1, 1-9, DOI: 10.1155/2015/163163

Szatrowski T.P., 1990, Fish oil supplementation and plasma cholesterol: the power of a clinical trial, Annals of Internal Medicine, 112(8), 633-4, DOI: 10.7326/0003-4819-112-8-633

Zala S.M., Penn D.J., 2004, Abnormal behaviours induced by chemical pollution: A review of the evidence and new challenges, Animal Behaviour, 68(4), 649-664, DOI: 10.1016/j.anbehav.2004.01.005