PERGAMON

Food and Chemical Toxicology 39 (2001) 751–755

Food and Chemical Toxicology

www.elsevier.com/locate/foodchemtox

Brief Communication

Behaviour of some organophosphorus and organochlorine pesticides in potatoes during soaking in different solutions

A. Zohair

Faculty of Specific Education, Home Economic Department, Minufiya University. Ashmoun, Minofiya, Egypt

Accepted 8 January 2001

Abstract

The efficiencies of acidic solutions (radish, citric acid, ascorbic acid, acetic acid and hydrogen peroxide), neutral solutions (sodium chloride) and alkaline solution (sodium carbonate) as well as tap water in the elimination of organochlorine and organophosphorus pesticides from naturally contaminated potatoes were examined. The results indicated that acidic solutions were more effective than neutral and alkaline solutions in the elimination of the organochlorine compounds under investigation, Radish solutions eliminated pesticides completely, except *o,p′*-DDE (73.1% loss), followed by citric and ascorbic acid solutions. On the other hand, organophosphorus pesticides (pirimphos methyl, malathion and profenofos) were eliminated more by acidic, neutral and alkaline solutions than by organochlorines. The percentage of removal ranged from 98.5 to 100% for pirimphos methyl, 87.9 to 100% for malathion and 100% for profenofos.

Keywords: Pesticides; Potatoes; Reagents

1. Introduction

Pesticides comprise a variety of toxic substances, and are used in agriculture as well as indoors to kill pests (Baxter, 1988). The health risk of pesticides to humans is worsened by the fact that many of these substances have been shown to be carcinogenic and mutagenic (Murphy, 1986). Organophosphorus pesticides have a higher acute toxicity than organochlorines, but they have the advantage of being rapidly degraded in the environment. Organochlorine compounds have been banned but their residues still appear as pollutants in food as well as the environment (Rea, 1996).

Several investigators found high levels of pesticide residues after the washing and/or safety period (Kariem et al., 1991; Ramadan et al., 1992; Saleh et al., 1993). The potato crop is considered one of the most important vegetable crops in Egypt, but it is attacked by many insect species (El-Tantawy et al., 1992). This study aimed to find more efficient washing reagents for removing pesticides from potatoes naturally contaminated with pesticides, which may be used both commercially and by individual households.

2. Material and methods

2.1. Samples

Twenty-five kg of potatoes were collected from the local market. A representative sample of about 2 kg was examined for pesticides, and washing treatments were carried out on potato samples previously naturally contaminated with pesticides.

2.2. Standards

Pesticide standards of endrin, dieldrin, lindane, aldrin, heptachlor epoxide, 2,2-dichloroethylene (*o,p′*-DDE), 1,1′-dichloro-2,2′-bis (*p′*-chlorophenyl) ethylene (*p,p′*-DDE), 1-(*o′*-chlorophenyl)-1-(*p′*-chlorophenyl)-2,2′-dichloroethane (*o,p′*-DDD), 1,1-dichloro-2,2′-bis (*p′*-chlorophenyl)ethane (*p,p′*-DDD),1-(*o′*-chlorophenyl)-1-(*p′*-chlorophenyl)-2,2,2′-trichoroethane (*o,p′*-DDT), 1,1,1-trichloro-2,2′-bis chlorophenyl) ethane (*p,p′*-DDT), pirimphos methyl, malathion and profenofos, were purchased from Chemical Service Inc. (West Chester, PA, USA).

2.3. Chemicals and reagents

All chemicals (citric acid, acetic acid, hydrogen peroxide, sodium chloride and sodium carbonate) used

E-mail address: azzazohair@hotmail.com

0278-6915/01/$ - see front matter
PII: S0278-6915(01)00016-3

were obtained from E. Merck Company (Germany). Radish (garden, *Raphaus sativus*) solutions were prepared by cutting the green part into small pieces and soaking in water at 5 and 10% concentrations.

2.4. Extraction and determination of pesticides

Pesticide residues were extracted from potato tubers according to the methods of the AOAC (1995). Aliquots of 1–2 μl of extract were injected into a Hewlett-Packard gas chromatography Model 5890 equipped with an Ni^{63} electron capture detector (ECD), flame ionization detector (FID) and integrator 3392, fitted with an HP-101 capillary column (cross-linked methyl silicon Gum), 30 m×0.25 mm×0.25 μM film thickness. The oven temperature was programmed from 160 to 220°C at the rate of 5°C/min, held for 20-min injection and detector temperatures were 220 and 300°C, respectively.

2.5. Treatment of contaminated potato

The contaminated intact potato samples were soaked for 10 min in (i) tap water; (ii) acidic reagents, radish, acetic acid, citric acid and ascorbic acid solutions at concentrations of 5 and 10%; (iii) neutral reagent, 5 and 10% NaCl solutions; and (iv) alkaline reagent, 5 and 10% Na_2CO_3 solutions.

3. Results and discussion

The concentrations of pesticide residues in potatoes are presented in Table 1. The results indicate that the

Table 1
Levels of pesticide residues in potato tubers[a]

Compound	Levels of pesticide (μg/kg±S.D.)	
	Skin	Pulp
Organophosphorus		
Pirimphos-methyl	122.9±15	4783.10±63
Malathion	41.50±10	–[b]
Profenofos	–	233.10±25
Organochlorines		
Endrin	20.90±7	–
Dieldrin	–	–
Lindane	9.30±3	4.50±1.5
Aldrin	1.50±0.5	1.00±0.3
Heptachlor-epoxide	13.90±5	0.70±0.1
o,p′-DDE	42.20±11	10.30±0.3
p,p′-DDE	66.70±14	15.20±5
o,p′-DDD	–	42.10±13
p,p′-DDD	–	–
o,p′-DDT	–	–
p,p′-DDT	–	–

[a] Values given are mean of five replicates.
[b] Non-detectable.

Table 2
Behaviour of organochlorine pesticide residues during soaking in acidic solution for 10 min

Treatment	Lindane		Aldrin		Heptachlor epoxide		*o,p′*-DDE		*p,p′*-DDE		*o,p′*-DDD	
	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)
Contaminated potato sample soaking	13.8±2		2.5±0.3		14.6±2.2		52.5±5.1		8.1±9		42.1±13	
Radish solution (5%)	–[b]	100	–	100	–	100	16.9±5	67.6	–	100	–	100
Radish solution (10%)	–	100	–	100	–	100	14.1±3	73.1	–	100	–	100
Acetic acid solution (5%)	4.6±1.8	66.7	0.7±0.4	72	0.7±0.3	95.2	13.±3	75.2	3.2±10	96.1	1.7±0.7	96
Acetic acid solution (10%)	3±1	78.3	0.4±0.15	84	0.5±0.1	96.6	7±2	86.7	2.1±1	97.4	1.1±0.5	97.4
Citric acid solution (5%)	–	100	0.6±0.2	76	–	100	14.5	73.1	1.6±0.4	98	–	100
Citric acid solution (10%)	–	100	0.37±0.1	85.2	–	100	11.8±2	77.5	1.3±0.3	18.4	–	100
Ascorbic acid solution (5%)	–	100	0.4±0.13	84	–	100	22.3±8	57.5	6.6±2	91.9	–	100
Ascorbic acid solution (10%)	–	100	0.23±0.0	90.8	–	100	17±5	67.6	4.2±1.2	94.9	–	100
Hydrogen peroxide solution (5%)	2.6±1	81.2	0.9±0.2	64	0.8±0.2	94.5	10.3±2	80.4	–	100	–	100
Hydrogen peroxide solution (10%)	1.5±0.4	89.1	0.55±0.1	78	0.6±0.2	95.9	6.8±2	87	–	100	–	100
Tap water	12.1±3	12	2.25±0.5	10	13.2±3	9.8	51.5±9	2	79±8	3.5	4.5±1	3.9

[a] Mean = μg/kg±S.D. Values given are mean of five replicates.
[b] Non-detectable.

organophosphorus compounds pirimphos methyl, malathion and profenofos were present at higher levels than the organochlorine compounds lindane, aldrine, heptachlor epoxide and DDT derivatives in the tested sample.

It is clear that tested potato samples contained different types of pesticides. The reason for the presence of heptachlor epoxide, despite the complete cessation of use in Egypt according to the Pest Control Program (Ministry of Agriculture), might be due to the transformation of chlordane (El-Mekkawi, 1994). The contamination by DDT indicated that this insecticide is probably still being applied despite the Ministry's recommendation. It also shows that organophosphorus compounds are widely used.

Pesticide residues in 21 species of edible vegetables and fruits collected from the Great Cairo governorate were investigated by Abou-Arab et al. (1998). They reported that potato samples contained the highest mean levels of DDT and its derivatives (0.438 μg/kg) and lindane (0.850 μg/kg).

The distribution pattern of pesticide residues in the contaminated potatoes (Table 1) indicates that lindane, aldrine, heptachlor epoxide, DDT, pirimphos methyl

Table 3
Behaviour of organophosphorus residues during soaking in acidic solution for 10 min

Treatment	Pirimphos-methyl		Malathion		Profenofos	
	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)
Contaminated potato sample soaking	4906±35	–[b]	41.5±10	–	233.1±25	–
Radish solution (5%)	–	100	–	100	–	100
Radish solution (10%)	–	100	–	100	–	100
Acetic acid solution (5%)	–	100	–	100	–	100
Acetic acid solution (10%)	–	100	–	100	–	100
Citric acid solution (5%)	–	100	2.2±0.8	94.7	–	100
Citric acid solution (10%)	–	100	1.3±0.5	96.9	–	100
Ascorbic acid solution (5%)	–	100	5±2	87.9	–	100
Ascorbic acid solution (10%)	–	100	3±1	92.7	–	100
Hydrogen peroxide (5%)	–	100	4.16±2	89.9	–	100
Hydrogen peroxide (10%)	–	100	2.9±1	93	–	100
Tap water	4273±50	12.9	36.5±10	11.6	201.6±20	13.5

[a] Mean = μg/kg±S.D. Values given are mean of five replicates.
[b] Non-detectable.

Table 4
Behaviour of pesticide residues during soaking in neutral and alkaline solutions for 10 min

Treatment	Organocglorine residues (mg/kg±S.D.)					
	Lindane		Aldrin		Heptachlor epoxide	
	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)	Mean[a]	Reduction (%)
Contaminated potato sample	13.8±2	–[b]	2.5±0.3	–	14.6±2.2	–
NaCl solution (5%)	9.9±3	28.3	0.8±0.3	68	3.9±1	73.3
(10%)	8±2	42	0.6±0.2	76	2.1±0.8	85.6
Na_2CO_3 solution (5%)	1.5±0.5	89.1	0.4±0.1	84	1±0.3	93.2
(10%)	1.1±0.3	92	0.3±0.1	88	0.7±0.1	95.2
Tap water	12.1±3	12	2.25±0.5	10	13.2±3	9.8

Treatment	Organophosphorus residues (mg/kg±S.D.) Pirimphos-methyl		
	Mean[a]	Reduction (%)	Mean[a]
Contaminated potato sample	4906±35	–	41.5±10
NaCl solution (5%)	–	100	–
(10%)	–	100	–
Na_2CO_3 solution (5%)	76.4±8	98.5	3.98±0.9
(10%)	60.1±5	98.8	–
Tap water	4273±50	12.9	36.5±10

[a] Mean = μg/kg±S.D. Values given are mean of five replicates.
[b] Non detectable.

and profenofos have the power to penetrate the surface of the contaminated potato into the pulp. It is known that some of the pesticide penetrates from the surface into the deep layer of plant tissues, and the penetration depends on the stability of the insecticide penetrating the skin layer.

The effect of washing procedures on pesticide residues in potatoes was studied. The data in Tables 2 and 3 showed the effect of soaking in acidic reagent solutions (5 and 10%) for 10 min. The results indicate the efficient role of washing by radish solution, citric acid, ascorbic acid, acetic acid and hydrogen peroxide in the elimination or reduction of organochlorine (lindane, aldrine, heptachlor epoxide and DDT) and organophosphorus (pirimphos methyl, malathion and profenofos) pesticides from naturally contaminated potato tubers. It was noticed that radish solutions of 5 and 10% eliminated pesticide residues completely, except for *o,p′*-DDE. Also, citric acid and ascorbic acid solutions of 5 and 10% eliminated pesticide residues of lindane, heptachlor epoxide, *o,p′*-DDD, pirimphos methyl and profenfos completely. Acetic acid and hydrogen peroxide washing came next in importance to washing with the above solutions. On the other hand, washing with tap water provided the least effective loss with the same pesticides as previously mentioned. These results agree with those obtained by Fahey et al. (1969), Powell et al. (1970), Mesallaw and Moharran (1980), Chirila and Florall (1985), Barrow et al. (1987), Gangwar and Kumar (1988), Rao et al. (1989), Sarode and Adule (1989), El-Nabarawy et al. (1992), Ismail et al. (1993), Abou-Arab et al. (1998) and Soliman (1999). These authors reported that partial removal was affected by the washing operation (water and/or acetic acid, sodium chloride).

The data in Table 4 showed the percentage rate of removal pesticides from naturally contaminated potatoes after soaking in neutral (NaCl) and alkaline (Na_2CO_3) solutions (5 and 10%) for 10 min. Alkaline solutions were more effective than neutral solutions in the elimination of lindane, aldrin and heptachlor epoxide. The results also indicate that both solutions have an efficient role in the elimination of total DDT and organophosphorus (pirimphos methyl, malathion and profenofos) pesticides from contaminated potatoes.

The results clearly indicate that organophosphorus pesticides are more rapidly degraded than organochlorine pesticides as expected.

The data from Tables 2–4 demonstrate that there was a gradual increase in the percentage of reduction due to the increase concentration of different washing reagents, being more efficient than tap water. These results agreed with those obtained by Lamb et al. (1968), Mesallaw and Moharran (1980), Ismail et al. (1993) and Abou-Arab et al. (1998).

From the above results, it is clear that pesticides should be applied correctly according to good agricultural practice, using only the amounts recommended. Washing with water and/or detergent solutions was necessary to decrease the intake of pesticide residues. The acidic detergent solutions are more effective in the elimination of the organochlorine pesticides under investigation than alkaline and neutral solutions. Radish is the most effective acidic solution in the elimination of pesticides, followed by citric and ascorbic acid solutions.

References

Abou-Arab, A.A.K., Soliman, K.M., Amra, H.A., Khyria Naguib, 1998. Pesticide residues content in Egyptian vegetable and fruits and removal by washing. Bulletin of the Nutrition Institute 117–138.

AOAC, 1995. Official Methods of Analysis. Multi-residues Methods. General Methods for Organochlorine and Organophosphorus Pesticides. Association of Official Analytical Chemists, Washington, DC.

Barrow, R., Esack, Y., Kalloo, C., 1987. The determination of pesticide residue levels on locally grown vegetables a preliminary study. Journal of the Agriculture Society of Trinidad and Tobago 87, 8–16.

Baxter, D., 1988. Chlordane: A Pesticide Review: Health and Environmental Effects and Alternatives. Washington, DC; NCAMP, p.2.

Chirila, R., Florall, S., 1985. Absorption, translocation, metabolization and accumulation of methidathion in cucumber and tomato plants. Anales Instituto de Cercetari Pentru Protectia Plantdor 18, 221–227.

El-Mekkawi, M.M.A. (1994). Monitoring of Pesticides Residues in Certain Food Items. MSc thesis, Al-Azhar University, Egypt.

El-Nabarawy, I.M., Abou-Donia, M.A., Amra, H.A., 1992. Determination of profenofos and malathion residues in fresh tomatoes and paste. Egypt Journal of Applied Science 7, 106–111.

El-Tantawy, M.A., El-Nabarawy, I.M., Sallam, A.A., 1992. Residues in fresh and blanched potatoes. Delta Journal of Science 16, 114–123.

Fahey, J.E., Gould, G.E., Nelson, P.E., 1969. Removal of gardona and Azodrine from vegetable crops by commercial preparative methods. Agricultural and Food Chemistry 17, 1204–1206.

Gangwar, S.K., Kumar, D., 1988. Persistence of endosulfan in/on tomato, *Lycopericum esculentum* Mill at medium altitude hills. Journal of Insect Science 1, 69–73.

Ismail, S.M.M., Ali, H.M., Habiba, R.A., 1993. GC–ECD and GC–MS analysis of profenofos residues and its biochemical effects in tomatoes and tomatoes products. Journal of Agricultural and Food Chemistry 41, 610–615.

Kariem, A.M., Ramadan, R.A., Mostafa, A.M., 1991. Fungicides in controlling strawberry fruit and their residues in fruits. Egyptian Journal of Applied Science 6, 710–719.

Lamb, F.C., Farraw, R.P, Cook, R.W., Kimball, J.P., 1968. Behavior of DDT in potato during commercial and home preparation. Agricultural and Food Chemistry 16, 247–275.

Mesallaw, A.S., Moharran, Y.G., 1980. Removal of lanate insecticide from tomatoes during processing. Alexandria Journal of Agricultural Research 28, 167–172.

Murphy, S.D., 1986. Toxic effects of pesticides. In: Klaassen, C.D., Amdur M.O., Dovil J. (Eds) Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd Edition, Macmillan. New York.

Powell, A.J.B., Strens, T., Mc Cully, K.A., 1970. Effect of commercial processing on residues of aldrin and dieldrin in tomatoes and residues in subsequent crops grown on the treated plots. Agricultural and Food Chemistry 18, 224–227.

Ramadan, R.A., Saleh, M.A., El-Shemy, M.K., 1992. Residues of some pesticides on cucumber, green pepper and eggplant fruits under plastic green house conditions. Egyptian Journal of Applied Science 7, 861–870.

Rao, B.N., Subbiah, K.R., Murthy, K.S.R.K., 1989. Removal of monocrotophos and carbaryl spray deposit from tomato by different processing procedures. South Indian Horticulture 32, 182–186.

Rea, W.J., 1996. Pesticides review. Journal of Nutritional and Environmental Medicine 6, 55–124.

Saleh, M.A, El-Shemy, M.K., Flaifel, M.A., 1993. Determination of benomyl, dichlorfluanid and prodione residues in strawberry fruits. Egyptian Journal of Applied Science 8, 15–20.

Sarode, S.V., Adule, P.G., 1989. Effect of different processes on fenitrothion residues in tomato. Indian Journal of Entomology 51, 475–477.

Soliman, K.M., 1999. Changes in concentration of some pesticide residues in potatoes during washing and cooking. Agricultural Science, Mansoura University 24, 2503–2511.