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Pesticide risk profile for the feeding of citrus pulp to cattle and sheep

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Abbreviations

ai	active ingredient
APVMA	Australian Pesticide and Veterinary Medicines Authority
bw	body weight
DM	dry matter
ECRP	Existing Chemical Review Program
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
g	gram
GAP	good agricultural practice
ha	hectare
HAFT	Highest average field trial
JMPR	Joint Meeting on Pesticide Residues
kg	kilogram
LOD	Limit of detection for the analytical method, sometimes also used for limit of determination which is the same as LOQ
LOQ	limit of analytical quantitation
mg	milligram = 0.001 grams
MRL	maximum residue limit
PAFC	primary animal feed commodity
PHI	pre-harvest interval
P _{ow}	octanol water partition coefficient
ppm	parts per million = mg/kg
PSD	Pesticide Safety Directorate
TF	transfer factor = concentration in animal tissue or milk divided by concentration in feed
TRR	total radioactive residue
US EPA	United States of America Environmental Protection Agency
WHP	withholding period
*	before MRL indicates that the residue is at or about the LOQ, <i>i.e.</i> should be less than the LOQ.

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Potential for violative residues in cattle and sheep fed citrus pulp

For by-products to be useful as animal feeds, they must not present safety or health problems to the animals nor present a risk of contaminating the animal product to be sold. In the production and utilization of by-products, all parties must take care to prevent contamination with pesticides, mycotoxins, and other materials that could be dangerous to the animals or contaminate the animal product.

By-products of the citrus industry that can be used in animal feeds are citrus pulp, citrus molasses and a limited amount of citrus meal, with citrus pulp being the most important. Large quantities of citrus pulp are potentially available each year for beef cattle feeding. Fresh fruit (oranges and grapefruits, as well as lemons) sometimes go to waste if they are not marketed. It is reported that cattle can consume large amounts of these fruits (up to 40 kg a day have been reported) with no apparent harmful effects.

Citrus pulp

Citrus pulp consists of 60-65% peel, 30-35% pulp, and 0-10% seeds. On average, citrus pulp represents 60% of the fresh weight, with a mean dry matter content of 19.7%. Citrus pulp contains 11 - 13% crude fibre, 8.3 - 9.7% crude protein, 59 - 70% nitrogen free extract, and 63 - 76% total digestible nutrients, which make the pulp a promising energy source for livestock. In addition, the relatively high level of crude fibre makes it a possible feed source for ruminants.

Mature cattle accustomed to this feed can consume 6-10 kg a day. Intakes of up to 120 kg a day have been reported for mature cows in hot climates. Because of the high water content and perishable nature of the waste, it can only be used economically close to the processing plant. The feed is rather difficult to handle, ferments and sours quickly, and can be a fly-breeding nuisance if allowed to spoil. Large amounts are available in the harvest seasons and the material can be ensiled for year-round feeding.

Dried citrus pulp (citrus meal)

To increase the use of citrus pulp, it can be preserved by drying. The dried pulp can be stored for year-round feeding and it is reported to deteriorate less in storage than many other feeds.

Citrus molasses

The liquid obtained from pressing citrus waste contains 10-15% soluble solids; of which 50-70% are sugars. This material, which may amount to more than half the total weight of the waste, can be concentrated into citrus molasses. Citrus molasses is normally thick viscous liquid, dark brown to almost black, with a very bitter taste. This bitter taste does not diminish its usefulness in cattle feeding, and citrus molasses can be used in the same way as sugar-cane molasses. When fed free-choice to cattle, they consume up to 3 kg per day.

Citrus seed meal

Citrus seeds are sometimes collected separately at the canning plants for oil extraction. The resulting oilcake, called citrus seed meal, compares favourably with many sources of vegetable protein. It is acceptable to ruminants and is comparable to cottonseed oil cake, having the same percentage of crude protein.

Chemical residues in animal feeds may be transferred to the tissues of livestock on feeding. While it is unlikely that the chemical residues present in meat and offal arising from feeding represent a concern regarding food safety they can result in disruption to trade where the relevant Australian and overseas market standards differ.

The observation of chemical product withholding periods (WHPs) should ensure Australian standards are met, but as pesticide use and tolerances differ internationally observance of the WHP does not guarantee that the chemical residues in the feed are such that when fed to livestock, the residues in milk, meat and offal will meet export market requirements.

The aim of the current report is to profile the risk of violative residues in export meat and edible offal posed by the presence of pesticide residues in citrus pulp fed to cattle and sheep.

Assessment of currently registered chemicals that may be used on citrus crops

Estimates of residues in livestock tissues and milk are usually made on the basis of the propensity of a chemical to transfer to tissues and milk combined with anticipated animal dietary exposure.

Most experiments in the area of transfer of pesticide residues to animal tissues and milk following ingestion have been designed based on the requirements of regulators. The relevant studies required are livestock metabolism studies (lactating goat or dairy cow) and animal transfer (feeding) studies.

The feeding studies are used to determine transfer factors (TF) that are defined as the ratio of the pesticide residue in the tissue or commodity of interest (fat, muscle, liver, kidney or milk) to the residue in the diet (expressed on a dry matter intake basis).

In utilizing transfer factors derived from feeding or metabolism studies for risk assessment management purposes, the user needs to be aware of the limitations and assumptions used. The TF derived is dependent on the duration of the feeding or dosing, the concentration in the feed or dose level, the nature of the feed (if added to the feed), lactational status, bodyweight, age, sex and breed of the animal studied. For chemicals administered as a mixture, the presence of other chemicals may alter the metabolism and/or rate of excretion by induction of the various routes of decontamination. The duration of a feeding study required for the steady state concentration to be reached in tissue or milk is a function of the elimination half-life. Residue definitions set by different regulators are not always the same and residue definition is a factor that should also be taken into account when utilizing TF for managing residue risks and trade. Care must be taken in extrapolating TFs from goat metabolism studies to all ruminants as is demonstrated by endosulfan, for which the residue definition is the sum of α -endosulfan, β -endosulfan and endosulfan sulphate, where only low levels of residues are found in goats but significant transfer to tissues occurs for cattle^{1,2}.

The transfer factors utilised here were calculated from residues reported in the scientific literature using the highest individual animal tissue divided by the nominal feed level. If the highest residue was not reported the average residue divided by the nominal feed level were used instead. In the case of milk the average residue was divided by the nominal feed level.

¹ Indraningsih, McSweeney, C.S. & Ladds, P.W. (1993) Residues of endosulfan in the tissues of lactating goats. *Aust. Vet. J.*, **70**, 59-62.

² Reregistration Eligibility Decision for Endosulfan Case No. 0014 EPA 738-R-02-013 November 2002 Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division. <http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg>

For the purposes of profiling risk conservative estimates of animal dietary burden (intake) are required. The APVMA “*Stockfeed Guideline Document 1 Primary Feed Commodities As A Proportion of Livestock Diets*” (Version 1.1 March 2002)³ lists the maximum proportion of citrus pulp included in animal feed as 20% and however, 30% was used in the current evaluation. Estimates of residues in citrus pulp were obtained from scaling of literature studies, MRLs or based on conservative assumptions. The dietary burden is then the residue in crop × maximum proportion in the diet. To overcome errors that may result from differences in moisture contents of feed items it is accepted practice to calculate dietary burdens for a ration on a dry matter basis.

The estimated residue in animal commodities is:

$Residue = TF \times dietary\ burden$ [ppm DM basis]

Unless stated otherwise, the following assumptions have been used in the risk assessment:

- The citrus are harvested at maturity and that the pulp is derived on processing.
- The crop has been treated at the maximum rate and with the shortest interval between application and harvest permitted by the product label⁴
- The maximum rate of incorporation in the ration/diet is 30%.
- That residue transfer for cattle is greater than for sheep and therefore that the assessment of residues in cattle also covers sheep.

The potential for violative residues in animals is assessed against the Australian, Codex and US tolerances as listed in December 2005⁵. Other markets may have different standards, however, for the bulk of Australian meat exports it is assumed that if the lower of these tolerances (or the LOQ of the analytical method if no Codex or US tolerance exists) can be met, the feeding of citrus pulp will not pose an unacceptable risk.

Appendix 1 provides the details of the risk profile for each of the compounds registered in Australia for use on citrus at the time of the assessment.

Most of the compounds registered for use on citrus also have registrations in other crops that are major animal feed commodities. Indeed, for most compounds listed in appendix 1 the major route of exposure for animals to the chemical is expected to be through feeding of these other crops (e.g. pasture, cereal waste etc).

The conclusion of the analysis is the risk of residue violations in meat and edible offal posed by the feeding of citrus pulp derived from citrus crops treated with currently registered products is low for the majority of chemicals. Based on the available information, the following pesticides are identified as requiring further investigation and/or development of additional risk management strategies:

³ http://www.apvma.gov.au/residues/Stockfeed_Guideline_1.pdf

⁴ In general, only one or two product labels were selected per pesticide. There is a possibility that the maximum permitted rate may be higher than identified.

⁵ MRLs and approved use patterns change with time. The assessments include the most recent decisions of the Codex Alimentarius Commission (28th Session, July 2005) with regard to Codex MRLs, US tolerances as listed in the Code of Federal Regulations at December 2005 and MRLs as they appear in Table 1 of the APVMA *MRL Standard* as at December 2005.

Pesticide	Tissue	Residue (mg/kg)		Decline information located	
		Estimated ¹	Target ²	Crop	Animal
Dicofol	Fat	0.75	0.01	Yes but no decline	No
Diuron	Tissues	0.12	0.01	No	No
Endosulfan ³	Fat	0.23	0.1	Yes	Yes
Imazalil ⁴	Liver	0.11	0.01	Yes	No

¹residue in tissue estimated using assumptions outlined above

²target residue = lowest of Australian, Codex and US MRL or in absence of these the LOQ (often assumed to be 0.01 mg/kg)

³Note label for endosulfan contains a statement advising of the risk from feeding treated crops and provides advice on a suitable period on “clean feed” before slaughter (ESI = 21 days).

⁴Note label for imazalil contains a statement advising against the feeding of treated produce and by-products. It is included in the above table as it was felt that in some situations, especially the processing for pulp, it is possible that the information regarding the residue status of the product is not transmitted to producers.

The current assessment has only identified pesticides of concern and not considered industry based QA programs that address the potential for residues in animal feeds to transfer to animals and mitigate risks; The National Vendor Declaration (NVD) form for traded livestock and the Commodity Vendor Declaration (CVD) and By-product Vendor Declaration (BVD) forms which are used for traded livestock feedstuffs.

Appendix 1

2,2-DPA (2,2-dichloropropionic acid also known as dalapon)

- is a systemic herbicide used for the control of annual and perennial grasses and rushes. It is registered on a variety of crops including potential animal feeds sunflower, maize, soybean and pastures. The application rates are 1.5-3.7 kg ai/ha for the crops mentioned above and up to 3 kg ai/ha for citrus. Application to citrus is to trees at least 4 years old with no more than 9 kg ai/ha/year.

The harvest WHP is 7 days.

All crops have the following grazing restraint:

DO NOT graze or cut for stock food for 2 days after application

There are no Codex or USA MRLs for 2,2-DPA in animal tissues. The critical Australian MRL are 0.2 mg/kg for meat (mammalian) and *0.1 mg/kg for milks. Significant residues are not expected in citrus at harvest, the relevant MRL is *0.1 mg/kg. Dalapon and all of its known breakdown products dissolve easily in water. They are readily washed from cells and tissues. Because dalapon is insoluble in organic solvents and lipids, it does not build up in animal tissues^{6,7}.

Note: the US EPA revoked tolerance for citrus was 5 ppm and for citrus pulp (dehydrated) 20 ppm. Utilising the US EPA revoked tolerances conservative TFs of 0.01 are estimated for meat and offal and 0.006 for milk. Assuming residues occur at the US revoked tolerance for citrus pulp, anticipated maximum residues in tissues are $0.3 \times 20 \times 0.01 = 0.06$ mg/kg and 0.036 mg/kg in milk below the LOQ of 0.1 mg/kg listed in the APVMA *MRL Standard*.

It is anticipated that animal product residues will be below typical method LOQs.

2,4-D

- is a selective herbicide used widely for the control of emerged broadleaf weeds prior to sowing crops. It is registered on a variety of crops including potential animal feeds pasture and cereals at rates up to 2.2 kg ai/ha. Use on citrus is at rates of up to 20 ppm pre-harvest and 500 ppm as a post-harvest dip.

No harvest WHP is required.

There are Australian, Codex and USA MRLs for 2,4-D in animal tissues however, the residue definitions that apply differ. The residue definition for Codex and Australia is parent compound. For the USA the residue definition is the sum of 2,4-D and 2,4-DCP. This added complication potentially makes comparison of the respective MRLs more difficult. The Australian MRLs are 0.2 mg/kg for meat (mammalian), 2 mg/kg for edible offal (mammalian) and *0.05 mg/kg for milks. The critical USA tolerance is 2 mg/kg for cattle kidney while the MRL for milk is 0.1 mg/kg. The critical Codex tolerances are 5 mg/kg for edible offal, 0.2 mg/kg for meat (mammalian) while the MRL for milk is 0.01 mg/kg. The Australian use-pattern is such that residues of up to 5 mg/kg in citrus are expected at harvest and after dipping.

The US MRL for citrus fruit is 0.1 (N).

⁶ Kuhnert M, Freytag B, Freytag HH, Fuchs V. (1992) [The tolerance and residue accumulation of sodium-2,2-dichloropropionate (Dalapon) administered over 90 days to dairy cows] *Dtsch Tierarztl Wochenschr.* 99 (4), 148-51. German.

⁷ Fertig, S. N.; Schreiber, M. M. (1961). Effects Of Herbicide Ingestion. Effect of dalapon ingestion on performance of dairy cattle and levels of residue in the milk. *J. Ag. Food Chem.* 9:369

In a processing study for lemons (JMPR 1998), a mean PF of 5 was found for dry lemon pulp. Applying this PF to the citrus MRL gives an estimate of 25 ppm for citrus pulp. In an animal transfer study cows were dosed at the equivalent of 1446, 2890, 5779 and 8585 ppm in the diet for 28 days⁸. Residues in liver, kidney, muscle and fat for the 1446 ppm group were 0.2, 6.5, 0.24 and 0.51 mg/kg respectively. If incorporated at 30%, residues in the target tissues (kidney & fat) could be $0.3 \times 25 \times 0.0045 = 0.03$ mg/kg for kidney and $0.3 \times 25 \times 0.00035 = 0.00035$ mg/kg for fat. The TF for milk is 0.00006 (2890 ppm feed level) giving an anticipated residue in milk of $0.3 \times 25 \times 0.00006 = 0.00045$ mg/kg.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

Abamectin

- is a macrocyclic lactone insecticide used for the control of various insects and mites. It is registered on citrus for the control of pest mites. The application rate is up to 0.45 g ai/hL. The harvest WHP is 7 days.

There are Australian, Codex and USA MRLs for abamectin (avermectin in the USA) in animal tissues. The MRLs for cattle fat are 0.1 mg/kg in Australia and 0.015 mg/kg in the USA. The Australian cattle milk MRL is 0.02 mg/kg while the US MRL is 0.005 mg/kg. The Codex MRLs are 0.1 mg/kg for cattle fat, 0.05 mg/kg for cattle kidney, *0.01 mg/kg for cattle meat and 0.005 mg/kg for cattle milk. The Australian MRL for citrus fruit is 0.01 mg/kg with no MRLs for citrus pulp. The USA MRL for citrus fruit (whole) of 0.02 mg/kg with an MRL of 0.10 ppm for citrus pulp (dry). In the absence of other information the USA pulp (dry) MRL was scaled by the ratio of the Australian to USA application rates to provide an estimate of the likely residue in citrus pulp (dry) (0.05 ppm).

A transfer factor of 0.02 for liver when fed at 0.1 ppm in the diet was reported and 0.04 for milk⁹. Applying these TFs to the estimated residue in citrus pulp fed at 30% of the diet gives a liver residue of 0.0003 mg/kg ($0.3 \times 0.05 \times 0.02$) and a milk residue of 0.0006 mg/kg ($0.3 \times 0.05 \times 0.04$), less than the relevant Australian, EU and USA MRLs. Abamectin is widely registered internationally as an animal protection product with associated MRLs and is not considered to present a significant risk to Australian trade.

It is anticipated that animal product residues will be below typical method LOQs.

Aldicarb

- is a carbamate insecticide used for the control of various insects and nematodes. It is registered on citrus as a single application for the control of citrus nematode, scale and mealy bug. The application is made once each year after harvest and after any out of season (second crop) fruit have been removed. The rate is up to 11.55 kg ai/ha.

The harvest WHP is 26 weeks.

DO NOT allow stock to graze in treated area.

There are Australian and Codex but no USA MRLs for aldicarb in animal tissues. The MRLs for meat (mammalian) and milk are the same at *0.01 mg/kg for Australia and Codex. The Australian

⁸ 1998 JMPR - Pesticide Residues in Food - 1998 Evaluations, Part I Residues FAO Plant Production and Protection Paper 152/1. FAO and WHO 1999

⁹ 1992 JMPR - Pesticide Residues in Food - 1992 evaluations. Part II. Toxicology. WHO, WHO/PCS/93.34, Geneva, 1993

MRL for citrus fruit is 0.05 mg/kg. There are US MRLs for oranges, lemons and limes at 0.3 mg/kg and one for citrus pulp (dried) at 0.6 ppm.

Residues of aldicarb in the tissues of goats fed at 2.5 ppm in the diet for 10 days were reported by JMPR and were 1.5 µg/kg in liver, 0.46 µg/kg in kidney, 0.11 µg/kg in fat and 0.1 µg/kg in muscle¹⁰. Assuming that the processing factor for citrus to pulp (dried) is 2 based on the US tolerances, residues in Australian citrus pulp would be no more than 0.1 mg/kg. Feeding at 0.1 ppm in the diet is not expected to result in significant residues in animal tissues. The TF for milk is <0.002, residues from feeding citrus pulp at 30% of the diet are expected to be $0.3 \times 0.1 \times <0.002 = <0.00006$ mg/kg.

It is anticipated that animal product residues will be below typical method LOQs.

Amitrole

-is a herbicide used to control weeds in a variety of situations. The application rate for citrus is 0.55 kg ai/ha as a directed spray.

Do not apply later than 56 days before harvest

There are Australian but no Codex or US MRLs for amitrole in animal commodities. The Australian MRLs, including milk, have all been set at *0.01 mg/kg. The Australian MRL for citrus fruit is *0.01 mg/kg. Significant residues are not expected in citrus pulp.

In addition the JMPR have stated¹¹ that “*There do not appear to be any grounds for assuming that livestock grazing on plant materials growing on land that had been treated with amitrole for the control of weeds would absorb or retain significant amounts of amitrole or its metabolites*”.

It is anticipated that animal product residues will be below typical method LOQs.

Azinphos-methyl

- is an acaricide used for the control of scale and aphids in citrus. The application rate is up to 49 g ai/hL.

The harvest WHP is 14 days.

There are Australian but no Codex or US MRLs for azinphos-methyl in animal tissues. The Australian MRLs have all been set at *0.05 mg/kg (meat, edible offal, milk). The Australian and US MRLs for citrus fruit are 2 mg/kg.

Residues in the tissues and milk of cattle fed at levels ranging from 11 to 77 ppm in the diet for 28 days were all <0.01 mg/kg¹².

It is anticipated that animal product residues will be below typical method LOQs.

¹⁰ 1994 JMPR - Pesticide Residues in Food - 1994 Evaluations, Part I Residues FAO Plant Production and Protection Paper 78. FAO and WHO 1995

¹¹ 1974 JMPR. Evaluations of some pesticide residues in food. FAO/AGP/1974/M/11; WHO Pesticide Residues Series No. 4, 1975

¹² Interim Reregistration Eligibility Decision for Azinphos-Methyl Case No. 0235 Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division.
<http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg>

Bifenthrin

- is a synthetic pyrethroid insecticide used for the control of various insects in crops. It is registered on citrus for control of leaf eating weevil (application made pre-emergence of the beetle for post-emergence). The application rate is up to 2.5 g ai/tree to the ground beneath the tree. Bifenthrin residues decline with typical half-lives of 26 and 7 days for soil and foliage respectively.
No harvest WHP required

There are Australian, Codex and USA MRLs for bifenthrin in animal tissues. The relevant MRLs for cattle fat are 2, 0.5 and 1 mg/kg for Australia, Codex and the USA respectively. The MRLs for milk are 0.5 mg/kg, *0.05 mg/kg (cattle milk) and 1 mg/kg (milk fat, 0.1 mg/kg for whole milk). The Australian MRL for citrus fruit is *0.05 mg/kg. There are also MRLs for fodder and forage of pulses at 1 and 5 ppm respectively. The USA MRL for citrus fruit is 0.05 mg/kg while the MRL for citrus pulp (dried) is 0.3 ppm (both to expire 31/12/2002). Assuming similar levels in Australian citrus pulp (dry) and a maximum TF of 0.3¹³ would give residues in fat of <0.03 mg/kg, lower than the relevant international tolerances (assumed 30% diet). The TF for milk is 0.02 giving anticipated residues in milk of $0.3 \times 0.3 \times 0.02 = 0.0018$ mg/kg.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

Bromacil

- is a selective herbicides used for the control of certain broad leaved weeds and grasses in citrus. It is applied to grass/weeds in the orchard. The application rate is up to 3.6 kg ai/ha.
No harvest WHP required.

There are no Codex or USA MRLs for bromacil. The Australian MRLs are *0.04 mg/kg for meat (mammalian), edible offal (mammalian) and milk. In fact all MRLs for bromacil including citrus fruit have been set at *0.04 mg/kg implying that significant residues are not expected (the asterix signifies residues are \leq LOQ).

It is anticipated that animal product residues will be below typical method LOQs.

Buprofezin

is an insecticide used for the control of jassids, scale and mealy bugs in citrus. The application rate is 26.4 g ai/hL.
The harvest WHP is 28 days
Do not allow livestock to graze grasses or weeds under treated trees

There are Australian and US but no Codex MRLs for buprofezin in animal commodities. The Australian and US MRLs for edible offal and meat (fat) are all *0.05 mg/kg and for milk *0.01 and 0.03 mg/kg respectively. The Australian MRL for citrus fruit is 2 mg/kg and for citrus pulp (dry) of 5 ppm. The US MRL for citrus fruit is 2 mg/kg and the MRL for pulp (dried) is 6 ppm.

Residues of buprofezin were not detected in the tissues of cows following dosing at rates equivalent to feeding levels of 5, 15 and 50 ppm in the diet¹⁴. The method LOQ was 0.05 mg/kg.

It is anticipated that animal product residues will be below typical method LOQs.

¹³ 1992 JMPR - Pesticide Residues in Food – 1992 evaluations. Part II. Toxicology. WHO, WHO/PCS/93.34, Geneva, 1993

¹⁴ 1999 JMPR - Pesticide Residues in Food - 1999 Evaluations, Part I Residues FAO Plant Production and Protection Paper 157. FAO and WHO 2000

Cadusafos

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for nematode control. The application rate is up to 0.5 kg ai/100 m based on a 1 m band treated each side of the trunk and applied twice, 2 months apart.

No harvest or grazing WHPs are required.

Do not allow graze treated area

Do not cut for stock food

There are no Australian, Codex and USA MRLs for cadusafos in animal tissues despite MRLs having been set for crops. Significant residues are not expected as is reflected in the Australian MRL for citrus of *0.01 mg/kg.

It is anticipated that animal product residues will be below typical method LOQs.

Carbaryl

- is a carbamate insecticide used for the control of various insects in crops. It is registered on citrus for control of rough bollworm. The application rate is up to 100 g ai/hL.

The harvest WHP is 3 days.

Carbaryl residues decline with typical half-lives of 10 and 7 days for soil and foliage respectively.

There are Australian, Codex and USA MRLs for carbaryl in animal tissues. The Australian and Codex residue definition is carbaryl for both plant and animal commodities. The Australian MRLs for edible offal and meat are 0.2 mg/kg while that for milk is 0.05 mg/kg. The Codex MRL for kidney is 3 mg/kg and liver 1 mg/kg while the MRL for meat is 0.05 mg/kg. The Codex milk MRL is 0.05 mg/kg. The Australian MRL for citrus is 7 mg/kg.

The USA residue definition is the sum of carbaryl and 1-naphthol expressed as carbaryl for plant commodities, the sum of carbaryl, 1-naphthol, 5,6-dihydrodihydroxycarbaryl and 5,6-dihydrodihydroxynaphthol expressed as carbaryl for animal tissues. The US tolerance for cattle kidney and liver is 1 mg/kg and that for milk 0.3 mg/kg. The US also has tolerances of 10 mg/kg for citrus fruit and 100 ppm for various forages.

No data were located for residues of carbaryl in citrus pulp. However, it is considered unlikely that residues in pulp dried would exceed 100 ppm when prepared from citrus with maximum residues of 7 ppm (concentration factor of 14). The TF for kidney is 0.007 for the Australian/Codex residue definition and 0.012 for the US residue definition¹⁵ giving rise to anticipated maximum residues in kidney from feeding citrus pulp at 30% of the diet of $0.3 \times 0.007 \times 100 = 0.21$ mg/kg and $0.3 \times 0.012 \times 100 = 0.36$ mg/kg respectively for the Australian/Codex and USA residue definitions. The TF for milk is 0.0002 for the Australian/Codex residue definition and 0.002 for the US residue definition giving rise to anticipated maximum residues in milk from feeding citrus pulp at 30% of the diet of $0.3 \times 0.0002 \times 100 = 0.006$ mg/kg and $0.3 \times 0.002 \times 100 = 0.06$ mg/kg respectively for the Australian/Codex and USA residue definitions.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

¹⁵ 2002 JMPR. Pesticide Residues in Food - 2002 Evaluations – Part I: Residues Volume 1, FAO Plant Production and Protection Paper 175/1. FAO and WHO 2003 <http://www.fao.org/ag/AGP/AGPP/Pesticid/Default.htm>

Carbendazim

- is a systemic fungicide used for the post-harvest control of blue and green moulds in citrus. It is registered on citrus as a post-harvest dip at 50 g ai/100L.

Not required when used as directed.

There are Australian and Codex but no US MRLs for carbendazim. The relevant MRL for cattle meat is 0.2 mg/kg for Australia. MRLs for milk are all 0.1 mg/kg. There is an Australian MRL for citrus fruit at 10 mg/kg, the same as the revoked US MRL which also had a citrus pulp (dried) MRL of 50 ppm.

In studies in which dairy cows were fed either carbendazim or benomyl at levels of 2, 10, or 50 ppm in the diet for 28 days, no carbendazim residues were found in samples of lean muscle, liver, kidney or fat although in the carbendazim feeding study low-level residues of 5-HBC were observed in the liver (0.01 mg/kg) and kidneys (0.06 mg/kg) of cows in the group receiving 50 ppm carbendazim¹⁶. However, residues of this compound were also apparent in a kidney sample in the control group. One week after the end of treatment with the test material no residues were detectable in any tissue sample.

It is anticipated that animal product residues will be below typical method LOQs.

Chlorpyrifos

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for the control of California red scale and wingless grasshopper. The application rate is up to 50 g ai/hL for scale or 250 g ai/ha (25 g ai/hL) for grasshopper.

The harvest WHP is 14 days.

The grazing WHP is 2 days (28 days for cotton). The label states that the Meat Research Corporation determined that an Export Animal Feed Interval was not required.

There are Australian, Codex and USA MRLs for chlorpyrifos in animal tissues. The Australian and Codex residue definition is chlorpyrifos while the USA definition includes the metabolite TCP. The MRLs for cattle fat are 0.5, 1 and 0.3 mg/kg for Australia, Codex and the USA respectively. The MRLs for milk are 0.2 [milk in the fat] mg/kg, *0.01 mg/kg and 0.01 mg/kg (0.25 mg/kg for milk fat). There is an Australian MRL for citrus of 0.5 mg/kg. The US MRLs for citrus fruits and pulp (dried) are 1 and 5 ppm respectively.

The maximum transfer factor for feeding cattle at 10 ppm in the diet was 0.016 for cattle fat and at 30 ppm 0.0007 for milk¹⁷. Residues from feeding citrus pulp (dry) with residues of 5 ppm at 30% of the diet would be $0.3 \times 5 \times 0.016 = 0.02$ mg/kg; below the Australian, Codex and USA MRLs USA MRL for fat. Anticipated residues for milk would be $0.3 \times 5 \times 0.0007 = 0.001$ mg/kg.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

¹⁶ 1998 JMPR - Pesticide Residues in Food - 1998 Evaluations, Part I Residues FAO Plant Production and Protection Paper 152/1. FAO and WHO 1999.

¹⁷ 2000 JMPR. Pesticide Residues in Food - 2000 Evaluations – Part I, FAO Plant Production and Protection Paper 165. FAO and WHO 2001 <http://www.fao.org/ag/AGP/AGPP/Pesticid/Default.htm>

Diazinon

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for the control of spined citrus bug, citrus leaf miner and grasshoppers. The application rate is up to 52 g ai/hL.

The harvest WHP is 14 days.

Do not harvest, graze or cut for stock food crops or pastures for 14 days after application

There are Australian, Codex and USA MRLs for diazinon in animal tissues. The MRLs for cattle fat are 0.7 mg/kg for Australia, Codex and the US. For milk the MRLs are 0.5 [in the fat], 0.02 F mg/kg and not specified. There is an Australian MRLs for citrus fruit at 0.7 mg/kg. The US MRL for citrus is also 0.7 mg/kg.

The TF for diazinon in animal fat is 0.001. Anticipated residues in cattle fat from feeding citrus pulp are $0.3 \times 0.7 \times 0.001 = 0.0002$ mg/kg, below the relevant international MRLs (Note assumed 30% of the diet). No residues were detected in milk of cows dosed at the equivalent of 120 ppm in the diet.

It is anticipated that animal product residues will be below typical method LOQs.

Dichlobenil

- is a selective herbicides used for the control of certain annual grasses and broad leafed weeds in citrus. It is applied to grass/weeds in the orchard. The application rate is up to 6 kg ai/ha (band 2 m wide \times 5 km).

No harvest WHP required.

Do not graze livestock on treated areas

There are no Australian, Codex or USA MRLs for dichlobenil in animal commodities. The Australian MRLs are 0.1 mg/kg for citrus fruit, pome fruit, stone fruit, grapes and tomatoes (US apple/pear 0.5 mg/kg).

It is anticipated that animal product residues will be below typical method LOQs.

Dicofol

- is an organochlorine miticide used for the control of various pests in a variety of crops. In citrus it is used for the control of mites. The application rate is up to 48 g ai/hL.

The harvest WHP is 7 days.

Do not graze or cut for stock food.

There are no Australian or USA MRLs for animal commodities. The Australian and Codex residue definitions differ. The Australian residue definition is the sum of dicofol + 2,2,2-trichloro-1-(4-chlorophenyl)-1-(2-chlorophenyl)ethanol calculated as dicofol while the Codex residue definition for animal commodities is the sum of dicofol + 2,2-dichloro-1,1-bis(4-chlorophenyl)ethanol (p,p'-FW152) calculated as dicofol. There is a Codex MRL of 3 for cattle fat, 0.1 mg/kg for milk (F) and 1 mg/kg for cattle edible offal. There is an Australian MRL for citrus has been set at 5 mg/kg (fruits other than strawberries). The US MRLs for dicofol on citrus are 10 mg/kg for oranges, limes, lemons and grapefruit.

Residues in soil and foliage decline with typical half-lives of 16- 60 days and >6 months respectively.

The TF for fat for the Australian and Codex residue definitions are 0.05-0.1 for Australia and 0.3-0.5 for the Codex residue definition¹⁸. Assuming residues in pulp do not concentrate and pulp is fed at 30% of the ration, the anticipated residues in fat are $0.3 \times 5 \times 0.5 = 0.75$ mg/kg for the Codex residue definition. Anticipated residues in milk are $0.3 \times 5 \times 0.04 = 0.06$ mg/kg for the Codex and $0.3 \times 5 \times 0.006 = 0.009$ for the Australian residue definition. Residues above LOQ are expected if citrus pulp derived from dicofol treated citrus is fed to animals.

Dicofol can contain up to 1000 mg/kg DDT and related compounds¹⁹, an application rate of 0.48 kg ai/ha (1000 L spray/ha) corresponds to a potential application of DDT at 0.48 g/ha. The TF for fat and milk fat are estimated to be 1.8 and 2.1 respectively. If residues DDT are present at the same ratio to dicofol as in the technical active ingredient and do not concentrate at more than 10× in pulp, the anticipated residues are $0.1 \times (10 \times 5 / 1000) \times 1.8 = 0.009$ mg/kg in subcutaneous fat and $0.1 \times (10 \times 5 / 1000) \times 2.1 = 0.01$ mg/kg in milk fat.

Livestock residues (dicofol) may exceed international and/or domestic market standards.

Dimethoate

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for the control of bronze orange bug, fruit fly, aphids, thrips and wingless grasshoppers. The application rate is up to 30 g ai/hL. The harvest WHP is 7 days.

There are Australian, Codex and USA MRLs for dimethoate in animal tissues. The Australian and Codex MRLs for animal commodities have been set at *0.05 mg/kg while the US ones are set at 0.02 mg/kg. There are Australian MRLs of 5 mg/kg for fruits (includes citrus). The US MRLs for citrus (oranges, lemons, grapefruit, mandarin) have been set at 2 mg/kg while the MRL for citrus pulp (dried) is 5 ppm.

A metabolism study with lactating goats dosed orally with dimethoate at a rate equivalent to feeding at 30 ppm in the diet suggests that residues are not expected in animal tissues²⁰.

It is anticipated that animal product residues will be below typical method LOQs.

Diquat

- is a herbicide used for the control of weeds in various crops. It is applied to citrus at an application rate of up to 0.3 kg ai/ha (30 g ai/hL).

No harvest WHP required

Grazing WHP is 1 day

The Australian and Codex MRLs for diquat in meat (mammalian) are the same at *0.05 mg/kg. The US MRL for meat is 0.02 mg/kg. The MRLs for milk are *0.01 mg/kg, *0.01 mg/kg and 0.02 mg/kg. Residues in soil and foliage decline with typical half-lives of *ca.* 1000 and 30 days respectively. The MRL for citrus is *0.05 mg/kg. No residues were detected in tissues of cows fed

¹⁸ Pesticide Residues in Food - 1994 Evaluations, Part I Residues FAO Plant Production and Protection Paper 78. FAO and WHO 1995

¹⁹ Australian Pesticides And Veterinary Medicines Authority, Minimum Compositional Standards (MCS) for Active Constituents as of 30 January 2004, <http://www.apvma.gov.au/tgac/mincompstandards.pdf>

²⁰ 1998 JMPR - Pesticide Residues in Food - 1998 Evaluations, Part I Residues FAO Plant Production and Protection Paper 152/1. FAO and WHO 1999

diquat for 28 days at 100 ppm in the diet and slaughtered on the last day of dosing (LOD 0.01 mg/kg)²¹. Residues in pulp (dried) would be expected to be less than 100 ppm.

It is anticipated that animal product residues will be below typical method LOQs.

Diuron

- is a herbicide used for the control of weeds in crop. It is applied to bare ground in spring and autumn with an instruction to not allow spray or drift to contact fruit of citrus foliage. The application rate is up to 3.6 kg ai/ha. No harvest or grazing WHP is required.

There are no Codex MRLs for diuron. The US and Australian residue definitions differ with the Australian definition including a metabolite in addition to the parent compound. The relevant US MRL for animal tissues is 1 mg/kg for cattle mbyb while the Australian MRL for edible offal of cattle is 3 mg/kg (the higher value probably reflecting the inclusion of the metabolite in the residue definition). The Australian MRL for milk is 0.1 mg/kg. Residues in soil and foliage decline with typical half-lives of 90 and 30 days respectively. Australia has a primary animal feed commodity MRL of 50 mg/kg while the MRL for citrus (fruits) is 0.5 mg/kg. The USA MRL for citrus fruits is 1 mg/kg while the MRL for citrus pulp (dried) is 4 ppm.

It is considered unlikely that residues in pulp would exceed 4 ppm, much less than the Australian primary animal feed commodity MRL.

NOTE: US MRLs have been established for animal feed items (including alfalfa forage and hay at 2 ppm and citrus pulp dry at 4 ppm) as well as for animal commodities. If the US MRLs are used to estimate the dietary burden using the US EPA Guideline, a dietary burden of ca. 4.8 ppm is estimated. An anticipated TF is the 1 ppm (animal commodity tolerances) ÷ 4.8 ppm (dietary burden) = 0.2 (crude estimate).

Scaling the US tolerance for residues in pulp (dry) for the Australian MRL, and assuming pulp is fed at 30% of the ration, the anticipated residues in tissues are $0.3 \times 2 \times 0.2 = 0.12$ mg/kg for the US residue definition.

Livestock residues may exceed international and/or domestic market standards.

Endosulfan

- is an organochlorine insecticide used for the control of various pests in a variety of crops. In citrus it is used for the control of the spined citrus bug, bronze citrus bug, heliothis and various other bugs. Residues in soil and foliage decline with typical half-lives of 50 and 3 days respectively although the decline of residues in senescent foliage is much slower.

The revised application rate (post APVMA review) is up to 10.5 g ai/hl (1.05 kg/ha).

The harvest WHP is 3 days.

Do not graze orchards after application.

ESI: Livestock that have been grazing on or fed treated crops should be placed on clean feed for 21 days prior to export slaughter.

²¹ Reregistration Eligibility Decision, Diquat Dibromide, List A, Case 0288, EPA 738-R-95-016 July 1995 Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division. <http://cfpub.epa.gov/oppref/rereg/status.cfm?show=rereg>

There are Australian, Codex and USA MRLs for animal commodities. The Australian and USA MRL for cattle fat is 0.2 mg/kg while the Codex MRL is 0.1 mg/kg. The Australian MRL for milk [in the fat] is 0.5 mg/kg, USA 0.5 mg/kg for milk fat and Codex 0.004 mg/kg. There is an Australian MRL for citrus set at 0.2 mg/kg and a primary animal feed commodity MRL of 0.3 mg/kg. The revised Australian MRL for citrus is 0.3 mg/kg (APVMA 2004). JMPR reported a PF of 2 for wet pulp. Residues according to the revised use pattern were a maximum of 0.17 mg/kg and the APVMA reported a processing factor of 2.3 for citrus to wet pulp. Citrus pulp contains approximately 20% dry matter.

The TF for fat is 0.3-0.4. Feeding citrus pulp (dry) at 30% of the diet would result in maximum anticipated residues of $0.3 \times 0.17 \times 2.3 / 0.2 \times 0.4 = 0.23$ mg/kg. Based on the available information, feeding of pulp derived from citrus treated with endosulfan may pose a risk with respect to residues. The TF for milk is 0.02. Residues in milk would be $0.3 \times 0.17 \times 2.3 / 0.2 \times 0.02 = 0.012$ mg/kg. The TF for cream is 0.12. Residues in cream would be $0.3 \times 0.17 \times 2.3 / 0.2 \times 0.12 = 0.07$ mg/kg.

Livestock residues may exceed international and/or domestic market standards.

Ethephon

- is a plant growth regulator. It is applied for thinning to increase fruit size etc. The application rate is up to 33.6 g ai/hL.

Not required when used as directed.

The Codex and Australian MRLs for ethephon in edible offal are the same at 0.2 mg/kg. The Codex and Australian milk MRLs are *0.05 and 0.1 mg/kg. The US tolerance for offal is 0.1 mg/kg as is the tolerance for milk. Residues in soil and foliage decline with typical half-lives of 10 and 5 days respectively. Australia has a primary animal feed commodity MRL of 10 mg/kg. The MRL for citrus is 2 mg/kg.

In a study where dairy cows were fed at up to 150 ppm in the diet for 28 days, residues in tissues were <0.1 mg/kg for muscle, <0.2 mg/kg for fat, liver and kidney and <0.12 mg/kg in milk²².

It is anticipated that animal product residues will be below typical method LOQs.

Fenamiphos

- is an organophosphate insecticide used for the control of various insects and nematodes. It is registered on citrus for the control of soil borne plant pathogenic nematodes. The application rate is up to 30 kg ai/ha (initial) and 15 kg ai/ha (maintenance).

No harvest or grazing WHPs are required.

There is no Codex MRL for fenamiphos in animal tissues. The relevant Australian and USA MRLs for fenamiphos in animal tissues are *0.05 mg/kg for meat. The Australian and US MRLs for milk are *0.005 and 0.01 mg/kg respectively. The primary animal feed commodity MRL for fenamiphos is 1 mg/kg. Australian use-pattern is such that significant residues are not expected in citrus at harvest (MRL *0.05 mg/kg). The USA MRLs for citrus have been set at 0.6 mg/kg with the MRL for citrus pulp (dry) of 2.5 ppm. In a dairy cattle feeding study, residues in tissues of cattle fed at the equivalent of 20 ppm in the diet were ≤ 0.01 mg/kg²³.

²² 1994 JMPR - Pesticide Residues in Food - 1994 Evaluations, Part I Residues FAO Plant Production and Protection Paper 78. FAO and WHO 1995

²³ 1999 JMPR - Pesticide Residues in Food - 1999 Evaluations, Part I Residues FAO Plant Production and Protection Paper 157. FAO and WHO 2000

It is anticipated that animal product residues will be below typical method LOQs.

Fenbutatin oxide

- is a miticide. Application to citrus is for control of mites and is at an application rate of 24.75 g ai/hL.

The harvest WHP is 7 days.

Do not graze or feed animals on cover crops in sprayed orchards

There are Codex but no Australian or US MRLs for fenbutatin oxide in animal tissues. The Codex MRLs are 0.2 mg/kg for edible offal and *0.05 mg/kg for meat mammalian and milk. The Australian MRL for citrus fruit is 5 mg/kg while that for citrus peel is 30 mg/kg.

Feeding at 96 ppm for 28 days resulted in residues of up to 0.06 mg/kg in fat and 0.22 mg/kg in liver/kidney and 0.11 mg/kg in cream and <0.02 mg/kg in skim milk (US residue definition)²⁴. Anticipated residues in fat are $0.3 \times 30 \times 0.06 / 96 = 0.005$ mg/kg (feeding at 30% of diet), less than likely regulatory method LOQs for fat.

It is anticipated that animal product residues will be below typical method LOQs.

Fenthion

- is an organophosphate insecticide used for the control of various insects and nematodes. It is registered on citrus for the control of fruit fly. The application rate is up to 82.5 g ai/hL.

The harvest WHP is 7 days.

There are Australian and US (due to expire 1/4/06) but no Codex MRLs for fenthion in animal tissues. The relevant Australian and USA MRLs for fenthion in animal tissues are 1 mg/kg in Australia and 0.1 mg/kg in the US. The relevant milk MRLs are 0.2 and 0.01 (N) mg/kg respectively. The MRL for citrus is 2 mg/kg.

Residues in tissues of lactating dairy cows fed at a nominal feed level of 7.6 ppm were all <0.05 mg/kg²⁵. The TF for milk is 0.002.

It is anticipated that animal product residues will be below typical method LOQs.

Fluazifop-p

- is a selective post-emergent herbicide used for the control of certain grasses in crops such as canola, cotton, sunflower, legumes and pastures. The application rate for citrus is up to 0.318 kg ai/ha.

A WHP is not required when used as directed

There are Australian and USA but no Codex animal tissue MRLs for fluazifop. The relevant Australian MRLs are *0.05 mg/kg for edible offal and meat and 0.1 mg/kg for milk. The US tolerances for animal commodities have all been set at 0.05 mg/kg (fluazifop-butyl). The Australian MRL relevant to citrus is *0.02 mg/kg. As no residues are expected in citrus or citrus pulp, feeding of these commodities to animals should not result in residues in animal commodities.

²⁴ 1979 JMPR - Pesticide Residues in Food - 1979 Evaluations, Part I Residues FAO Plant Production and Protection Paper 20 Suppl. FAO and WHO 1980

²⁵ 2000 JMPR. Pesticide Residues in Food - 2000 Evaluations – Part I, FAO Plant Production and Protection Paper 165. FAO and WHO 2001

It is anticipated that animal product residues will be below typical method LOQs.

Fluometuron

- is a selective post-emergent herbicide used for the control of certain grasses in crops such as canola, cotton, sunflower, legumes and pastures. The application rate for citrus is up to 4.4 kg ai/h. The harvest WHP is 7 weeks.

There are no Australian, Codex or US animal tissue MRLs for fluometuron. The Australian MRLs for citrus have been set at 0.5 mg/kg.

The log P_{ow} for fluometuron is 2.2-2.4. It is considered unlikely that residues of fluometuron would be detected in animal tissues. The US EPA reported two feeding studies, one using fluometuron (10 and 20 ppm) and the other hydroxylated metabolites (11, 33 and 110 ppm)²⁶. No residues of fluometuron or hydroxylated metabolites were detected in muscle or fat when fed at any feed level. Residues in liver were 0.28 mg/kg for fluometuron fed at 20 ppm and 0.042 ppm for hydroxy metabolites fed at 33 ppm. Residues in milk were <LOQ for fluometuron fed at 20 ppm and 0.13 mg/kg for hydroxy metabolites fed at 110 ppm.

It is anticipated that animal product residues will be below typical method LOQs.

Glufosinate ammonium

-is a non-selective foliar herbicide used for the control of broadleaf weeds and grasses in crops such as cotton, maize, sorghum and winter cereals as well as pastures. It is applied as a shielded spray to citrus. The application rate is up to 1 kg ai/ha.

No harvest WHPs are required.

Do not graze or cut treated areas for stock food for 8 weeks after application

The relevant Australian MRLs are the same at 5 mg/kg for offal, 0.1 mg/kg for meat and *0.05 mg/kg for milks. The Codex MRLs are *0.1 mg/kg for edible offal, *0.05 mg/kg for meat mammalian and *0.02 mg/kg for milks. The relevant USA MRL is 6 mg/kg for cattle mbyp while the MRLs for meat and fat are 0.15 and 0.4 mg/kg respectively. The US MRL for milk is 0.02 mg/kg. There is an Australian MRL for mixed pasture of 15 mg/kg while the citrus MRL is 0.1 mg/kg.

The JMPR have reported that residues were <0.01 mg/kg in edible offal and meat of cattle fed at the equivalent of 27 ppm in the diet²⁷.

It is anticipated that animal product residues will be below typical method LOQs.

Glyphosate

-is a non-selective foliar herbicide used for the control of broadleaf weeds and grasses in crops such as cotton, maize, sorghum and winter cereals as well as pastures. It is applied as a shielded spray to

²⁶ Memorandum dated: 30 November 2004, Fluometuron. Summary of Analytical Chemistry and Residue Data for the Reregistration Eligibility Decision (RED) Document. DP Barcode: D300553 PC Code: 035503. Case Number: 0040 Chemical Class: Phenylurea 40 CFR §: 180.229. From: Samuel Ary, Chemist Reregistration Branch II Health Effects Division (7509C) To: Elissa Reaves, Risk Assessor Reregistration Branch II Health Effects Division (7509C) Kylie Rothwell, Chemical Review Manager Reregistration Branch III Special Review and Reregistration Division (7508C)

²⁷ Pesticide Residues in Food - 1998 Evaluations, Part I Residues FAO Plant Production and Protection Paper 152/1. FAO and WHO 1999

citrus. The application rate is up to 0.36 kg ai/ha for late season application to weeds (citrus not treated, shielded spray).

No harvest or grazing WHPs are required.

The relevant Australian and Codex MRLs are the same at 2 mg/kg for offal and 0.1 mg/kg for milk. The relevant USA MRL is 4 mg/kg for cattle kidney. The primary animal feed commodity MRL for glyphosate is 150 mg/kg, the citrus MRL is 0.5 mg/kg. The US MRL for citrus fruit is 0.5 mg/kg and the MRL for citrus pulp (dried) is 1.5 ppm.

Residues in cattle, pig and poultry meat, eggs and milk were determined after the animals were fed with a diet containing 100 ppm glyphosate and aminoglyphosate acid²⁸. The highest residues were in pig liver and kidney (up to 0.16 and 0.91 mg/kg, respectively) and cattle kidney (up to 1.4 mg/kg). TF cattle kidney = 0.014

It is anticipated that animal product residues will be below typical method LOQs.

Guazatine

- is a systemic fungicide used for the post-harvest control of blue and green moulds in citrus. It is registered on citrus as a post-harvest dip at 52 g ai/100L.

Not required when used as directed.

There are no Australian, USA and Codex MRLs for guazatine in animal tissues. There is an Australian MRL for citrus fruit at 5 mg/kg.

The results of commercial processing studies on citrus fruits indicate that the residues are on the surface. Processing factors calculated for dried peel were 4.9, 6.4, 13 and 15 with a mean value of 9.8²⁹. Negligible residues were observed in fat and muscle (<0.02 mg/kg) in a feeding study conducted at 2.5 and 25 ppm.

It is anticipated that animal product residues will be below typical method LOQs.

Haloxypop-R

- is a selective post-emergent herbicide used for the control of certain grasses in crops such as grain legumes, oilseeds (including cotton) and legume pastures. The application rate for citrus is up to 416 g ai/ha as a directed spray.

No harvest WHP required

There are Australian but no USA or Codex animal tissue MRLs for haloxypop. The relevant Australian MRLs are 0.5 mg/kg for edible offal, 0.02 mg/kg for meat (fat) and 0.02 mg/kg for milk. The Australian MRL relevant to citrus is *0.05 mg/kg.

It is anticipated that animal product residues will be below typical method LOQs.

Imazalil

- is a systemic fungicide used for the post-harvest control of blue and green moulds in citrus. It is registered on citrus as a post-harvest dip at *ca.* 50 g ai/100L.

²⁸ 1986 JMPR Pesticide Residues in Food - 1986 Evaluations, Part I Residues FAO Plant Production and Protection Paper 78. FAO and WHO 1986

²⁹ 1997 JMPR Pesticide Residues in Food - 1997 evaluations, FAO Plant Production and Protection Paper 146. FAO and WHO 1998

Not required when used as directed.

Do not feed treated produce or by-products to food producing animals, including poultry.

There are USA but no Australian and Codex MRLs for imazalil in cattle tissues. The US MRL for cattle liver is 0.5 mg/kg while the other MRLs for cattle tissues and milk are set at 0.01 mg/kg. There is an Australian MRL for citrus fruit at 10 mg/kg. The US MRL for citrus fruit is 10 mg/kg and pulp (dried) 25 mg/kg.

Residues in oranges in trials ranged from 0.9 to 2.8 unwaxed and 4.8 to 5.8 mg/kg waxed (MRL based on maximum levels of 7.1 & 8.8 mg/kg found in lemons).

Residues of imazalil in tissues of cows following dosing at a rate equivalent to a feed level of 33 ppm were 0.00-0.014 mg/kg in fat and muscle and 0.14-0.51 mg/kg in liver³⁰. Anticipated residues in liver are $0.3 \times 25 \times 0.015 = 0.11$ mg/kg while anticipated residues in milk are $0.3 \times 25 \times 0.0005 = 0.00375$ mg/kg.

Livestock residues may exceed international and/or domestic market standards.

Maldison (malathion)

- is an organophosphate insecticide used for the control of various insects and nematodes. It is registered on citrus for the control of fruit fly, scale and various other bugs. The application rate is up to 100 g ai/hL.

The harvest WHP is 3 days.

There are Australian and USA but no Codex MRLs malathion in animal tissues. The relevant Australian and USA MRLs for malathion in animal tissues are 1 mg/kg in Australia and 4 mg/kg in the US. The Australian MRL for milk is 1 [in the fat] mg/kg while the US MRL is 0.5 mg/kg for milk fat (from application to dairy cows). The MRL for citrus is 4 mg/kg in Australia and 8 mg/kg in the US (oranges).

No residues of malathion were detected in tissues in a goat metabolism study conducted at a nominal feeding level of 115 ppm³¹..

It is anticipated that animal product residues will be below typical method LOQs.

Mancozeb

- is a dithiocarbamate fungicide used on a variety of crops. It is used on citrus for the control of black spot and mites at an application rate of 150 g ai/hl or 12 kg ai/ha.

No harvest WHP required

There are Australian, Codex and US MRLs for mancozeb in animal commodities. The Australian MRL for edible offal is 2 mg/kg while the Codex MRL is 0.5 mg/kg, both as CS₂. The USA residue definition is zinc ethylenebisdithiocarbamate and the MRL 0.5 mg/kg for liver and kidney. The MRLs for milk are *0.2 mg/kg and *0.05 mg/kg respectively.

The Australian PAFC MRL is 50 ppm and the citrus MRL 0.2 mg/kg. Residues in citrus pulp (dried) would be expected to be much less than 50 ppm. The target tissue is liver. The TF for liver

³⁰ Reregistration Eligibility Decision Residue Chemistry Considerations PC Code No. 111901; Case 2325 Imazalil. Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division

³¹ 1999 JMPR - Pesticide Residues in Food - 1999 Evaluations, Part I Residues FAO Plant Production and Protection Paper 157. FAO and WHO 2000

(45 ppm feeding study) was 0.003^{32} giving an anticipated maximum residue from the feeding of citrus pulp at 30% of the diet of $0.3 \times <50 \times 0.003 = <0.05$ mg/kg, less than the relevant international MRLs. The TF for milk was <0.008 .

It is anticipated that animal product residues will be below typical method LOQs.

Methidathion

- is an organophosphate insecticide used for the control scale, mealy bugs and aphids etc in citrus. The application rate is up to 50 g ai/hL. Methidathion residues decline with typical half-lives of 7 and 3 days for soil and foliage respectively.

The harvest WHP is 21 days

There are Australian and Codex but no USA MRLs for methidathion in animal tissues. The Australian (Codex) and USA residue definitions differ: methidathion (Australia, Codex), sum of methidathion, its oxygen analogue, the sulfoxide and the sulfone (USA). The Australian and Codex MRLs that apply to animal tissues are 0.5 and *0.02 mg/kg respectively. The corresponding milk MRLs are 0.5 [in the fat] and 0.001 mg/kg. The Australian and US MRL for citrus is 2 mg/kg except for mandarins which is 5 mg/kg in Australia.

No residues of methidathion were observed in tissues of cows fed at up to 50 ppm in the diet when measured by the Australian or USA residue definitions³³.

It is anticipated that animal product residues will be below typical method LOQs.

Methomyl

- is a carbamate insecticide used for the control of heliothis, mealy bugs, bronze citrus bug etc in citrus. The application rate is up to 45 g ai/hL or 0.45 kg ai/ha. Methomyl residues decline with typical half-lives of 7 and 4 days for soil and foliage respectively.

The harvest WHP is 2 days.

There are Australian and Codex but no USA MRLs for methomyl (as thiodicarb) in animal tissues. The MRLs have all been set at the LOQ. The Australian MRL for citrus is 1 mg/kg.

No residues of methomyl/thiodicarb were observed in tissues (<0.01 mg/kg) of cows fed at up to 86 ppm in the diet when measured by the Australian or USA residue definitions³⁴.

It is anticipated that animal product residues will be below typical method LOQs.

Norflurazon

-is a fluorinated pyridazinone herbicide used for the pre-emergent control of annual grasses and broadleaf weeds in cotton, citrus, grapes and stone fruit etc. It is applied at an application rate of up to 2 kg ai/ha as a shielded spray.

No harvest or grazing WHPs are required.

³² 1993 JMPR - Pesticide Residues in Food - 1993 Evaluations, Part I Residues FAO Plant Production and Protection Paper 124. FAO and WHO 1994

³³ Methidathion Reregistration Eligibility Decision Residue Chemistry Considerations Shaughnessy No. 100301; Case No. 0034 Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division

³⁴ 2001 JMPR Pesticide Residues in Food - 2001 Evaluations – Part I, FAO Plant Production and Protection Paper 171. FAO and WHO 2002

There are no Australian or Codex MRLs for norflurazon in animal tissues. The Australian (parent) and US (parent + metabolite) residue definitions differ. The relevant US MRLs for animal tissues are 0.25 mg/kg for cattle liver and 0.1 mg/kg for other tissues and milk. The Australian MRL for citrus is 0.2 mg/kg. The US MRL for citrus fruit is 0.2 and pulp (dried) 0.4 mg/kg.

No data on the effect on residues on processing of oranges to pulp or animal transfer were located. A US EPA report noted³⁵ “Metabolism of norflurazon in livestock has been studied and tolerances for livestock commodities have been established. A ruminant study adequately identified the metabolites in milk, liver and kidney. Norflurazon was not detected in ruminant milk or tissue, and total radioactive residues in fat and muscle were <0.01 part per million (ppm)” however, the dose level administered was not given in the report. Noting the similarity in US and Australian use-patterns and MRLs for citrus, it is considered unlikely that residues in livestock would exceed the US animal commodity tolerances.

NOTE: US MRLs have been established for animal feed items (alfalfa forage and hay at 3 and 5 ppm respectively) as well as for animal commodities. If the US MRLs are used to estimate the dietary burden using the US EPA Guideline, a dietary burden of 7.7 ppm is estimated (3 ppm grass forage, 35% DM, 70% diet + 5 ppm hay, 89% DM 30% diet). An anticipated TF is the 0.25 ppm (animal commodity tolerances, liver) ÷ 7.7 ppm (dietary burden) = 0.03 (crude estimate). An anticipated TF is the 0.1 ppm (animal commodity tolerances, fat) ÷ 7.7 ppm (dietary burden) = 0.01 (crude estimate).

It is anticipated that animal product residues will be below typical method LOQs.

Omethoate

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for the control of scale and aphids. The application rate is up to 60 g ai/hL. The harvest WHP is 7 days.

There are Australian but no Codex or US MRLs for omethoate in animal tissues. The Australian MRLs for animal commodities including milk have been set at *0.05 mg/kg. There are Australian MRLs of 2 mg/kg for fruits and 20 ppm for a series of miscellaneous forage and fodder crops.

A metabolism study with lactating goats dosed orally with dimethoate suggests that residues of omethoate are not expected in animal tissues³⁶.

It is anticipated that animal product residues will be below typical method LOQs.

Oryzalin

- is a dinitroaniline herbicide used for the control of weeds in various crops. The application rate is up to 3.4 kg ai/ha as a directed spray. There is no harvest WHP.

There are no Australian, US or Codex MRLs for oryzalin animal commodities. The Australian MRL for citrus is 0.1 mg/kg and the US MRL is 0.05 mg/kg.

³⁵ Reregistration Eligibility Decision Norflurazon List A Case 0229, Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division

³⁶ 1998 JMPR - Pesticide Residues in Food - 1998 Evaluations, Part I Residues FAO Plant Production and Protection Paper 152/1. FAO and WHO 1999

The US EPA reported in their assessment on oryzalin³⁷ that studies conducted at highly exaggerated feeding levels with laying hens and beef and dairy cattle indicated that oryzalin is either poorly absorbed or rapidly metabolized via hydroxylation and cleavage of the alkyl side chain to yield polar components that are excreted and that there is "*No reasonable expectation of finite residues in animal commodities*".

It is anticipated that animal product residues will be below typical method LOQs.

Paraquat

- is a herbicide used for the control of weeds in various crops. The application rate is up to 4 L/ha as a directed spray = 500 g ai/ha or 50 g ai/hL. (NOTE diquat = 300 g ai/ha or 30 g ai/hL)

No harvest WHP required

Do not graze or cut sprayed vegetation for stock food for at least 1 day after application.

Remove stock from treated areas 3 days before slaughter.

The Australian and Codex MRLs for paraquat in kidney and milk are the same at 0.5 and *0.01 mg/kg respectively. The US MRL for kidney is 0.3 mg/kg and for milk 0.01 (N) mg/kg. Residues in soil and foliage decline with typical half-lives of *ca.* 1000 and 30 days respectively. The MRL for citrus is *0.05 mg/kg in both Australia and the US.

For residues in kidney to be less than the US MRL of 0.3 mg/kg, cattle would have to fed at less than *ca.* 80 ppm in the diet.

It is anticipated that animal product residues will be below typical method LOQs.

Parathion-methyl

- is an organophosphate insecticide used for the control of various insects in crops. It is registered on citrus for the control of black citrus aphids and scale. The application rate is up to 49.5 g ai/hL.

The harvest WHP is 14 days.

Do not graze or cut for stock food for 14 days after application

There are Australian but no Codex or US MRLs for parathion methyl in animal commodities. The Australian MRLs for animal commodities have been set at T*0.05 mg/kg. There are Australian MRLs of T1 mg/kg for citrus fruit and T25 ppm for legume animal feeds.

A metabolism study with lactating goats dosed orally with parathion methyl at the equivalent of 6.25 ppm in the diet suggests that residues of parathion methyl are not expected in animal tissues³⁸.

It is anticipated that animal product residues will be below typical method LOQs.

Pendimethalin

-is a selective herbicide used for the control of annual ryegrass and certain broadleaf weeds in cotton, cereals etc. It is applied at an application rate of up to 3.96 kg ai/ha as a directed spray.

No harvest or grazing WHPs are required.

³⁷ Reregistration Eligibility Decision Oryzalin List A Case 0186, Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division

³⁸ 2000 JMPR. Pesticide Residues in Food - 2000 Evaluations – Part I, FAO Plant Production and Protection Paper 165. FAO and WHO 2001

There are no Codex or US MRLs for pendimethalin in animal tissues while the Australian MRLs have all been set at *0.01 mg/kg. Residues decline in soil and foliage with typical half-lives of 90 and 50 days respectively. The Australian MRL for citrus fruit is *0.05 mg/kg. The US EPA notes that animal metabolism studies in goats conducted at exaggerated feeding levels indicate that there is no reasonable expectation for residues of pendimethalin in tissues³⁹.

It is anticipated that animal product residues will be below typical method LOQs.

Permethrin

- is a synthetic pyrethroid insecticide used for the control of various insects in crops. It is registered on citrus for the control of citrus leaf miner in nursery plants and as the time between application and fruiting is so long no residues are expected.

It is anticipated that animal product residues will be below typical method LOQs.

Piperonyl butoxide (PBO)

- is a synergist used to increase the effectiveness of various synthetic pyrethroid (SP) insecticides. It is registered for use with various pyrethrin in the control of insect pests on citrus. The application rate is up to 32 g ai/hL.

The harvest WHP is 1 day

There are Australian and Codex but no US MRLs for PBO in animal commodities. PBO is exempt from the requirement for tolerances in the US. The Australian MRLs for animal tissues have all been set at 0.1 mg/kg. The Codex MRL for mammalian meat (fat) (except cattle) is 2 mg/kg and for cattle meat (fat) 5 mg/kg. The Australian MRL for milks is *0.05 mg/kg. There is an Australian and US MRL of 8 mg/kg for citrus (fruits) (oranges in the US).

The JMPR have reported a processing factor for oranges to dried pulp of 5.7. The TF for PBO in fat is 0.004⁴⁰ (feeding at 100 ppm in the diet) resulting in an anticipated maximum residue from feeding citrus pulp at 30% of the diet of $0.3 \times 8 \times 5.7 \times 0.004 = 0.05$ mg/kg, below the relevant Australian, Codex and US MRLs.

The TF for PBO in milk is 0.0001 (feeding at 100 ppm in the diet) resulting in an anticipated maximum residue from feeding citrus pulp at 30% of the diet of $0.3 \times 8 \times 0.0001 = 0.0002$ mg/kg, less than the relevant Australian, Codex and US MRLs and likely regulatory method LOQ.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

Pirimicarb

- is a carbamate aphicide used for the control of aphids in various crops. It is registered on citrus for control of citrus aphid and aphids. The application rate is up to 25 g ai/hL or 550 g ai/ha.

The harvest WHP is 2 days

There are Australian and Codex but no USA MRLs for pirimicarb in animal commodities. The Australian MRLs for meat and milk are *0.1 mg/kg while the Codex MRLs are *0.05 mg/kg, both set at the limit of analytical quantitation and are essentially the same. The Australian MRL for citrus is 0.5 mg/kg (fruits).

³⁹ Reregistration Eligibility Decision Pendimethalin List A Case 0187, Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division

⁴⁰ 2002 JMPR. Pesticide Residues in Food - 2002 Evaluations – Part I: Residues Volume 1, FAO Plant Production and Protection Paper 175/1. FAO and WHO 2003

No data was located for residues of pirimicarb in citrus pulp (dry) however in a feeding study reported by JMPR residues of pirimicarb were <0.05 mg/kg for animals dosed at the equivalent of 200 ppm in the diet⁴¹, a level of exposure much greater than would be anticipated to arise from citrus pulp. The TF for milk is 0.00065 indicating a little likelihood that residues would be detected in milk.

It is anticipated that animal product residues will be below typical method LOQs.

Propineb

- is a propylenethiourea fungicide used on a variety of crops. It is used on citrus for the control of black spot and mites at an application rate of 140 g ai/hl or 1.4 kg ai/ha.

The harvest WHP is 7 days

There are Australian and Codex but no US MRLs for propineb in animal commodities. The Australian MRL for edible offal is 2 mg/kg while the Codex MRL is 0.5 mg/kg, both as CS₂. The Australian PAFC MRL is 50 ppm and the citrus MRL 0.2 mg/kg. Residues in citrus pulp (dried) would be expected to be much less than 50 ppm. The target tissue is liver. The TF for liver (45 ppm feeding study with mancozeb) was 0.003⁴² giving an anticipated maximum residue from the feeding of citrus pulp at 30% of the diet of $0.3 \times <50 \times 0.003 = <0.05$ mg/kg, less than the relevant international MRLs.

It is anticipated that animal product residues will be below typical method LOQs.

Pyrethrins

- is a natural pyrethroid insecticide used for the control various insect pests in citrus and other fruit crops. The application rate is up to 8 g ai/hL.

The harvest WHP is 1 days.

There are US but no Australian or Codex MRLs for pyrethrins in animal commodities. The MRLs applicable to cattle fat (target tissue) have all been set at 0.1 mg/kg. There is an Australian MRL of 1 mg/kg for citrus while the US MRL is also 1 mg/kg (post-harvest).

In a feeding study with lactating cows, residues in tissues of animals dosed orally at a level equivalent to 5 ppm in the feed had residues in tissues that were <LOQ (0.038 mg/kg) for muscle, liver and kidney and 0.048-0.075 mg/kg in fat⁴³. The processing factor reported by 2000 JMPR for citrus fruit to pulp (dry) was 7.5. Anticipated residues in fat from feeding citrus pulp derived from fruit with residues at the MRL are $1 \times 7.5 \times 0.3 \times 0.015 = 0.03$ mg/kg. Feeding citrus with residues of 1 ppm should not result in tissues residues above typical LOQs for pyrethrins (0.038 mg/kg).

It is anticipated that animal product residues will be below typical method LOQs.

Simazine

⁴¹ 1978 JMPR - Pesticide Residues in Food - 1978 Evaluations, FAO Plant Production and Protection Paper 15 Suppl. FAO and WHO 1979

⁴² 1993 JMPR - Pesticide Residues in Food - 1993 Evaluations, Part I Residues FAO Plant Production and Protection Paper 124. FAO and WHO 1994

⁴³ 2000 JMPR. Pesticide Residues in Food - 2000 Evaluations – Part I, FAO Plant Production and Protection Paper 165. FAO and WHO 2001

- is a triazine herbicide and is used for the control of grass and broadleaf weeds in crops including citrus. It is applied to bare ground as a directed spray at 110 g ai/hL

No harvest or grazing/feeding WHPs required.

There are Australian and US but no Codex MRLs for animal commodities. The Australian MRLs have all been set at *0.01 mg/kg. The US MRLs are 0.02 (N) mg/kg for animal commodity MRLs. The Australian MRL for citrus is *0.1 mg/kg while the US MRL is 0.25 mg/kg.

Studies in rats, goats, and sheep reveal that 60 to 70% of the ingested dose may be absorbed into the system, with approximately 5 to 10% distributed systemically to tissues⁴⁴. The remainder is eliminated via urine within 24 hours. Distribution led to detectable levels in red blood cells (highest), liver, kidney, fat, bone, and plasma. When a cow was fed 5 ppm for 3 days, no simazine was found in the cow's milk during the next 3 days. It has been reported that simazine residues were present in the urine of sheep for up to 12 days after administration of a single oral dose. The maximum concentration in the urine occurred from 2 to 6 days after administration.

It is anticipated that animal product residues will be below typical method LOQs.

SOPP (sodium ortho-phenyl phenol or 2-phenyl phenol)

-is a fungicide used post-harvest for the prevention of blue mould in citrus. The application rate is 1.9 kg ai/hL.

A WHP is not required when used as directed.

There are no Australian, Codex or US animal commodity MRLs. The Australian MRL for citrus fruit is 10 mg/kg as is the US tolerance.

An average processing factor of 3.6 has been reported for the concentration of residues in processing whole fruit to dried pulp. In a ruminant metabolism study conducted at a dose equivalent to 32 ppm in the feed, no residues of OPP were detected in the tissues after 5 days of dosing⁴⁵.

It is anticipated that animal product residues will be below typical method LOQs.

Thiabendazole

- is a systemic fungicide used for the post-harvest control of blue and green moulds and stem rot in citrus. It is registered on citrus as a post-harvest dip at 100 g ai/100L.

Not required when used as directed.

There are Australian, Codex and US MRLs for thiabendazole in cattle tissues. The Australian MRLs for animal tissues have been set at 0.2 mg/kg while the milk MRL is 0.05 mg/kg. There is an Australian MRL for citrus fruit at 10 mg/kg. The Codex MRL for cattle kidney is 1 mg/kg while the MRL for cattle milk is 0.1 mg/kg. The US MRLs for animal tissues are 0.1 mg/kg while the milk MRL is 0.4 mg/kg. The US MRL for citrus fruit is 10 mg/kg and pulp (dried) 35 mg/kg.

The TF for kidney (target tissue) is 0.004⁴⁶ giving anticipated residues of $0.3 \times 35 \times 0.004 = 0.04$ mg/kg if fed at 30% diet, below the Australian, Codex and US tolerances.

⁴⁴ Evaluation of fully approved or provisionally approved products: Issue No. 72 simazine (2) July 1993: Evaluation on: Simazine (2) Disclosure document, Evaluation of the mammalian and ecotoxicity of simazine, UK PSD

⁴⁵ 1999 JMPR - Pesticide Residues in Food - 1999 Evaluations, Part I Residues FAO Plant Production and Protection Paper 157. FAO and WHO 2000

The TF for milk is 0.001 giving anticipated residues of $0.3 \times 35 \times 0.001 = 0.01$ mg/kg if fed at 30% diet.

Livestock residues are not anticipated to exceed international and/or domestic market standards.

Trifluralin

- is a selective herbicide of the dinitroaniline class and is used for the control of grass and broadleaf weeds in crops including citrus. It is applied to citrus as a shielded or directed spray to bare ground. The application rate is up to 1.1 kg ai/ha. No harvest or grazing/feeding WHPs required.

There are no Codex or US MRLs for trifluralin in animal tissues although there are registrations in the US including on citrus (MRL citrus fruit *0.05 mg/kg). The Australian MRL for meat (mammalian) and milk are *0.05 mg/kg. The US EPA evaluation of trifluralin states that based on a goat metabolism study where animals were fed at exaggerated rates there is no expectation of finite residues of trifluralin in animal tissues⁴⁷. Residues decline in soil and foliage with typical half-lives of 60 and 3 days respectively.

It is anticipated that animal product residues will be below typical method LOQs.

Zineb

- is a dithiocarbamate fungicide used on a variety of crops. It is used on citrus for the control of black spot and mites at an application rate of 140 g ai/hl or 1.4 kg ai/ha. The harvest WHP is 7 days

There are Australian and Codex but no US MRLs for zineb in animal commodities. The Australian MRL for edible offal is 2 mg/kg while the Codex MRL is 0.5 mg/kg, both as CS₂. The Australian PAFC MRL is 50 ppm and the citrus MRL 0.2 mg/kg. Residues in citrus pulp (dried) would be expected to be much less than 50 ppm. The target tissue is liver. The TF for liver (45 ppm feeding study for mancozeb) was 0.003⁴⁸ giving an anticipated maximum residue from the feeding of citrus pulp at 30% of the diet of $0.3 \times 50 \times 0.003 = <0.05$ mg/kg, less than the relevant international MRLs.

It is anticipated that animal product residues will be below typical method LOQs.

⁴⁶ 2000 JMPR. Pesticide Residues in Food - 2000 Evaluations – Part I, FAO Plant Production and Protection Paper 165. FAO and WHO 2001

⁴⁷ Reregistration Eligibility Decision, Trifluralin, List A Case 0179, Environmental Protection Agency, Office of Pesticide Programs, Special Review and Reregistration Division EPA 738-R-95-040, April 1996

⁴⁸ 1993 JMPR - Pesticide Residues in Food - 1993 Evaluations, Part I Residues FAO Plant Production and Protection Paper 124. FAO and WHO 1994