PERMETHRIN

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Permethrin, a pyrethroid insecticide, has been evaluated at each JMPR Meeting from 1979 to 1989 and 1991. Technical grade permethrin contains four stereoisomers deriving from chirality of the cyclopropane ring at the C-1 and C-3 positions. Glenn and Sharpf (1977) have shown that the ratio of *cis* to *trans* isomers varies with the method of synthesis. It is desirable to produce different *cis/trans* ratios for certain insecticidal applications (e.g., lower *cis/trans* ratios for animal health products). It is therefore important to note the isomer ratios in products used in the supervised trials and metabolism studies. *Cis*-permethrin is more insecticidally potent than the *trans* isomer. The isomers also differ significantly in rates of photolysis and hydrolysis, in biotransformations and in bioaccumulation. The conclusions and recommendations of the 1979 JMPR meeting are based entirely on agricultural and horticultural uses of technical grade permethrin containing *cis/trans* isomers in approximately a 40:60 ratio. Furthermore, the term permethrin from the 1979 and 1980 JMPR reports relates only to this mixture.

The four major manufacturers of permethrin jointly submitted information to the 1979 meeting (Manufacturers, 1979) indicating that the technical grade products of any of the four manufacturers also meet the following general specifications:

1. Purity not less that 89% permethrin (typically 91-93%); (ii) Physical state: yellow-brown to brown oily liquid; (iii) specific gravity =1.214; (iv) Solubility: easily soluble in hexane, benzene, chloroform, ethanol and acetone. Solubility in water <1 mg/kg, and each impurity present at <2%.

USE PATTERN

Permethrin is effective at low rates against a wide range of *Lepidoptera*, *Hemiptera*, *Diptera* and *Coleoptera*. Unlike natural pyrethrins and earlier synthetic pyrethroids, permethrin is photostable that allows it to be used effectively in agriculture. It has adulticidal, ovicidal and particularly larvicidal activity and is effective against the great majority of insects that have become resistant to standard treatments such as organochlorines and organophosphates (JMPR, 1980). Permethrin is not plant systemic and has very little fumigant and translaminar activity; a program of sprays is usually required (JMPR, 1980).

In reviewing pre-harvest uses, including those on forage crops, the 1979 JMPR noted that in several countries target pests and use patterns are well defined, and pre-harvest withholding intervals reflecting good agricultural practices can be specified. However in many countries where climatic conditions are conducive to a rapid build-up of insect infestations, flexibility in treatments may be necessary for full effectiveness. Therefore, in many countries no pre-harvest withholding intervals are specified. This is made possible by a combination of the low effective use rates and resulting comparatively low residues immediately after spraying. Data indicate that permethrin residues on sprayed crop plants decline relatively slowly. Therefore, any benefit of a pre-harvest withholding interval as a means of reducing residue levels tend to be less than what accrues (JMPR, 1980).

In East Africa, permethrin (3 g ai/t) is used in combination with pirimiphos-methyl (16 g ai/t) as a grain protectant. In French-speaking Africa the treatment rates for bulk maize are 1.5 g ai/t and 8 g ai/t for permethrin and pirimiphos-methyl respectively. In Spain, permethrin is used as a grain protectant at 0.9-1.2 g ai/t with pirimiphos-methyl at 3-4 g ai/t. Permethrin is used as a grain protectant in Australia in combination with piperonyl butoxide. It is recommended for use at 1 and 0.5 g ai/t for 3-9 months and less than 3 months storage respectively (JMPR, 1991).

Permethrin can also be used as a dust, spray or dip to control various ectoparasites of cattle, horses, sheep, pigs and poultry. It can be applied either directly to animal, to buildings in which they are housed or to insect breeding and resting sites (JMPR, 1980).

RESIDUES FROM SUPERVISED TRIALS

Pre-harvest

A large body of residue data from supervised trials was reviewed which noted that permethrin and its metabolites are effectively non-systemic in plants. Residues are highest when crop parts are exposed to the spray as in the case of

forage crops. Residue levels decline comparatively slowly - the half-lives vary from about 1-3 three weeks depending on the crop. The major degradation products are the *cis* and *trans*-isomers of 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (DCVA) plus 3-phenoxybenzyl alcohol (3-PBAlc), present primarily as conjugates (and also identified as animal metabolites). In forage crops such as alfalfa, residue levels of the metabolite DCVA and 3-phenoxybenzyl alcohol are small compared with the corresponding permethrin residues. This pattern was found on a range of crops reviewed by the 1979 JMPR. In addition to crops grown specifically for forage, livestock feed can also contain by-products of food processing such as apple pomace and cotton cake) (JMPR 1980).

Residues

Cotton, oilseeds and other field crops

In cotton where levels in the seeds are influenced by the degree of protection by the boll during late season spraying, residues were generally below 0.1 mg/kg. Samples analyzed were the ginned (undelinted) seed. The highest value reported at effective use rates is 0.27 mg/kg. At effective use rates, maximum residues reported were 0.05 mg/kg in soybeans, 0.07 mg/kg in sweet corn kernels, 0.08 mg/kg in peas and less than 0.01 mg/kg in peeled coffee beans. Sprays are normally applied to oil seed rape seven weeks or more before harvest. Residues in the oil seeds were non-detectable (less than 0.01 mg/kg).

Legume vegetables

Residues in Phaseolus beans, which are generally eaten in the pod, are higher than those in soybeans or peas where the seeds are protected from the spray. Mean residues of 0.1-0.2 mg/kg in Phaseolus compare with less than 0.1 mg/kg in soybeans and in peas.

Pome fruits, stone fruits, citrus, berries and other fruits

Considerable residue data are available on apples, on which the rate of residue decline tends to be smaller than on varieties of vegetables. At effective use rates, residues were below 2 mg/kg. Similar patterns were seen on pears, peaches and cherries, although levels on plums were 0.1 mg/kg or less. In oranges, melons and kiwifruits, residues were found almost exclusively in the peel; in edible flesh levels were not found to exceed 0.03 mg/kg. As the data for citrus were confined to a single study with oranges in Spain, the results from supervised trials with other citrus fruits in other countries were considered to be desirable.

Post-harvest uses

Grains

The only significant post-harvest use of permethrin is its application to bulk stored grain. This has undergone extensive laboratory studies and silo-scale trials for this purpose in Australia. All the residue studies show that permethrin is persistent on grains under the prevailing conditions of temperature and moisture content in Australian storage. Initial residues on grain were about 20% below the level expected from the amount applied. Residues decline very slowly in storage; about 80% of the initial (1 month) residue in grain remains after 6-9 months. This level of persistence is found consistently in studies on wheat, barley and sorghum, and probably could be generalized for all stored grain. Studies show also that the initial ratio of *cis/trans* isomers is not changed during 8 months of storage.

Animals

Cows

Cows were given five whole-body sprays of permethrin at a rate of 1.0 g ai/cow, with 14 days between sprays, using a 5% emulsifiable concentrate formulation. Cows were allowed free access to a self-oiler containing a 0.03 g ai/l solution, ensuring at least two applications per day for a period of ten weeks. Cows were housed in premises that were sprayed at a rate of 0.06 g ai/m^2, five sprays taking place with a 14-day interval between sprays; cows had free access to the premises during spraying. This exposure level is at the high end of the range that is likely to occur in normal husbandry practice. Milk samples were taken for analysis before and during the ten days after the fifth application. Only four of 70 milk samples had measurable residues of permethrin or its metabolites *cis*, *trans*-3-(2,2-dichlorovinyl)-2, 2-dimethyl cyclopropane carboxylic acid (DCVA), 3-phenoxybenzoic acid (3-PBAcid) and 3-phenoxybenzylalcohol (3-PBAlc) (Ussary and Braithwaite, 1980a).

Cows were given 6 whole-body sprays of permethrin at a rate of 1.0 g ai/cow with 14 days between sprays. They were allowed free access to a self-oiler containing a 0.03 g ai/l solution ensuring at least two applications per day for a period of ten weeks. The cows, housed in premises that were sprayed at a rate of 0.06 g ai/m^2 with six sprays taking place with

a 14-day interval between sprays, had free access to the premises during spraying. This exposure level is at the high end of what is likely to occur in normal husbandry practice. Cows were slaughtered five days after the sixth application. Permethrin levels in muscle, liver the kidney were low (<0.01 mg/kg). The highest levels of permethrin were 0.10 mg/kg and 0.04 mg/kg in the intestinal and subcutaneous fat, respectively (Ussary and Braithwaite, 1980b).

Pig

Pigs were housed in premises treated with mist applications of 0.06 g permethrin per m^3 at 14-day intervals and slaughtered one day after the sixth application. Permethrin residues were not measurable in skin, liver or kidney tissues (limit of determination: 0.01 mg/kg) and only low levels of permethrin were found in the fat and muscle tissues (0.02 and 0.01 mg/kg, respectively) (Ussary and Braithwaite, 1980c).

Chicken

Hens were present at the times of application when premises received six mist applications of 0.06 g permethrin per m^3 at 14-day intervals. Eggs were collected at intervals up to 50 days following the first application and hens were sacrificed five days after the sixth application. Eggs were found to contain permethrin at 0.02 mg/kg on one occasion only and below 0.01 mg/kg in muscle, skin, liver and eggs at all other times. A residue of 0.02 mg/kg was detected in fat tissues (Ussary and Braithwaite, 1980d).

Processing studies

The fate of permethrin residues during the processing of cotton, soybeans, apples, pears, grapes and tomatoes was reviewed at the 1979 Meeting. Residues in the seeds of cotton and beans of soya, and in their respective processing fractions used in animal feeds, are well below 0.5 mg/kg (FAO/WHO, 1980).

Apples, Pears and Grapes

Residues in dried apple pomace were 25-30 times the levels in corresponding whole apples. No residues were detected in apple juice and apple sauce (limit of determination, 0.01 mg/kg). The pomace may be used as animal feed (Ussary, 1977a, c; JMPR, 1980)

Tomato

As with apples, permethrin residues in whole tomatoes remain primarily in the pomace during processing. Permethrin levels in tomato juice, tomato puree and tomato ketchup were consistently much smaller than those found in whole tomatoes. The pomace may be used as animal feed (JMPR 1979). Residues in wet tomato pulp typically containing 25% dry matter were 10-50 (mean = 25) times the levels in whole tomatoes (Ussary, 1977d) (JMPR 1980).

Wheat

During the processing of treated whole wheat grain, permethrin residues are retained mainly in the bran component although a significant proportion (12%) remains with the white flour. Permethrin residues in flour from treated whole grain are carried over into bread baked from that flour; there is no reduction in residue level on a commodity dry-weight basis (Simpson, 1979). White flour retains about 12% of the whole grain residue. The major part of the residue, about 62%, remains with the bran and about 26% is in the pollard. Therefore, whilst white bread prepared from treated grain would have a residue of about 0.15-0.2 mg/kg, the corresponding level in whole meal bread would be about 0.7-1 mg/kg (Simpson, 1979). The processing operations simulated those used in commercial practice; the unbaked bread recipe included potassium bromate and benzoyl peroxide. Whole meal flour was formulated after reconstituting the wheat fractions in the original ratio.

FATE OF RESIDUES

Plants

The metabolic fate in plants has been investigated both in the field and under greenhouse conditions. The metabolic products from plants were identical with permethrin metabolites observed in mammals with the exception that glucose is the primary conjugating moiety. The major metabolites were products of ester cleavage (occurring in plants as well as mammals more rapidly with the *trans*- than the *cis*-isomer) and conjugation of the liberated acid and alcohol fragments. Minor oxidative pathways of both the acid and alcohol fragments have been identified.

The two important plant metabolites are 3-phenoxybenzyl alcohol and the *cis*- and *trans*-isomers of 3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropane carboxylic acid (DCVA), also identified as animal metabolites. Levels of these metabolites in crops are much smaller than corresponding permethrin residues in food animals and they do not need to be included in routine plant residue analysis (JMPR, 1980).

In general, permethrin residues from foliar sprays are not translocated from site of deposition, nor is there any appreciable uptake into the aerial parts of plants from soils. Permethrin per se is relatively persistent on plant surfaces. On leaf surfaces, permethrin is degraded mainly by ester cleavage, occurring more rapidly with the *trans*-isomer than the *cis*-isomer. The major degradation products are the *cis*- and *trans*-isomers of 3-(2,2-dichlorovinyl) 2,2-dimethyl-cyclopropane carboxylic acid (DCVA) and 3-phenoxybenzyl alcohol (3-PBA), both free and as conjugates (Gatehouse et al., 1976a, b; Gaughan et al, 1976; Gaughan and Casida, 1978; Ohkawa et al, 1977; Selim and Robinson, 1977a, b).

The degradation of ^{14}C-permethrin has been studied on cotton leaves, bean seedlings, cabbage leaves and apple fruits. In all cases permethrin degraded comparatively slowly. Unchanged permethrin accounted for 23-58% of the radioactivity on cotton leaves after 28 days (Gatehouse et al, 1976b) more than 80% of the radioactivity in apple fruits after 28 days and more than 60% of the radioactivity on cabbage leaves after 42 days (Gatehouse et al, 1976b). On bean plants *trans*-permethrin was shown to degrade more readily than *cis*-permethrin with half-lives of 7 and 9 days, respectively (Gaughan and Casida, 1978; Ohkawa et al, 1977). Both isomers undergo ester cleavage and oxidation of the phenoxy group to produce the resulting acid and alcohol

Animals

Permethrin is extensively metabolized and rapidly excreted by cows and goats after oral administration. Residue levels in milk, muscle and fat are small, as they are in the skin, muscle and eggs of hens. Permethrin constitutes more than half of the residue in milk, eggs and fat, and in the muscle of livestock. In all cases, residue levels decline notably on cessation of exposure (JMPR 1980).

Cow

Groups of lactating cows were administered permethrin orally or dermally. Milk, blood and excretory products were analyzed for 7 or 14 days after which the animals were sacrificed for tissue analysis. Permethrin is rapidly absorbed by both routes of administration. Residue levels in the milk of both orally- and dermally- administered cows increased for 24 to 48 hours following administration, although following dermal administration, residues in milk were exceedingly low. Within 7 days all residues not detectable (Bewick and Leahey, 1976). In the animals dosed orally, 40% of the excreted radioactivity was found in the urine with 60% found in the faeces. Residue levels in adipose tissue were characterized as permethrin.

Lactating cows administered permethrin in ethanol orally at a dose of 1 mg/kg for three consecutive days had no adverse effect on the cows. At the end of a 12-days trial the animals were sacrificed and tissues and organs examined for residues. Permethrin was rapidly absorbed and excreted with the majority of residue, from 90-100% of the administered dose, recovered predominantly in urine and faeces. Milk and milk fat analyses were performed and small quantities of residues of both *cis*- and *trans*-permethrin (*cis*-isomer predominated) were observed, mainly in the lipid fraction. In general, there was a more rapid elimination of *trans*-permethrin and its metabolites than of *cis*-permethrin and its metabolites.

In general, the fat soluble permethrin isomers are rapidly metabolized and excreted by cows and goats (Gaughan, et al., 1978a; Hunt and Gilbert, 1977). In cows, permethrin is found in small quantities in milk fat and adipose tissue. Following multiple administration (3 days) to cows, the recovery of permethrin was nearly quantitative within 12 to 13 days.

Individual isomers of *cis*- and *trans*-permethrin were orally administered to lactating cows for three consecutive days at a dose rate of approximately 1 mg/kg body weight. Residues in milk consisted almost entirely of unmetabolized *cis*-permethrin. Trace levels of hydroxylated permethrin residues were also found in milk. The major excretory metabolites included hydroxylated permethrin (on the gem-dimethyl group), 3-phenoxybenzyl alcohol and a glutamic acid conjugate of 3-phenoxybenzoic acid. As noted with milk, most of the residues in adipose tissue were unmetabolized permethrin. In comparison with the metabolic profile observed in rats, cows excrete a larger proportion of ester metabolites, including their glucuronides, and are unique in utilizing glutamic acid for conjugation of the acidic metabolites. Quantitatively, cows carry out more extensive hydroxylation on the gem-dimethyl moiety and less on the benzoyl moieties resulting in a greater concentration of 4'-hydroxyphenoxybenzoic acid- (sulfate) metabolite in rats than in cows. Qualitatively, similar results to those noted with cows have been observed with goats (Hunt and Gilbert, 1977).

Goat

Goats were administered orally at a dosage rate of 20 mg/kg/day for 7 consecutive days. Low levels of residues were observed in the milk. The residue level appeared to plateau within 4-5 days of the initial treatment. A sample of milk, containing approximately 0.026 ppm in the whole milk, was analyzed for residues in milk fat. Fifty percent of the total residues was extracted from milk fat and was found to be unchanged permethrin although the cis:trans ratio changed from approximately 4:6 to 2:1 (Leahy, et al., 1977). At the conclusion of the study, low levels of residues were noted in various organs (i.e., kidney, liver and muscle) with extremely low levels in adipose tissue.

Chickens

Permethrin is absorbed, distributed, metabolized and excreted in hens with rates substantially faster than in mammalian species. Permethrin administered to laying hens for three consecutive daily doses of 10 mg/kg was rapidly absorbed and distributed, being eliminated within one day after the final dose. Approximately 90% of the administered dose was recovered in excreta with small residues noted in eggs (predominantly yolk) and in adipose tissue. The residue observed in hen was predominantly the *cis*-isomer.

The metabolic fate in hens was investigated following oral administration of a dose of 10 mg/kg/day for three consecutive days. The overall metabolic pathway was similar to that noted with mammalian species. Permethrin was effectively hydrolyzed and oxidized with the *trans*-isomer being metabolized more extensively. In egg yolk, permethrin and *trans*-hydroxymethyl *cis*-permethrin were detected as residues. Extensive metabolism via hydrolytic, oxidative and conjugative reactions is probably responsible for the relative insensitivity of permethrin in avian species (Gaughan, et al., 1978b).

METHODS OF ANALYSIS

The preferred method of permethrin residue analysis in crops is by gas chromatography using an electron capture detector. Recoveries are essentially quantitative and the method has been applied successfully to a wide range of crops, raw cereal grains and processed products derived from them, such as flour, bran and bread. A limit of determination of 0.01 mg/kg (expressed as permethrin *cis* and *trans*-isomers). *Cis* and *trans*-isomers are capable of being determined separately by this method. With small modifications, the method has been applied successfully to the determination of permethrin residues in meat, milk and eggs, and with adaptation, may be suitable for regulatory purposes. GLC/mass spectrometry was cited as a procedure for qualitative and quantitative estimation of residue.

The free and conjugated metabolites DCVA and 3-PBA can also be determined by GLC/EC after derivatization. Conjugates are freed by refluxing in acid and determined as the 2,2,2-trichloroethyl ester of DCVA and the heptafluorobutyl ester of 3-PBA. The lower limits of detection are reported to be 0.02-0.10 mg/kg for DCVA and 0.02-0.05 mg/kg for 3-PBA (depending on substrate).

APPRAISAL

In pre harvest uses, residues are highest where a crop part is exposed directly to the spray e.g. forage crops. Ground and aerial application yield similar residue levels. Although residues decline comparatively slowly after spraying, there is no obvious build-up of residues of permethrin or its two most important plant metabolites on repeated application, within the rates and frequency of permethrin spraying that are needed to obtain good insecticidal control. The two important plant metabolites are 3-phenoxybenzyl alcohol and the *cis*- and *trans*-isomers of 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (DCVA). These are also animal metabolites. The amounts of these metabolites in crops are very much smaller than permethrin residues and they do not need to be included in routine residue analyses (JMPR, 1980).

Permethrin levels in stored grains decline slowly. During the processing of treated whole wheat grain, the permethrin residue is retained mainly in the bran component, although a significant proportion (12%) remains with the white flour and follows through into bread baked from that flour.

After both oral and dermal administration to livestock, the small amounts of permethrin constitute the major portion of the residue in milk, eggs, muscle and fat. After oral administration to goats, metabolites form the major part of the residue in kidney and liver; DCVA occurs in both organ tissues, 3-phenoxybenzyl alcohol plus its 4'-hydroxy derivative, in liver and 3-phenoxybenzoic acid plus its 4-hydroxy derivative, in liver and kidney.

Following direct application to dairy cattle (1.0 g ai/cow and with free access to a self-oiler) permethrin levels are low in milk (<0.02 mg/kg) and in muscle, liver and kidney (<0.01 mg/kg). Highest levels (up to 0.1 mg/kg) have been found in fat.

Cows maintained on a diet containing 50 mg/kg of permethrin yielded milk containing low levels of residue (0.1 mg/kg), and the level in muscle was less than 0.1 mg/kg. The residue in milk declined to below 0.01 mg/kg after five days on returning the cows to a control diet.

Residues in eggs are also low and contamination of eggs laid during the treatment of poultry houses will not result in detectable residues in yolk and albumen. Permethrin is not detected in the albumen of eggs from hens receiving the compound at levels up to 33 mg/kg in the diet; levels in yolk are approximately 2% of corresponding permethrin dietary levels. In all cases studied, residues of permethrin and its metabolites in products of animal original declined notably on cessation of exposure.

Only small residue levels have been found in products of animal origin following direct application of permethrin to livestock. In view of the levels of permethrin found in forage crops, such as alfalfa, and the importance of such crops in animal feedstuffs, it seems likely that residue levels in products of animal origin will be higher following forage crop uses than from use for ectoparasite control (JMPR 1980).

MAXIMUM RESIDUE LIMITS

Codex MRLs have been established for a variety of fruits and vegetables. Feed commodities include alfalfa fodder, apple pomace, maize fodder, sorghum straw and fodder (dry) and soya bean fodder. MRLs for animal products include: edible offal (mammalian), eggs, meat (from mammals other than marine mammals), milks and poultry meat. The MRLs are summarised in Table 1.

Table 1. Permethrin MRLs in plant and animal products

Main uses	8 INSECTICIDE
JMPR	79, 80R, 81, 82R, 83R, 84R, 85R, 86, 87T, 88R, 89R, 91R (99T')
ADI	0.05 mg/kg body weight (1987)
RESIDUE	Permethrin (sum of isomers) (fat-soluble) ADI applies to the nominal 40% cis-, 60% trans- and 25% cis- 75% trans-materials only

Code	Commodity Name	MRL (mg/kg)	Step	JMPR	CCPR
AL 1020	Alfalfa fodder	100 dry wt	CXL		
TN 0660	Almonds	0.1	CXL		
AB 0226	Apple, pomace, Dry	50	CXL		
VS 0621	Asparagus	1	CXL		
VD 0071	Beans (dry)	0.1	CXL		
FB 0264	Blackberries	1	CXL		
VB 0400	Broccoli	2	CXL		
VB 0402	Brussels sprouts	1	CXL		
VB 0403	Cabbage, Savoy	5	CXL		
VB 0041	Cabbages, Head	5	CXL		
VR 0577	Carrot	0.1	CXL		
VB 0404	Cauliflower	0.5	CXL		
VS 0624	Celery	2	CXL		
GC 0080	Cereal grains	2 Po	CXL		
VL 0467	Chinese cabbage (type petsai)	5	CXL		
FC 0001	Citrus fruits	0.5	CXL		
SB 0716	Coffee beans	0.05	CXL		
VP 0526	Common bean (pods and/or immature seeds)	1	CXL		
SO 0691	Cotton seed	0.5	CXL		
OR 0691	Cotton seed oil, Edible	0.1	CXL		
VC 0424	Cucumber	0.5	CXL		
FB 0021	Currants, black, red, white	2	CXL		
FB 0266	Dewberries (including boysenberry and loganberry)	1	CXL		
MO 0105	Edible offal (mammalian)	0.1 V	CXL		
VO 0440	Eggplant	1	CXL		

Code	Commodity Name	MRL (mg/kg)	Step	JMPR	CCPR
PE 0112	Eggs	0.1	CXL		
VC 0425	Gherkin	0.5	CXL		
FB 0268	Gooseberry	2	CXL		
FB 0269	Grapes	2	CXL		
DH 1100	Hops, Dry	50	CXL		
VR 0583	Horseradish	0.5	CXL		
VL 0480	Kale	5	CXL		
FI 0341	Kiwifruit	2	CXL		
VB 0405	Kohlrabi	0.1	CXL		
VA 0384	Leek	0.5	CXL		
VL 0482	Lettuce, head	2	CXL		
AS 0645	Maize fodder	100 dry wt	CXL		
MM 0095	Meat (from mammals other than marine mammals)	1 (fat) V	CXL		
VC 0046	Melons, except watermelon	0.1	CXL		
ML 0106	Milks	0.1 (fat)	CXL		
VO 0450	Mushrooms	0.1	CXL		
FT 0305	Olives	1	CXL		
SO 0697	Peanut	0.1	CXL		
VP 0064	Peas, shelled (succulent seeds)	0.1	CXL		
VO 0051	Peppers	1	CXL		
TN 0675	Pistachio nuts	0.05	CXL		
FP 0009	Pome fruits	2	CXL		
VR 0589	Potato	0.05	CXL		
PM 0110	Poultry meat	0.1	CXL		
VR 0591	Radish, Japanese	0.1	CXL		
SO 0495	Rape seed	0.05	CXL		
FB 0272	Raspberries, red, black	1	CXL		
AS 0651	Sorghum straw and fodder, dry	20	CXL		
VD 0541	Soya bean (dry)	0.05	CXL		
AL 0541	Soya bean fodder	50 dry wt	CXL		
OC 0541	Soya bean oil, crude	0.1	CXL		
VL 0502	Spinach	2	CXL		
VA 0389	Spring onion	0.5	CXL		
VC 0431	Squash, Summer	0.5	CXL		
FS 0012	Stone fruits	2	CXL		
FB 0275	Strawberry	1	CXL		
VR 0596	Sugar beet	0.05	CXL		
SO 0702	Sunflower seed	1	CXL		
OC 0702	Sunflower seed oil, crude	1	CXL		
OR 0702	Sunflower seed oil, Edible	0.1	CXL		
VO 0447	Sweet corn (corn-on-the-cob)	0.1	CXL		
DT 1114	Tea, green, black	20	CXL		
VO 0448	Tomato	1	CXL		
CM 0654	Wheat bran, unprocessed	5 PoP	CXL		(1993)
CF 1211	Wheat flour	0.5 PoP	CXL		(1993)
CF 1210	Wheat germ	2 PoP	CXL		(1993)
CF 1212	Wheat wholemeal	2 PoP	CXL		(1993)
VC 0433	Winter squash	0.5	CXL		

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