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GUIDANCE DOCUMENT ON RISK ASSESSMENT USING BREW FACTOR FOR FIXATION OF MRLS OF PESTICIDES IN TEA

(Prepared by Indian and Chinese delegations, Working Groups on MRL and Tea Brew of FAO-IGG on Tea with comments from USA , Japan and Sri Lanka)

SUMMARY

Tea is mostly consumed after brewing dry tea leaves in hot water. Risk assessment on the basis of solid dry tea leaf is a gross overestimation and will eliminate a number of useful compounds as only a portion of the residues in dry tea leaves is actually transferred into tea brew (liquor). The main reason for opposition to fixing MRL in tea brew is that the brew is not the commodity on sale. The FAO-Intergovernmental Group (IGG) on Tea Working groups on MRL and Tea Brew, therefore, had a detailed discussion on the issue and as a way forward suggested the following approach to be adopted in sequence:

- Generation of data on residues in dry tea leaves and tea brew.
- Determination of brew factor (Ratio of residues in brew to residues in dry tea leaves).
- Carry out risk assessment based on brew factor.
  - Multiply [HR or STMR x Dry tea leaf consumed] by BF (Brew Factor) to obtain TMDIb
  - Compare TMDIb with ADI
- Risk assessment of Proposed MRL (MRLp) based on brew factor.
  - Multiply [MRLp x Dry tea leaf consumed] with BF to obtain TMDIb (MRLp)
  - Compare TMDIb(MRLp) with ADI
- Data submission to regulators for fixation of MRL in tea.

This approach will ensure food safety as well as provide setting realistic MRLs in tea that would also not contradict with one of the purposes of the Codex MRLs as *MRLs for trade* and it would also not be unfair to growers with critical GAP (Good Agricultural Practices). Thus, this approach will have more acceptability than the proposal to set MRLs in tea brew in general and will help fixing realistic MRLs without jeopardizing food safety and smooth trade.

Note:

1. Brew Factor (BF) = Residues in tea brew ÷ Residues in dry tea leaves.
2. Brew Factor is distinctly different from Processing Factor.
   [Processing Factor = Residues in fresh tea shoots ÷ Residues in dry tea leaves].
3. MRLp obtained from OECD MRL Calculator.
4. TMDI: Theoretical Maximum Daily Intake.
5. TMDIb: Theoretical Maximum Daily Intake with brew factor incorporated.
6. ADI: Acceptable Daily Intake.
7. HR: Highest Residues from supervised trials.
8. STMR: Supervised Trials Median Residues.

FAO-IGG ON TEA: WORKING GROUP ON MRL IN TEA BREW

GUIDANCE DOCUMENT ON RISK ASSESSMENT USING BREW FACTOR FOR FIXATION OF MRLS OF PESTICIDES IN TEA

1 BACKGROUND

The Working groups on MRL and Tea Brew of FAO-Intergovernmental (IGG) on Tea has presented a policy document entitled "Assessment of MRLs for Pesticides in Tea" presented by China and India at the 44th CCPR Session at Shanghai, China on 23-28 April 2012 under Agenda item 12 (b) supported by two reference documents [Ref Doc: PR 44 CRD 10 (China) & PR 44 CRD 29 (India)]. The presentation highlighted the fact that though the dry tea leaves is the traded commodity, it is the brew or liquor which is the form actually consumed. Hence all standard setting bodies including JMPR, Codex and national regulatory agencies should consider the residue in tea brew or both in brew and tea leaves, when setting MRLs. The concept of using the brew factor (Barooah et al., 2011) and compilations of available data on extent of possible transfer of pesticide residues into tea liquor from dry tea (Chen, 2011) has served as the basis of this logic. The consideration for taking into account the pesticide residues in tea infusion in the establishment of MRLs in tea was evident in the 44th CCPR Committee conclusion which mentioned that "…**The Committee supported the current procedure of JMPR in the establishment of MRLs for pesticides in tea and encouraged countries to submit relevant data / information on brewing factors and standard methods to JMPR for consideration in estimation of MRLs for pesticides in tea**." The recognition of brew factor has a great significance as it will pave the way for setting realistic MRLs in tea as risk assessment on dry tea alone would have eliminated a number of useful products. MRLs fixed in tea after assessing risk to consumers based on brew factor will satisfactorily ensure food safety and should be acceptable to all stakeholders. It will also give the scope for upward revision of many stringent MRLs set earlier based on risk assessment on dry tea leaves alone.

2. Developments at FAO-IGG on Tea

FAO, Intergovernmental Group on tea (IGG) and its Working Group on MRL and Tea Brew held an intersessional meeting on 17-18 Sept 2012 at Washington DC since the last CCPR 44 session held in Shanghai on 23-28 April 2012 decided to prepare a detail methodology and a policy document on how to approach the regulators following dispensation in the 44th session of CCPR of the proposal to fix MRL in tea based on risk assessment using brew factor. This document will act as a guidance document for fixing MRLs in tea and will be circulated to all members to assist them approach national and international regulators including manufacturers.

3. The Concept

The main reason for opposition to fixing MRL in tea brew was that the brew or the tea liquor is not the commodity on sale. The Working group on MRL and Tea Brew, therefore, had a detailed discussion on the issue and as a way forward suggested the following approach to be adopted in sequence:

- Generation of data on residues in dry tea leaves and tea brew.
- Determination of brew factor.
- Risk assessment based on brew factor.
- Risk assessment of Proposed MRL (MRLp) based on brew factor.
- Data submission to regulators for MRL fixation in tea.

This approach will ensure food safety as well as provide setting realistic MRLs in tea that would also not contradict with one of the purposes of the Codex MRLs as *MRLs for trade* and it would also not be unfair to growers with critical GAP (Good Agricultural Practices). Thus, this approach will have more acceptability than the proposal to set MRLs in tea brew in general. Risk assessment on the basis of solid tea is a gross overestimation of risk and will eliminate a number of useful compounds. The proposed approach has scope for fixing realistic MRLs without jeopardizing food safety and smooth trade.

This is also what has reflected in the conclusion of the 44th CCPR meeting in China in April 2012 and also the recommendations of the Core Committee in India in 2011 that rate of transfer from dry tea leaves to brew should be adopted by Food Safety & Standards Authority of India during risk assessment while fixing MRLs for the three compounds namely, bifenthrin, imidacloprid and dimethoate in tea. Use of such factors relating to transfer of residues into tea infusion has in fact been reported by European Food Safety Authority [EFSA Scientific report (2009), 267, 1-24] citing a provisional processing factor of 0.44 for the pesticide flufenoxuron residues for green tea infusion.

This document is therefore prepared to assist regulators while fixing MRLs of pesticide in tea.

4. Scope

This document is applicable in assisting regulators, scientists or other competent bodies while fixing MRLs of pesticide in dry tea leaves (traded commodity) using brew factors for risk assessment.

5. Definitions and terms used in this document

5.1 Black Tea: As defined in ISO 3720 or equivalent national standards.

5.2 Green Tea: As defined in ISO

5.3 Dry tea leaves: Refers to any dry tea leaves of fermented tea (black tea), semi-fermented tea (Oolong tea), non-fermented tea (green tea, white tea) and post-fermented tea (Pu-er tea).

5.4 Tea shoots: Fresh green tea shoots comprising mostly 2 leaves and a bud, plucked to produce dry tea leaves.

5.5 Brew: Tea liquor produced by adding hot boiling water to dry tea leaves.

5.6 Brew Factor: Brew Factor (BF) = Residues in tea brew ÷ Residues in dry tea leaves.

5.7 Processing Factor: Processing factor (PF)= Residues in fresh tea shoots ÷ Residues in dry tea leaves.

5.8 ADI: Acceptable Daily Intake

5.9 TMDI: Theoretical Maximum Daily Intake

5.10 STMR: Supervised Trial Median Residues

6. Procedure for determination of Brew Factor

To determine the brew factor, the data on residues of a pesticide in both dry tea leaves and the residues in the tea brew prepared from the same dry tea leaves are required. The brew factor can be determined from residue data as follows:

Brew Factor (BF) = Residues in tea brew ÷ Residues in dry tea leaves (*Equation.1*)

The residue in tea brew is the residues in tea liquor expressed *in mg per kg of dry tea leaves* (black or green tea) *used for preparing the brew*. It is obtained by dividing the *amount of residues in brew (mg)* by *the amount of black or green tea used (kg)* for preparing the brew. The residues in dry tea leaves (black or green tea) are expressed in mg/kg. The Brew Factor thus, has no units as illustrated in Table 1 and Table 2

Table 1. Residues of pesticides (mg/kg) in black tea and in tea brew and Brew Factor

Pesticides	Rate of application In field (kg·ai/hm2)	RBT (mg/kg)	RTB (mg/kg black tea used)	Brew Factor (BF) (RTB ÷ RBT)	Transfer into brew (BF×100) (%)
Deltamethrin	0.0056	0.34	0.003	0.0090	0.90
Bifenthrin	0.08	0.83	0.038	0.0458	4.58
Fenpropathrin	0.03	1.38	0.002	0.0019	0.19
Hexaconazole	0.05	1.90	0.022	0.0114	1.14
Propiconazole	0.25	1.66	0.218	0.1315	13.15

Note: 1. RBT: Residues in black tea. 2. RTB: Residues in tea brew. [Adapted from Barooah, *et al,* (2011)].

Table 2. Residues of pesticides (mg/kg) in green tea and in tea brew and Brew Factor

Pesticides	Rate of application In field (kg·ai/hm2)	RGT (mg/kg)	RTB (mg/kg green tea used)	Brew Factor (BF) (RTB ÷ RBT)	Transfer into brew (BF×100) (%)
Dimethoate	0.36	1.34	1.32	0.983	98.3
Tolfenpyrad	0.122	8.93	0.018	0.002	0.2
Indoxacarb	0.05	1.85	0.115	0.062	6.2
Fenitrothion	0.203	1.27	0.96	0.756	75.6
Malathion	0.405	7.76	6.70	0.863	86.3
Chlorfenapyr	0.045	2.55	0.0038	0.0015	0.15

Note: 1. RGT: Residues in green tea. 2. RTB: Residues in tea brew. [Adapted from Chen ZM et al, (2012)].

6. Brew Factor and rate of transfer of residues from dry tea to tea brew

The transfer of pesticide residues from dry tea to tea brew (as percentage of residues in dry tea) is calculated from the brew factor (BF) using the following formula:

$$\text{Transfer of residues into tea brew (\%)} = \text{BF} \times 100 \qquad (\textit{Equation 2})$$

The rate of transfer of residues of 5 pesticides tea leaves in black and 8 in green dry tea leaves to tea brew is indicated in the last column of Table 1 and Table 2 above as calculated from the brew factor.

A number of scientific published literatures are available on transfer rate of pesticide residues from dry tea leaves to tea infusion and the brew factors for each pesticide can also be calculated from the published data. Typical examples of brew factors that can be calculated from the published data are illustrated in Table 3.

Table 3. Transfer rate of pesticide residue from dry tea leaves to tea brew and Brew Factor

pesticide	Transfer rate (%)	Water solubility (mg/L)	References[#]	**Brew Factor*** (using *Equation 6.2*)
Alpha-cypermethrin	1.4	0.01 ((25℃)	Barooah and Borthakur (1994)	0.014
Cypermethrin	1.4-2.1	0.01 ((25℃)	Chen Zongmao et al, (1986)	0.014-0.021
	0.006		Jaggi et al (2001)	0.0006
DDT	<1	0.0012 (25℃)	Chen Zongmao et al, (1980)	0.01 (taking 1% transfer)
Deltamethrin	<1	0.002 (25℃)	Chen Zongmao et al (1983).	0.01 (taking 1% transfer)
	0.14-0.46		Manikanadan at el (2009)	0.0014 to 0.0046
	0.9		Barooah et al. (2011)	0.009
Fenpropathrin	0.19	0.014	Barooah et al (2011)	0.0019
	0.14-2.63		Manikanadan (2009)	0.0014 – 0.0263
Hexaconazole	0.14-1.85	17	Manikanadan et al (2009).	0.0014-0.0185
	1.14		Barooah et al. (2011)	0.0114
	8.84-8.88		Kumar et al (2004)	0.0884-0.0888
Fenvalerate	10-30	0.002	Sharma. et al (2008)	0.1-0.3
Endosulfan	1.67-2.05	0.3	Manikanadan et al (2009)	0.0167
	1.8		Jaggi et al (2001)	0.018
	7.72-8.74		Chen Zongmao et al (1998)	0.072-0.0874
Dicofol	2.2	0.8	Chen Zongmao et al (1988)	0.022
	1.64		Barooah et al. (1994)	0.0164
	0.1		Jaggi et al (2001)	0.001
Ethion	2.36	2	Barooah et al. (1994),	0.0236
	2.25-2.5		Manikanadan et al (2009)	0.0225 – 0.025
	0.8		Jaggi et al (2001)	0.008
Fenazaquin	2.80	0.007	Kumar et al (2004)	0.028
	3-22		Kumar et al (2005)	0.03-0.22
Permethrin	3.9-4.67	0.07	Chen Zongmao et al (1981)	0.0396-0.0467
Bifenthrin	4.2-4.6	0.1	Chen Zongmao et al (1986)[1]	0.042 -0.046
	1.5-14		Tewary et al (2005)	0.015-0.14
	4.58		Barooah et al (2011)	0.0458
Isoxathion	<5	0.001	Nagayama et al (1989)	0.05 (taking 5% transfer)
Prothiophos	<5	0.001	Nagayama et al (1989)	0.05 (taking 5% transfer)
BHC	5-8	10(20℃)	Chen Zongmao et al(1980)	0.05 – 0.08
Propiconazole	13.2	100 (20℃)	Barooah et al (2011)	0.132

Pyridaben	6.68	0.1(25℃)	Chen Zongmao et al (1997)	0.0668
Chlorpyrifos	9.12	1.4	Manikanadan et al (2009)	0.0912
	11		Ozbey et al (2007)	0.11
	3.14		Jaggi et al (2001)	0.0314
Pirimiphos-ethyl	13.0	2.3	Ozbey et al (2007)	0.13
Monocrotophos	19.78	1000	Jaggi et al (2001)	0.1978
Quinalphos	21.4-44.5	17.8 (23℃)	Chen Zongmao et al (1986)	0.214 – 0.445
	8.04		Jaggi et al (2001)	0.0804
	9.2		Manikanadan et al (2009)	0.092
Triazophos	29.06	39	Wu et al (2007)	0.296
Parathion-methyl	25.8	55	Jaggi et al (2001)	0.258
Imidacloprid	29.2-42.0	610	Gupta and Shanker (2008)	0.292-0.42
	62.2-63.1		Hou et al (2013)	0.622-0.631
Phosphamidon	33.3	1000	Jaggi et al (2001)	0.333
Chlorfenvinphos-E	45	145	Nagayama et al (1989)	0.45
Malathion	48.8-86.3	145 (23℃)	Chen Zongmao et al (1980)	0.488-0.863
	62.0		Ozbey et al (2007)	0.62
	12.14		Jaggi et al (2001)	0.121
Chlorfenvinphos-Z	52	145	Nagayama et al (1989)	0.52
Acetamiprid	36.8 -50	4200	Gupta and Shankar (2008)	0.368-0.50
	78.3-80.6		Hou et al (2013)	0.783-0.806
Fenitrothrin	69.7-75.6	19	Chen Zongmao et al (1991)	0.697-0.756
	48		Nagayama et al (1989)	0.48
Methidathion	83	250	Nagayama et al (1989)	0.83
Dimethoate	97.5-98.3	39800	Chen Zongmao et al (1991)	0.975-0.983
	91		Ozbey et al (2007)	0.91
Cyhalothrin	1.73	0.004	Chen Zongmao et al (1990)	0.0173
	0.11-1.15		Wu et al (2007)	0.0011-0.0115
Propargite	23.6-40	0.215	Kumar et al (2005)	0.236-0.4
Thiamethoxam	80.5-81.6	4100	Hou et al (2013)	0.805-0.816
Thiacloprid	49.7	184	Banerjee et al (2012)	0.497
Profenofos	2.44-7.2	28	Pramanik et al(2005)	0.0244-0.072

*Note: The Brew Factor shown in the last column was calculated from the transfer rate values published.

7. Procedure for assessment of risk from pesticide residues in tea

7.1 Risk assessment based on the residues in dry tea leaves

In the current procedure for establishing MRLs in tea, the Theoretical Maximum Daily Intake (TMDI) is computed from the Highest Residues (HR) or Supervised Trial Median Residues (STMR) from field trial data and the daily consumption of dry tea leaves.

TMDI = HR or STMR x Dry tea consumed daily (*Equation 3*).

The TMDI so computed is then compared with the Acceptable Daily Intake (ADI) per person, for a particular compound. However, this comparison of TMDI (so obtained) with ADI is actually a gross overestimation of potential risk to consumers as the dry tea leaves are never consumed raw. In addition, the consequence of such overestimation of risk will unduly eliminate a number of otherwise useful pesticides that could have been used for effective management of pests and diseases in the tea plantations.

7.2 Risk assessment based on the brew factor

The use of brew factor gives much scope for assessing the actual intake of residues. The intake of pesticide residues can be calculated by multiplying the concentration of residues in dry tea by average daily per capita consumption of tea. The actual intake of pesticide residues through consumption of tea liquor can be obtained by multiplying the intake values obtained above by the brew factor as only tea liquor is consumed.

The dietary risk assessment through consumption of tea liquor can therefore be assessed by incorporation of the brew factor in the intake calculations as given below;

TMDIb = HR or STMR x Dry tea consumed daily x Brew Factor (*Equation 4*).

where, TMDIb is Theoritical maximum Daily Intake based on Brew factor

Recent studies showed that the actual intakes of residues through tea consumption can be determined by incorporating this new parameter termed "brew factor" in the conventional estimates of TMDI. The compound specific brew factor improves risk assessment and will enable setting realistic maximum residue limits for pesticides in tea.

Illustrations on the use of brew factor for assessing risk from residues in teas are given below:

Illustration-I

Computation of MRL for Fenpyroximate in tea

(For an Indian adult of 50kg weight) (ADI : 0.01 mg/kg bw)

Pesticide	Highest residues (HR) (mg/kg)	Food consumption (g)	TMDI (mg/day) based on HR	TMDI (mg/day) based on proposed MRL of 4 mg/kg	ADI (mg/kg/ day)	ADI per person (mg/day)	% of ADI per person based on HR	% of ADI per person based on proposed MRL	#Proposed MRL (mg/kg)
Fenpyroximate	1.78	10	0.0178	0.04	0.01	0.5	3.56	8	4.0
	1.78	10	0.0178 x 0.031* = 0.000552	0.0.04 x 0.031* = 0.00124	0.01	0.5	0.11	0.25	4.0

* [Brew Factor] # [Obtained using OECD MRL Calculator]

The MRL of 4 mg/kg for fenpyroximate is proposed for dry tea leaves based on TMDIb (calculated using brew factor) which is only 0.26 percent of the ADI per person which is unlikely to be of any health concern.

Illustration-II

Computation of MRL for Indoxacarb in tea

(For a Chinese adult of 60 kg weight) (ADI : 0.01 mg/kg bw)

Pesticide	Highest residues (HR) (mg/kg)	Food consumption (g)	TMDI (mg/day) based on HR	TMDI (mg/day) based on proposed MRL of 3mg/kg	ADI (mg/kg /day)	ADI per person (mg/day)	% of ADI per person based on HR	% of ADI per person based on proposed MRL	Proposed MRL (mg/kg)
Indoxacarb	1.85	13	0.02405	0.039	0.01	0.6	4.01	6.5	3
	1.85	13	0.02405 x 0.062* = 0.00149	0.039x 0.062*= 0.002481	0.01	0.6	0.25	0.414	3

* [Brew Factor]

The MRL of 3 mg/kg for Indoxacarb is proposed for dry tea leaves based on TMDIb (calculated using brew factor) which is only 0.414 percent of the ADI per person which is unlikely to be of any health concern.

7.3 Tea Brew preparation method

Tea brew needs to be prepared using the dry tea leaves corresponding to the GAP PHI which is (7 days for tea) and following the standard of International Organization for Standardization (ISO) for organoleptic testing of teas for preparation of infusion (ISO 3130:1980).

This involves extracting black/green/white tea leaves with boiling hot water (1:50=black tea : hot water ratio) for 5-6 min, partitioning the residues into an organic solvent (n-hexane) and estimating the residues after concentration to suitable volumes.

8. **Brew factor** vs **Processing factor**

Brew factor has been defined earlier and denotes proportion of residues that can be transferred from dry tea leaves to tea brew, the form which is finally consumed. On the other hand the '*Processing factor*" refers to the proportion of residues in raw agricultural commodity (*here freshly plucked tea shoots*) to residues in dry tea leaves which has been obtained after processing the fresh tea shoots in factories.

Since MRL is fixed on the dry tea leaves which is the traded commodity and only the tea brew (hot water extract) is consumed, the use of the term "Brew Factor" will be more relevant in case of tea than the term "Processing Factor" which may be applicable for other dry commodities directly consumed unlike tea.

This explanation is expected to remove any confusion for those regulators or other users of this document who are not familiar with tea.

9. Determination of National Estimated Daily Intake (NEDI) using brew factor

Determination of any national estimates of daily intakes using the Brew factor for assessing actual risk from residues in tea can be made by suitable replacement of the following parameters in the Illustrations- I & II as applicable for a particular member country / region:

(a) Daily Tea consumption (g/person/day)

(b) Average adult body weight (kg)

10. Determination of International Estimated Daily Intakes (IEDI) or international estimated short term intake (IESTI) using brew factor

Determination of the long-term dietary intakes are calculated by multiplying the STMRs, or recommended MRLs by the average daily per capita consumption estimated for each commodity on the basis of the GEMS/Food diets and summing the intakes for each food. Introducing the brew factor as an additional multiplication factor will refine these estimates as well by realistic proportioning of the contribution of residues from tea. The estimated amount will then be compared with the acute reference dose (ARfD).

The highest residue from the supervised residue trials at maximum GAP was generally seen as the better option than the MRL for short-term dietary intake calculations. Introducing the brew factor is illustrated below:

IESTI = [LP x HR x Brew factor] ÷ BW

where, LP is large portion of tea consumed (kg food/day) used for IESTI calculation [97.5% of the daily consumption of dry tea leaves]

HR: Highest residues in the maximum PHI

BW: Average body weight of adult.

11. Advantage of assessing intakes with brew factors:

The advantages of the brew factor based assessment of risk from residues whether one is required to use the HR or the proposed MRL depending on the objective are indicated in Table 4 and Table 5.

The brew factor will also help in both short and long term risk assessment to improve the estimate of intake of pesticide residues in tea as a *reduction factor* which was found to be compound specific. The illustration showed that the actual intakes of the residues of these seven pesticides were up to 526 fold lower than the intakes predicted conventionally. Table 6 illustrates the international estimated daily intakes of these terminal residues in tea for a 60 kg adult using the per capita tea consumption figures for five regional diets used earlier (WHO, 2003). The 13 GEMS/Food Consumption Cluster Diets proposed later [Ref: http://www.who.int/foodsafety/ chem/countries.pdf] as well as the current 17 Cluster diets proposed in 2012 can also be suitably considered for brew factor based risk assessment for MRL fixation in tea. [Ref: http://www.who.int/foodsafety/chem/gems/en/index1.html]. Table 7 illustrates estimated highest daily intakes of these terminal residues in green tea for a 60 kg adult in China.

The brew factor approach of risk assessment has a greater significance as with the actual risk assessment for assuring food safety, there will also be ample scope for fixation or revision of MRLs in tea to realistic levels acceptable to all stakeholders.

Table 4. Daily intake of pesticide residues in tea assessed with or without brew factor for an average Indian adult (Body weight: 50 kg)

Residues in Black tea (mg/kg)	[a]Per capita black tea consump- tion (g)	Brew Factor (BF)	Intake (µg/person)		Intake as % of ADI per person	
			Without BF [Col 1 x Col 2]	With BF [Col 3 x Col 4]	(Without BF) [(Col 4 ÷ ADI) x 100]	(With BF) [(Col 5 ÷ ADI) x 100]
1	2	3	4	5	6	7
Bifenthrin (ADI: 0.01 mg/kg body weight or 500 µg/person)						
0.83	10	0.0458	8.3	0.38014	1.66	0.076
5 (MRL)[b]	10	0.0458	50	2.29	10	0.458
Fenpropathrin (ADI: 0.03 mg/kg body weight or 1500 µg/person)						
1.38	10	0.0019	13.8	0.02622	0.92	0.002
2 (MRL)[b]	10	0.0019	20	0.038	1.33	0.003
Deltamethrin (ADI: 0.01 mg/kg body weight or 500 µg/person)						
0.34	10	0.009	3.4	0.0306	0.68	0.006
5 (MRL)[b]	10	0.009	50	0.45	10	0.09
Cypermethrin (ADI: 0.005 mg/kg body weight or 250 µg/person)						
0.39	10	0.0051[d]	3.9	0.01989	1.56	0.008
2 (MRL_P)[c]	10	0.0051[d]	20	0.102	8	0.041
L-cyhalothrin (ADI: 0.02 mg/kg body weight or 1000 µg/person)						
0.18	10	0.0111[d]	1.8	0.01998	0.18	0.002
1 (MRL)[b]	10	0.0111[d]	10	0.111	1	0.011
Hexaconazole (ADI: 0.005 mg/kg body weight or 250 µg/person)						
1.90	10	0.0114	19	0.2166	7.6	0.087
3 (MRL_P)[c]	10	0.0114	30	0.342	12	0.137
Propiconazole (ADI: 0.04 mg/kg body weight or 2000 µg/person)						
1.66	10	0.1315	16.6	2.1829	0.83	0.109
2 (MRL_P)[c]	10	0.1315	20	2.63	1	0.132

[a] Per capita tea consumption: 10g in a total Indian diet of 1.5 kg/day

[b] MRL: EU MRL;

[c] MRLp: MRL proposed for this illustration.

[d] Calculated considering the residues in tea brew at LOD (0.002 mg/kg).

Source of ADI values: The Pesticide Manual (2006).

Table 5. Daily intake of pesticide residues in green tea assessed with or without brew factor for an average Chinese adult (Body weight: 60 kg)

Residues in green tea (mg/kg)	[a]Per capita green tea consum-ption (g)	Brew Factor (BF)	Intake (µg/person)		Intake as % of ADI per person	
			Without BF [Col 1 x Col 2]	With BF [Col 3 x Col 4]	(Without BF) [(Col 4 ÷ ADI) x 100]	(With BF) [(Col 5 ÷ ADI) x 100]
1	2	3	4	5	6	7
Dimethoate (ADI: 0.002 mg/kg body weight or 120 µg/person)						
1.34	13	0.983	17.42	17.12386	14.51	14.26
0.05(MRL)[b]	13	0.983	0.65	0.63895	0.54	0.53
Imidacloprid (ADI: 0.06 mg/kg body weight or 360 µg/person)						
1.07	13	0.28	13.91	3.8948	3.86	1.08
0.05 (MRL) [b]	13	0.28	0.65	0.182	0.18	0.05
Acetamiprid (ADI: 0.07 mg/kg body weight or 4200 µg/person)						
5.46	13	0.85	70.98	60.333	1.69	1.43
0.1(MRL) [b]	13	0.85	1.3	1.105	0.03	0.03
Tolfenpyrad (ADI: 0.0056 mg/kg body weight or 336 µg/person)						
8.93	13	0.002	116.09	0.23218	34.55	0.07
20(MRL$_P$)[c]	13	0.002	260	0.52	77.38	0.15
Indoxacarb (ADI: 0.01 mg/kg body weight or 600 µg/person)						
1.85	13	0.062	24.05	1.4911	4.01	0.25
3(MRL$_P$) [c]	13	0.062	39	2.418	6.5	0.40
Fenitrothion (ADI: 0.006 mg/kg body weight or 360 µg/person)						
1.27	13	0.756	16.51	12.48156	4.59	3.47
0.05(MRL)[b]	13	0.756	0.65	0.4914	0.18	0.14
Malathion (ADI: 0.03 mg/kg body weight or 1800 µg/person)						
7.76	13	0.863	100.88	87.05944	5.60	4.84
0.5(MRL)[b]	13	0.863	6.5	5.6095	0.36	0.31
Chlorfenapyr (ADI: 0.003 mg/kg body weight or 180 µg/person)						
2.55	13	0.0015	33.15	0.049725	18.42	0.03
20(MRL$_P$)[c]	13	0.0015	260	0.39	144.44	0.22

[a] Per capita tea consumption: 13g in a total Chinese diet of 1.5 kg/day

[b] MRL: EU MRL;

[c] MRLp: MRL proposed for this illustration

Source of ADI values: The Pesticide Manual (2006).

Table 6. International estimates of intake of pesticide residues in tea by a 60 kg adult assessed using brew factor

Pesticides	Residues in Black tea (mg/kg)	[a]Per capita black tea consum-ption (g)	Brew Factor (BF)	Intake (µg) [Col 2 x Col 3 x Col 4]	ADI (µg/person)	Intake as % of ADI
1	2	3	4	5	6	7
Middle Eastern						
Bifenthrin	0.83	2.3	0.0458	0.0874322	600	0.0157
Fenpropathrin	1.38	2.3	0.0019	0.0060306	1800	0.0003
Deltamethrin	0.34	2.3	0.009	0.007038	600	0.0012
Cypermethrin	0.39	2.3	0.0051	0.0045747	300	0.0015
L-cyhalothrin	0.18	2.3	0.0111	0.0045954	1200	0.0004
Hexaconazole	1.90	2.3	0.0114	0.049818	300	0.0167
Propiconazole	1.66	2.3	0.1315	0.502067	2400	0.0209
Far Eastern						
Bifenthrin	0.83	1.2	0.0458	0.0456168	600	0.0076
Fenpropathrin	1.38	1.2	0.0019	0.0031464	1800	0.0002

Deltamethrin	0.34	1.2	0.009	0.003672	600	0.0006
Cypermethrin	0.39	1.2	0.0051	0.0023868	300	0.0008
L-cyhalothrin	0.18	1.2	0.0111	0.0023976	1200	0.0002
Hexaconazole	1.90	1.2	0.0114	0.025992	300	0.0087
Propiconazole	1.66	1.2	0.1315	0.261948	2400	0.0109
African						
Bifenthrin	0.83	0.5	0.0458	0.019007	600	0.0032
Fenpropathrin	1.38	0.5	0.0019	0.001311	1800	0.0001
Deltamethrin	0.34	0.5	0.009	0.00153	600	0.0003
Cypermethrin	0.39	0.5	0.0051	0.0009945	300	0.0003
L-cyhalothrin	0.18	0.5	0.0111	0.000999	1200	0.0001
Hexaconazole	1.90	0.5	0.0114	0.01083	300	0.0036
Propiconazole	1.66	0.5	0.1315	0.109145	2400	0.0045
Latin American						
Bifenthrin	0.83	0.5	0.0458	0.019007	600	0.0032
Fenpropathrin	1.38	0.5	0.0019	0.001311	1800	0.0001
Deltamethrin	0.34	0.5	0.009	0.00153	600	0.0003
Cypermethrin	0.39	0.5	0.0051	0.0009945	300	0.0003
L-cyhalothrin	0.18	0.5	0.0111	0.000999	1200	0.0001
Hexaconazole	1.90	0.5	0.0114	0.01083	300	0.0036
Propiconazole	1.66	0.5	0.1315	0.109145	2400	0.0045
European						
Bifenthrin	0.83	2.3	0.0458	0.0874322	600	0.0146
Fenpropathrin	1.38	2.3	0.0019	0.0060306	1800	0.0003
Deltamethrin	0.34	2.3	0.009	0.007038	600	0.0012
Cypermethrin	0.39	2.3	0.0051	0.0045747	300	0.0015
L-cyhalothrin	0.18	2.3	0.0111	0.0045954	1200	0.0004
Hexaconazole	1.90	2.3	0.0114	0.049818	300	0.0167
Propiconazole	1.66	2.3	0.1315	0.502067	2400	0.0209

[a] Source of tea consumption figures: WHO (2003) GEMS/Food Regional Diets

Source of ADI values: The Pesticide Manual (2006).

Table 7. International estimates highest intake of pesticide residues in green tea by a 60 kg adult assessed using the brew factor in China

Pesticides	Residues in green tea (mg/kg)	[b]Per capita green tea consumption (g)	Brew Factor (BF)	Intake (µg) [Col 2 x Col 3 x Col 4]	ADI (µg/person)	Intake as % of ADI
1	2	3	4	5	6	7
Dimethoate	1.34	13	0.983	1.4489	120	14.27
Tolfenpyrad	8.93	13	0.002	0.0196	336	0.07
Indoxacarb	1.85	13	0.062	0.1262	600	0.25
Fenitrothion	1.27	13	0.756	1.0561	360	3.47
Malathion	7.76	13	0.863	7.3666	1800	4.84
Chlorfenapyr	2.55	13	0.0015	0.0042	180	0.03

Source of ADI values: The Pesticide Manual (2006).

CONCLUSION

Tea plant (*Camellia sinensis)* is the most popular beverage globally and a common man's drink. With the increasing awareness on the health benefits of tea, it is only natural that more and more people will turn to tea. Tea is produced in more than 45 countries and involves intensive cultivation practices. Tender tea shoots are plucked and processed in factories to dry tea leaves (black or green) and is traded. However, unlike other agricultural and horticultural crops, tea is never consumed directly. Consumers mostly drink the infusion of tea leaves in hot water. Hence for assessing food safety from the point of view of residues of crop protection products in tea, it is necessary to consider the residues in both marketed but not eaten forms as well as in brew the form in which tea is consumed. A number of studies have indicated that only a portion of the residues detected in the dry tea leaves in fact are transferred into the liquor which led to the proposal of brew factor based risk assessment for fixation of MRLs of pesticides in tea.

Following dispensation of this proposal in the 44th Session of CCPR held at Shanghai on April 23-28, 2012 and in pursuance of the decision taken at the intersessional meeting of the FAO-IGG on Tea held in Washington DC in Sept 17-18, 2012, this document is prepared as a guidance for assessing risk from pesticide residues in tea using brew factor for fixation of MRL in tea. The document aims at providing the basis and procedures with simple illustration to assist regulators, reviewers and other stakeholders involved in MRL fixation.

Reference

Banerjee D and Banerjee H (2012). Thiacloprid residues and its safety evaluation in Darjeeling tea. *Bull Environ Contam Toxicol.,* 89(3):598-601.

Barooah A K, Borthakur Monorama, Kalita J N, Hussain,T, Chowdury Kasturi and Nath R (2011). Pesticide Residues in Tea and their Intake assessment Using Brew Factor. *Journal of Tea Science,* 31 (4): 289-294.

Barooah A K and Borthakur M C (1994). Residues of alphamethrin in tea and its potential daily intake. *Pesticide Science Journal*, 6(2): 161-166.

Barooah A K, Kalita J N, Collier P D, and Barbora B C (1994). Residues of pesticides in made tea and hot water brew. In *Proceedings of the 32nd Tocklai Conference* (pp196-211). Jorhat: TRA.

Chen Z M (2012). Compilation of available work. CRD 10 (44th CCPR 2012).

Chen Z M and Wan H B. (1988). Factors affecting residues of pesticides in tea. *Pesticide Science*, 23: 109-118.

Chen Z M, and Liu G (2003). The fate of pesticides on tea plant and the prediction of pesticide residues in fresh leaves of tea plant. *International Journal of Tea Science*, 2(4): 109-118.

Chen Z M, Wan H B and Xia W L (1992). Prediction on degradative rates of pesticides on tea plant, made tea and tea infusion. *Biochem& Biophy Communication*, 189(1): 689-693

Chen ZM, Wan HB and Wang YH,(1986). Degradative dynamics of quinzophos in tea, *Sinica*, 13(3): 205-210.

Chen ZM, Chen XF, Wang YH, Zhu YC, Xue YZ, Wan HB,Xiao Q and Xia HL (1986). Application of bifenthrin in tea pest management and residue research. Tea Science Research Journal, 32-42.

Gupta M and Shanker A (2008). Persistence of Imidacloprid in tea and its transfer from made tea to infusion. *Food Chemistry,* 111: 805-810.

Chen Z M, Han HQ, Yue R Z (1983). Degradation of pyrethroid decis (NRDC 161) on tea-shoots. *Acta Entomoologica Sinica*, 26:146-153.

Chen Z Mand Yue R Z (1983).The degradative dynamics of pesticides in tea plant and the selective parameters of the safety pesticide design. *Agricultural Sciences in China*, 1: 62-79.

Chen Z M, Han H Q andHe W K (1981). Degradation pyrethroid permethrin (Nrdc 143) on tea-shoots. *Acta Entomoologica Sinica*, 24: 9-16.

Chen Z M and Liu G M (1997). Investigation on the degradative dnamics of pridaben residues in tea. *Pesticides*, 36: 27-28.

Chen Z M, Wan H Band Xia H L (1990). The fate of pesticides in plantation crops and the design of parameters for selecting suitable pesticides. Academic conference proceedings: Recent developments in the field of pesticides and their application to pest control. 328-337.

Hou R, Hu J, Qian X, Su T, Wang X, Zhao X and Wan X (2013). Comparison of the Dissipation Behaviour of Three Neonicotinoid Insecticides in Tea. *Food Additives & Contaminants Part A.,* 30(10): 1761-1769.

ISO 3103, (1990). International Organization for Standardization Standard. Tea -- Preparation of liquor for use in sensory tests. [IS 6400, (1993). Indian Standard. Method of preparation of tea infusion for sensory evaluation (I rev.), Bureau of Indian Standards, Manak Bhavan, New Delhi.

Jaggi S, Sood C, Kumar V, Ravindranath S Dand Shankar A (2001). Leaching of pesticides in tea brew. *Journal of Agricultural and Food Chemistry*, 49: 5479-5483.

Kumar V, Tewari D K, Ravindranath SD and Shankar A (2001). Investigation in tea on fate of fenazaquin residues and its transfer in brew. *Food and Chemical Toxicology*, 42: 423-428.

Kumar V, Ravindranath S D and Shankar A (2004). Fate of hexaconazole residues in tea and its behavior in brewing process. *Chemical Health & Safety*, 11(1):21-25.

Kumar V, Sood C, Jaggi S, Ravindranath SD, Bhardwaj SP and Shankar A (2005). Dissipation behavior of propargite-an acaricide residues in soil, apple (*Malus pumila*) and tea (*Camellia sinensis*) .*Chemosphere*,58: 837-843.

Manikandan K N, Karthika C, Muraleedharan N, Seenivasan S and Selvasundaram R (2006). Studies on the residues of copper and hexaconazole during their combined application and their subsequent transfer into tea infusion. *Journal of Plantation Crops*, 34 (3): 405-409.

Manikandan K N, Seenivasan S, Ganapathy M N K, Muraleedharan, N and Selvasundaram R (2009). Leaching of residues of certain pesticides from black tea to brew. *Food Chemistry*, 113:522-525.

Muraleedharan N, Selvasundaram Rand Manikandan K N (2001). Pesticide residues in tea: The present scenario. *The Planters' Chronicle*, 97 (7): 279-285.

Nagayama T. (1996). Behaviour of residual organophosphorus pesticides in foodstuffs during leaching or cooking. *Journal of Agricultural and Food Chemistry*, 44: 2388–2393.

Ozbey A and Uygun U (2007). Behaviour of some organophosphorous pesticide residues in tea during infusion process. *Journal Food chemistry* 104 (1):237-241.

Pramanik S K, Dutta S, Bhattacharyya J, Saha T, Dey PK, Das S and Bhattacharyya A(2005). Persistence of profenofos residue on tea under northeast Indian climatic conditions. *Bulletin of Environmental Contamination and Toxicology,* 74(4):645-51.

Shanker A, Vipin, Kumar and Tewary D K (2003). Fate of pesticide residues on tea from leaf to cup. *International Journal of Tea Science*, 2(4):18-26.

Sharma A, Gupta M and Shanker A (2008). Fenvalerate residue level and dissipation in tea and in its infusion. *Food Additives & Contaminants Part A,* 25(1): 97-104.

Tewary D K, Kumar Vand Ravindranath SD(2005). Dissipation behavior of bifenthrin residues in tea and its brew. *Journal Food Control*. 16(3): 231-237.

The Pesticide Manual (2006). 14th ed. UK: British Crop Protection Council.

Wan H B, Xia H L and Chen Z M (1991). Extraction of pesticide residues in tea by water during the infusion process, *Food Additives & Contaminants.* 8(4): 497-500.

WHO (1997). Guidelines for predicting dietary intake of pesticide residues (revised). Prepared by the Global Environment Monitoring System-Food Contamination Monitoring and assessment Programme (GEMS/Food) in collaboration with Codex Committee on Pesticide Residues (WHO/FSF/FOS/97.7), Geneva.

WHO (2003). GEMS/Food Regional Diets: regional per capita consumption of raw and semi-processed agricultural commodities. Prepared by Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme (GEMS/Food). Document WHO/FSF/FOS/98.2 (Revised edition), Geneva.

Wu J G, Luan T G, Lan CY, Lo W H and Chan G Y S (2007). Efficacy evaluation of low-concentration of ozonated water in removal of residual diazinon, parathion, methyl-parathion and cypermethrin on vegetable. *Journal of Food Engineering*. 79: 803–809.