Overview of Vapour Heat Treatment for Fresh Fruits in Sri Lanka

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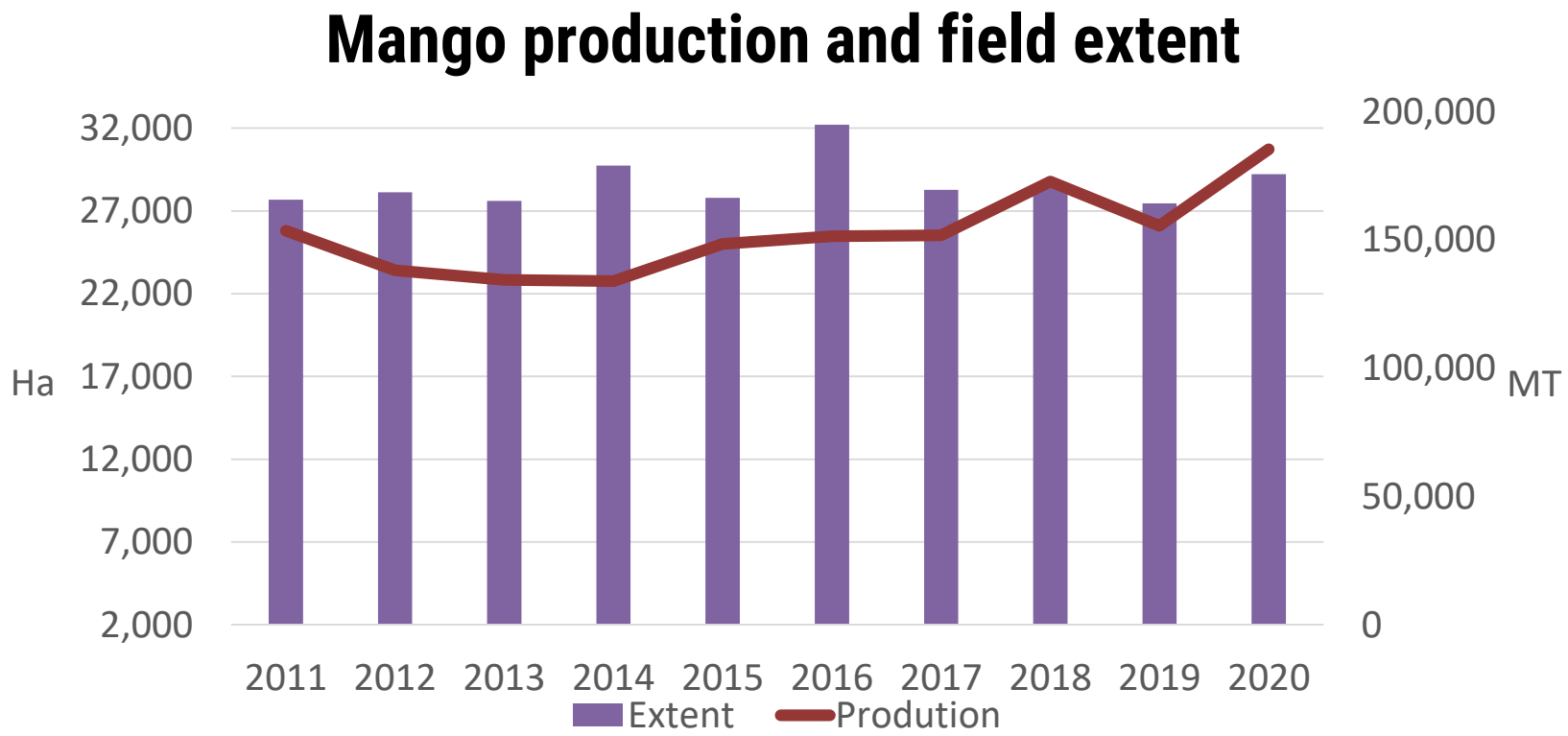
Content

- Introduction
- Fruit fly diversity and host plant in Sri Lanka
- Phytosanitary certification procedure for fruits and vegetable against fruit fly species
- Fruit fly studies and VHT standards on Mango in Sri Lanka

Introduction



- There is a high demand for the Sri Lankan high quality export potential mango fruits from the high-end markets such as Japan, Korea and China
- However, due to the fruit fly infestation of local fruits, it needs to apply plant quarantine treatment for the mangoes in order to comply with export phytosanitory conditions

Diversity of fruit flies in Sri Lanka

- 16 fruit fly species were identified with 45 species of host plants (Tsuruta *et al*., 1997)

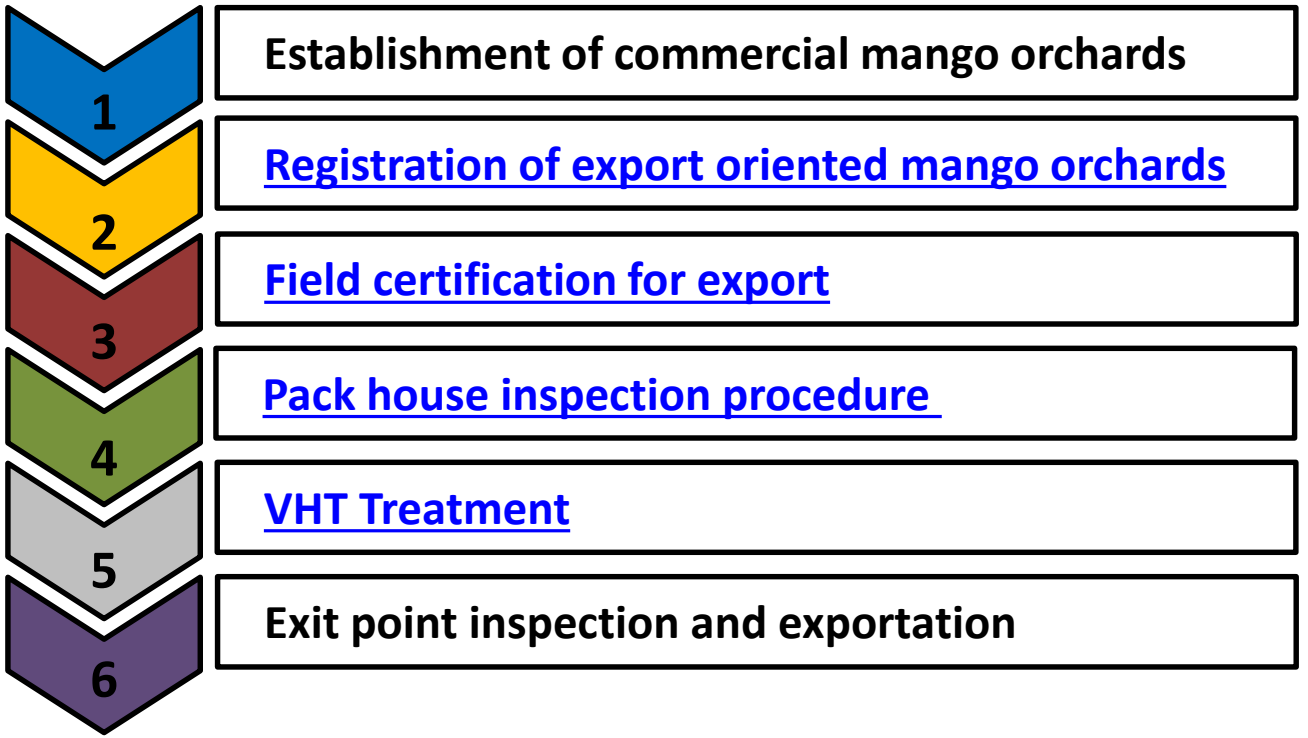
- 39 fruit fly species have been reported (Leblanc *et al.,* 2018)
  - 12 fruit fly species have been reported to damage to fruits of many agricultural crops throughout the country

Fruit fly species damage to fruit and vegetable and their host plants in Sri Lanka

Fruit fly species	Host plants
Bactrocera dorsalis	**Mango**, Cashew, Avacado etc.
Bactrocera kandiensis	**Mango**, Cashew, Guava, Papaya etc
Bactrocera correcta	Guava, **Mango**, Soursop , etc.
Bactrocera latifrons	Yellow-fruit nightshade
Bactrocera nigrotibialis	Indian Almond
Bactrocera versicolor	Sapodilla
Bactrocera zonata	Wild guava, Indian almond etc.
Dacus ciliatus	Cucurbit fruit pest
Zeugodacus caudatus	Cucurbit flower pest
Zeugodacus cucurbitae	Cucurbit flower pest
Zeugodacus. diversus	Cucurbit flower pest
Zeugodacus tau	Cucurbit flower pest

Process Map for Exportation of Sri Lankan Mango with VHT Treatment

Fruit fly infestation is the major barrier for the exportation of local mango. Therefore, farmers should adhere to the supply chain introduced by the NPQS



Phytosanitory treatment could only be applied for the fruits produced from NPQS certified fields

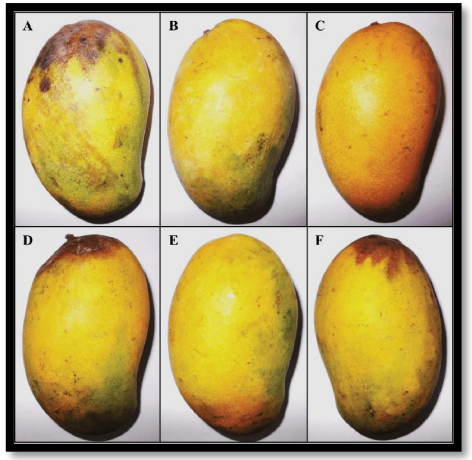
Vapour Heat Treatment (VHT) studies carried out in Sri Lanka

Vapor Heat Treatment against four species of fruit flies in mango (Var. “Karthakolomban”)

Target insects

Bactrocera dorsalis	*Bactrocera correcta*
	
Zeugodacus tau	***Zeugodacus cucurbitae***
	

Target fruit



Mango ‘Karthakolomban’ fruits (*Mangifera indica*)

Mango ‘Karthakolomban’ orchard

Mango ‘Karthakolomban’ flower

Mango ‘Karthakolomban’ fruits on the tree

Mortality Test of Fruit Fly

1. Hot Water ImmersionTest	To determine the most heat tolerant species of fruit fly
2. Susceptibility Mortality Test by VHT	To determine the most heat tolerant species & life stage of fruit fly
3. Small-Scale Mortality Test by VHT	To Determine VHT standards (Fruit core temp. and Holding time)
4. Large-Scale Mortality Test by VHT	To confirm VHT standards (100% mortality with more than 30,000 effective insects)

Mass rearing of fruit fly

- Maintenance 4:1 (Female :male) sex ratio in the test population
- Collect eggs using an egging device
- All adults and subsequent larval stages are reared separately and fed with relevant artificial diet

Artificial Adult diet

Egging device

Eggs

Artificial larval diet

Hot water immersion test

- **Purpose**

  To determine the most heat tolerant species of fruit flies for heat generated by ***Hot water immersion***

- **Materials**

  Test insect : ***B. dorsalis , B. kandiensis, B. cucurbitae and B. tau***

  Target stage : Eggs (mature), larvae (1^{st}, 2^{nd} , 3^{rd} instar)

- **Methods**

✓ Insects was immersed in hot water

✓ Temperature : 45.0 ^{o}C

✓ Exposure time : 4, 7, 10, 13, 16, 19, 22, 25, 28 & 31 min

Result of hot water immersion test

Corrected mortality of each developmental stage of *B. dorsalis*, *B. kandiensis*, *B. cucurbitae* and *B. tau* in hot water immersion test

Exposure time (min)	Mortality (%)															
	B. *dorsalis*				B. *kandiensis*				B. *cucubitae*				B. *tau*			
Stage	ME	1st	2nd	3rd	ME	1st	2nd	3rd	ME	1st	2nd	3rd	ME	1st	2nd	3rd
4	11.51	0	0	11.36	24.83	8.39	33	12.5	9.3	25.17	0	22.93	47.73	24.68	27.41	6.72
7	25	35.24	10.85	22.73	51.34	12.77	24.5	31.5	28.86	39.86	30.59	57.52	45.62	32.82	70.72	61.56
10	20.63	31.28	40.57	39.55	51.34	16.42	83.5	78	42.02	48.6	65.75	80.45	49.85	56.74	92.21	97.31
13	40.87	30.4	47.64	78.18	45.68	32.48	71	79.5	45.02	68.88	77.17	95.86	49.24	77.35	94.08	100
16	50.4	47.58	76.42	81.36	57.05	45.62	89.5	89.5	50.25	82.17	88.58	96.99	58.61	96.69	98.75	99.73
19	55.56	36.12	81.6	83.18	58.39	63.14	94.5	97.5	51.74	88.11	87.21	98.87	62.84	99.24	99.69	100
22	66.27	56.39	89.15	92.73	63.31	80.66	97	99.5	56.47	86.01	91.32	99.25	75.53	100	100	100
25	63.89	61.23	97.17	94.09	60.43	75.55	100	99.5	67.66	95.8	98.17	100	89.73	100	100	100
28	63.49	87.67	98.58	99.55	73.74	82.48	100	99	81.09	96.15	99.54	100	93.96	100	100	100
31	62.7	92.51	100	98.64	80.94	93.07	100	99	87.81	97.2	99.54	100	98.49	100	100	100

B. dorsalis has shown the highest heat tolerance at the hot water immersion test

Susceptibility mortality test by VHT

■ **Purpose:**

To determine the most heat tolerant stage of fruit fly against high temperature

■ **Materials**

Test insect : ***B. dorsalis , B. kandiensis, B. cucurbitae and B. tau***

Target stage : **Mature eggs , Larvae (1st, 2nd , 3rd instar)**

Mango Size : **250-300 g**

■ **Methods**

- Artificially infested mango was treated in vapor heat treatment (VHT)
- Fruit core temperature : 41, 43, 44, 45, 46, 47^{o}C and Control

Result of susceptibility mortality test

Corrected mortality of each developmental stages of B. *dorsalis*, B. *kandiensis*, B. *cucurbitae* and B. *tau* in heat susceptibility test by VHT method

Temperature	Mortality (%)															
	B. dorsalis				B. kandiensis				B. cucubitae				B. tau			
	ME	1st	2nd	3rd	ME	1st	2nd	3rd	ME	1st	2nd	3rd	ME	1st	2nd	3rd
41	4.30	37.21	6.23	20.89	37.26	43.44	0.58	17.28	79.87	19.83	4.61	4.44	47.13	0	40.46	33.16
43	13.58	45.64	9.76	0	32.8	45.48	8.65	48.73	78.22	33.52	29.28	38.41	41.08	13.81	45.72	63.73
44	44.37	57.56	0	41.23	51.91	47.23	10.95	71.39	87.46	42.74	38.16	90.77	47.45	54.7	80.59	99.22
45	21.85	65.99	43.63	65.18	64.97	81.05	36.89	80.45	100	99.44	83.55	100	96.63	96.96	99.67	100
46	54.64	93.9	73.44	89.03	76.11	88.63	92.22	100	100	100	100	100	100	100	100	100
47	99.57	97.67	96.21	100	100	100	100	100	100	100	100	100	100	100	100	100

Eggs, 1st and 2nd instar of B. dorsalis has shown the highest heat tolerance at the Vapour Heat Treatment

Small scale mortality test by VHT

- **Purpose:**

To Determine VHT standards (fruit core temperature and holding time)

- **Materials**

Test Insect Target stage : ***B. dorsalis***

Mango size : **Mature eggs, *1st and 2nd instar***

: **250-300 g**

- **Treatment Conditions**

Temperature (^{0}C)	Time (min)
46.0	2
46.5	0
46.5	10
46.5	20
47.0	0
47.0	10

Results of small scale mortality test by VHT

Corrected mortality of each developmental stages of B. *dorsalis* in heat susceptibility test by VHT method

Stages	Mortality (%)						
	Temperature (Time)						Control
	46.0 (2 min)	46.5 (0)	46.5 (10)	46.5 (20)	47.0 (0)	47.0 (10)	
Egg	50.44%	81.44%	100%	100%	100%	100%	47.58%
1st	81.39%	100%	100%	100%	100%	100%	85.00%
2nd	85.58%	100%	100%	100%	100%	100%	88.27%

The Study showed that 46.5^0- 10 min, 46.5^0- 20 min, 47.0^0- 0 min & 47.0^0- 10 min effective to eradicate eggs, 1st Instar and 2nd Instar of fruit fly

Fruit injury test

09 fruit quality parameters were tested with different temperature and time combinations

Parameter
Weight loss
Ripeness at survey
pH
Brix
Taste & flavor
Shrinkage
Cavity and spongy tissue in pulp
Fruit decay
Anthracnose

Treatment Conditions	
Temp. and Time Combination	**Maturity stage**
46.5 ^{0}C (20)	R, G
46.5 ^{0}C (30)	R, G
47.0 ^{0}C (08)	R, G
47.0 ^{0}C (10)	R, G
47.0 ^{0}C (20)	R, G
47.0 ^{0}C (30)	G
47.0 ^{0}C (60)	R, G
48.0 ^{0}C (00)	G

Fruit injury test

Test No.	Trea9tment Condition	Weight loss	Ripeness at survey	Fruit Rot	Shrinkage	Anthracnose	pH	Brix	Others
1	47.0 – 20	T:10.8% C:11.2% (T=C)	T:4.1% C:4.0% (T=C)	T:0.2 C:1.1 (T<C)	T:1.4 C:1.2 (T=C)	T:0.7 C:1.9 (T<C)	T:5.62 C:5.09 (T=C)	T:12.1 C:12.1 (T=C)	
2	46.5 - 30	T:11.9% C:11.0% (T=C)	T:3.9% C:4.3% (T=<C)	T:0.8 C:2.1 (T<C)	T:2.1 C:2.0% (T=C)	T:1.7 C:2.2 (T=<C)	T:6.0 C:6.23 (T=C)	T:11.0 C:13.2 (T=<C)	Taste & Flavor (T=C)
3	47.0 - 20	T:9.7% C:10.2% (T=C)	T:3.7% C:3.4% (T=C)	T:0.4 C:0.5 (T=C)	T:0.5 C:0.7 (T=<C)	T:0.3 C:1.1 (T<C)	T:4.68 C:4.78 (T=C)	T:8.7 C:9.2 (T=C)	Taste & Flavor (T=C)
4	47.0 - 60	T:14.0% C:13.8% (T=C)	T:4.1% C:4.2% (T=C)	T:1.1 C:1.3 (T<C)	T:1.1 C:1.3 (T=C)	T:0.4 C:1.4 (T<C)	T:4.53 C:4.91 (T=C)	T:7.6 C:8.4 (T=<C)	Taste & Flavor (T=C)
5	48.0 – 00	T:7.3% C:11.8% (Different conditions) (T<C)	T:2.9% C:3.3% (T=<C)	T:0.1 C:1.6 (T>=C)	T:0.1 C:1.6 (Different conditions)	T:0.1 C:0.5 (T<C)	T:4.65 C:4.82 (T>=C)	T:7.7 C:7.6 (T=C)	Taste & Flavor (T=C)
6	46.5 - 30	T:14.8% C:13.3% (T>=C)	T:3.9% C:3.8% (T=C)	T:2.3 C:2.3 (T<C)	T:2.3 C:2.3 (T=C)	T:0.4 C:0.9 (T<C)	T:4.41 C:4.49 (T=C)	T:10.0 C:10.4 (T=C)	Taste & Flavor (T=C)
7	47.0 - 60	G(10d):T=2.5 % C=3.2% R(5d):T=2.2% C=1.3% (T=C)	G(10d):T=2.7 C=2.7 R(5d):T=2.8 C=2.4 (T=C)	G(10d):T=0 .1 C:1.7 R(5d):T=0.6 C=0.4 (T=<C)	G(10d):T=0 C=0 R(5d):T=0.8 C=0.6 (T=C)	G(10d):T=0 C=0.7 R(5d):T=0.1 C=0.3 (T<C)	G(10d):T=4.14 C=4.67 R(5d):T=4.45 C=4.19 (T=<C)	G(10d):T=8.4 C=11.0 R(5d):T=9.0 C=11.0 (T=<C)	
8	47.0 - 10	G:T =2.6% C=3.2% R:T=1.5% C=1.3% (T=C)	G:T =2.4 C=2.7 R:T=2.7 C=2.4 (T=C)	G:T =3 C=1.7 R:T=3 C=0.4 (T<C)	G:T =0 C=0 R:T=1 C=0.6 (T=<C)	G:T =0 R:T=0.2 (T<C)	G:T =3.76 C;4.67 R:T=3.88 C;4.19 (T=C)	G:T =7.7 C:11.0 R:T=8.9 C:11.0 (T=<C)	

Test No.	Treatment Condition	Weight loss	Ripeness at survey	Fruit Rot	Shrinkage	Anthracnose	pH	Brix	Others
9	46.5 - 20	G:T =2.5% C=3.2% R:T=1.6% C=1.3% (T=C)	G:T =2.4 C=2.7 R:T=2.8 C=2.4 (T=C)	G:T =3 C=1.7 R:T=3 C=0.4 (T<C)	G:T =0.2 C=0 R:T=0.2 C=0.6 (T=C)	G:T =0.4 C=0.7 R:T=0.5 C=0.3 (T=<C) G>R	G:T =4.33 C:4.67 R:T=4.24 C:4.19 (T=C) G<R	G:T =11.2 C:11.0 R:T=9.5 C:11.0 (T=C)	
10	47.0 - 10	T:9.4% C:8.8% (T=C)	T:3.9% C:3.8% (T=C)	T:0.1 C:1.7 (T<C)	T:2.2 C:1.9 (T=C)	T:0.2 C:1.2 (T<C)	T:5.02 C:5.15 (T=C)	T:16.1 C:15.9 (T=C)	
11,12	47.0-8, 47.0 -30	47.0-8 T:10.1%, 10.9% 47-30 C:9.8%- (T=C)	47-8 T:4.0 47-30 C:3.8 (T=C)	47-8 T:0.3 47-30 C:1.1 (T<C)	47-8 T:1.6,1.5 47-30 C:1.0 (T>C)	47-8 T:0.4,0.2 47-30 C:0.4 (T=<C)	47-8 T:5.48,5.49 47-30 C:5.34 (T=C)	47-8 T:14.5,14.1 47-30 C:14.9 (T=C)	ST: 47-8 T=0 47-30 C:0
13	47.0 - 08	T:8.6% C:8.6% (T=C)	T:4.0 C:4.2 (T=C)	T:0.2 C:0.6 (T<C)	T:1.2 C:1.7 (T=<C) G=R	T:0.2 C:0.4 (T<C)	T:5.68 C:5.51 (T=C)	T:12.7 C:13.5 (T=C)	
14	47.0 - 08	T:G 9.1% R:9.1% C:G 9.8% R:8.4% (T=C)	T:G 3.8 R:4.2 C:G 4.0 R:8.4.2 (T=C)	T:G 0.2 R:0.2 C:G 0.9 R:1.2 (T<C)	T:G 0.9 R:1.3 C:G 1.6 R:1.4 (T=C)	T:G 0.1 R:0.1 C:G 0 R:1.2 (T<C)	T:G 5.38 R: 5.95 C:G 5.91 R:5.99 (T=C)	T:G 10.9 R:14.4 C:G 10.4 R:13.4 (T=C) G<R	Taste & Flavor (T=C)
15	47.0 - 10	T:7.9% C:7.0% (T>=C)	T:2.8 C;2.7 (T=C)	T:0 C:0.3 (T=<C)	T:0.1 C:0.1 (T=C)	T:0 C:0.1 (T=C)	T:4.49 C:4.93 (T<C)	T:12.9 C:13.6 (T=C)	
16	47.0 - 08	T:9.54% C:10.0% (T=C)	T:2.5 C:2.1% (T>=C)	T:0.4 C:1.9 (T<C)	T:1.8 C:1.5 (T=C)	T:0.2 C:0.5 (T=<C)	T:5.29 C:4.30 (T>C)	T:8.4 C:9.2 (T=<C)	
17	47.0 - 08	T:9.5% C:7.03% (T>C)	T:3.3 C:26 (T>C)	T:0.2 C:1.5 T=0.5 C=1.9 (T<C)	T:0.8 C:1 (T=C)	T:0.1 C:0.2 (T=<C)	T:4.76 C:3.93 (T>=C)	T:8.6 C:7.9 (T>=C)	

Summary of the results of fruit injury test

Parameter	Result
Weight loss	**No difference in weight loss** was observed in most cases
Ripeness at survey	**No difference in ripeness** was observed between treated and control mango
pH	**No difference in pH** was observed between treated and control mango
Brix	**No difference in Brix** was observed between treated and control mango
Taste & flavor	**No difference in taste and flavor** was observed between treated and control mango
Shrinkage	**Similar shrinkage of outer skin was observed** between treated and control mango
Fruit decay	**Fruit decay was reduced in treated mango** than control
Anthracnose	**Anthracnose was reduced/low in treated mango** than control

Cavity formation & spongy tissue formation in pulp

Experiment No.	Treatment condition Temp °C - time/min.	Ripeness	No.of fruits with spongy tissue		Cavity formation	
			Treatment	Control	Treatment	Control
9	46.5 - 20	*G **R	5 0	0 0	0.5(7) 0.6(7)	0.6(4) 0.3(6)
2	46.5 -30	R	3	0	1.1(8)	2.0(10)
6	46.5 - 30	G	8	0	1.3(10)	0.5(8)
12	47.0 - 8	R	1	0	0.7(8)	0.7(8)
11	47.0 - 8	G	0	0	0.4(5)	0.4(6)
13	47.0 - 8	G R	2 0	0 0	0.8(4) 0.3(4)	0.6(5) 0.6(6)
15	47.0 - 8	G	3	0	0.9(6)	0.6(6)
16	47.0 - 8	G	0	0	1.6(8)	0.5(6)
14	47.0 - 10	G	1	0	0.5(4)	0.2(3)
10	47.0 - 10	G	1	0	0.5(6)	0.7(7)
8	47.0 - 10	G R	7 1	0 0	1.0(10) 0.6(6)	0.6(4) 0.3(6)
01	47.0 - 20	R	0	2	0.3(3)	0.6(4)
3	47.0 - 20	G	3	1	0.6(7)	0.5(4)
11	47.0 - 30	G	0	0	0.6(7)	0.4(6)
4	47.0 - 60	G	4	1	2.5(9)	0.6(5)
7	47.0 - 60	G R	5 2	0 0	0.3(5) 1.4(10)	0.6(4) 0.3(6)
5	48.0 - 0	G	10	2	2.3(10)	0.8(8)

- Spongy formation is increased with the exposure time more in green than ripen

✓ 47^0C – 08, 10, 20, 30 & 60 min

- Irrespective of the ripeness, cavity formation of the following temperature-time combinations are very slight

✓ 46.5^0C –20 & 30 min

✓ 47^0C – 08, 10, 20, 30 & 60 min

It is concluded that ripen fruit stage is more suitable for the VHT treatment

Optimized Treatment Conditions of Fruit Injury Test

- 46.5^{0}C – 20 min
- 47.0^{0}C – 08 min
- 47.0^{0}C – 10 min
- 47.0^{0}C – 20 min

100% Mortality Achieved in Small-scale Mortality Test

- 46.5^{0}C – 10 min
- 46.5^{0}C – 20 min
- 47.0^{0}C – 00 min
- 47.0^{0}C – 10 min

47.0^{0}C – 08 min was selected for the Large Scale Mortality test

Large scale mortality test by VHT

- **Purpose:**

To confirm a 100 % mortality for more than 30,000 effective insects

- **Materials**

Test insect	: ***B. dorsalis***
Target stage	: **Mature eggs**
Mango size	: **250-300 g**
Maturity	: **Mature green to ½ ripeness**

- Mango were obtained from Minuwangoda area
- 200 mature eggs were inoculated per fruit

Large scale mortality test by VHT

- **Methods:**

Treatment conditions:

Setting of VHT machine : Program mode

Setting Value of Chamber Temp : **47.5 ºC (+1 ºC)**

Target Temperature : **47 ºC + Holding Time 8 Min**.
(Core Fruit)

Relative Humidity : **55% - 95%**

- Both control and treated fruits were kept in air circulation plastic container at 22^0C until eggs become 3rd install larvae in control fruits
- This test was repeated until total estimated number of test insects based on the number of survivors in control plot become over 30000

Results of large scale mortality test

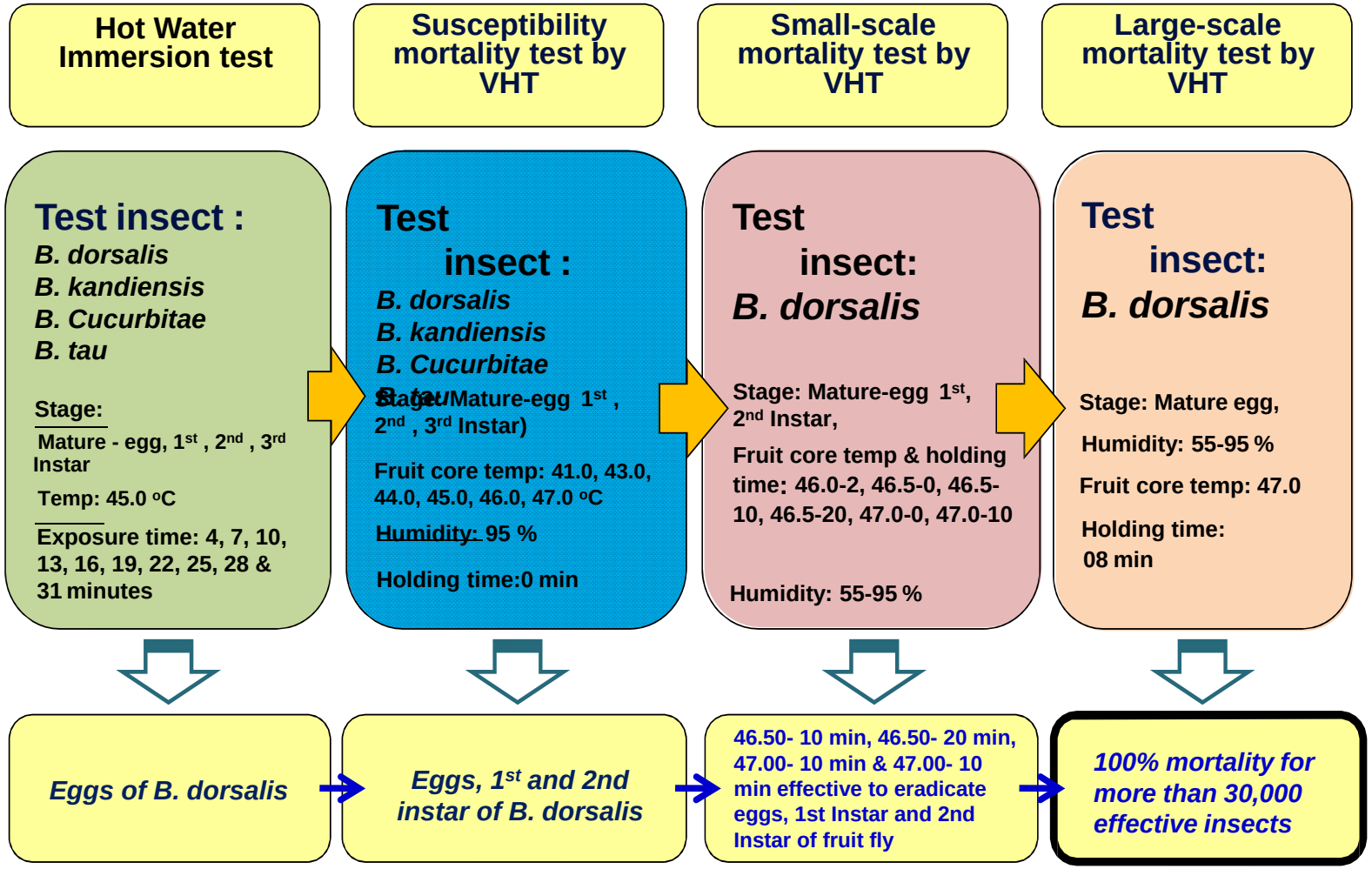
Number of test fruits, no. of survivor and corrected mortality in the Large Scale Mortality Test, *B. dorsalis* (Mature egg) in VHT

Replication	Control		Treatment - 47 ºC + Holding Time 8 Min			
	No of fruits	No of survivors	No of fruits	No of effective insects	No of survivors	Corrective mortality
1	18	1146	54	3438	0	100
2	18	1259	54	3777	0	100
3	18	1229	54	3687	0	100
4	18	896	54	2688	0	100
5	18	2211	54	6633	0	100
6	19	1876	57	5628	0	100
7	18	2013	54	6039	0	100
Total	127	10630	381	31890	0	

More then 30,000 effective insects

Complete mortality

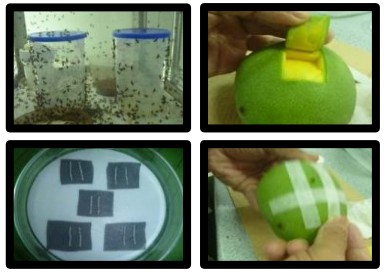
Summary


Hot Water Immersion test
Susceptibility mortality test by VHT
Small-scale mortality test by VHT
Large-scale mortality test by VHT
Test insect :
B. dorsalis
B. kandiensis
B. Cucurbitae
B. tau
Stage:
Mature - egg, 1st , 2nd , 3rd Instar
Temp: 45.0 oC
Exposure time: 4, 7, 10, 13, 16, 19, 22, 25, 28 & 31 minutes
Test insect :
B. dorsalis
B. kandiensis
B. Cucurbitae
B. tau
Stage: Mature-egg 1st , 2nd , 3rd Instar)
Fruit core temp: 41.0, 43.0, 44.0, 45.0, 46.0, 47.0 oC
Humidity: 95 %
Holding time:0 min
Test insect:
B. dorsalis
Stage: Mature-egg 1st, 2nd Instar,
Fruit core temp & holding time: 46.0-2, 46.5-0, 46.5-10, 46.5-20, 47.0-0, 47.0-10
Humidity: 55-95 %
Test insect:
B. dorsalis
Stage: Mature egg,
Humidity: 55-95 %
Fruit core temp: 47.0
Holding time: 08 min
Eggs of B. dorsalis
Eggs, 1st and 2nd instar of B. dorsalis
46.50- 10 min, 46.50- 20 min, 47.00- 10 min & 47.00- 10 min effective to eradicate eggs, 1st Instar and 2nd Instar of fruit fly
100% mortality for more than 30,000 effective insects

Recommendation

- VHT condition with 47.0 ºC of fruit core temperature and 08 minutes holding time proved a 100% mortality for more than 30,000 effective insects

- Therefore, on commercial scale treatment, these conditions can be used as a standard to ensure complete mortality of all stages of *B. dorsalis , B. kandiensis, B. cucurbitae and B. tau*



Vapor Heat Treatment against fruit flies in mango (Var. TomEJC)

Effect of Vapor Heat Treatment on eradication of fruit fly *Bactrocera dorsalis* (Diptera: Tephritidae) in export TJCmango

Test fruits

Programming VHT machine

Mortality Test

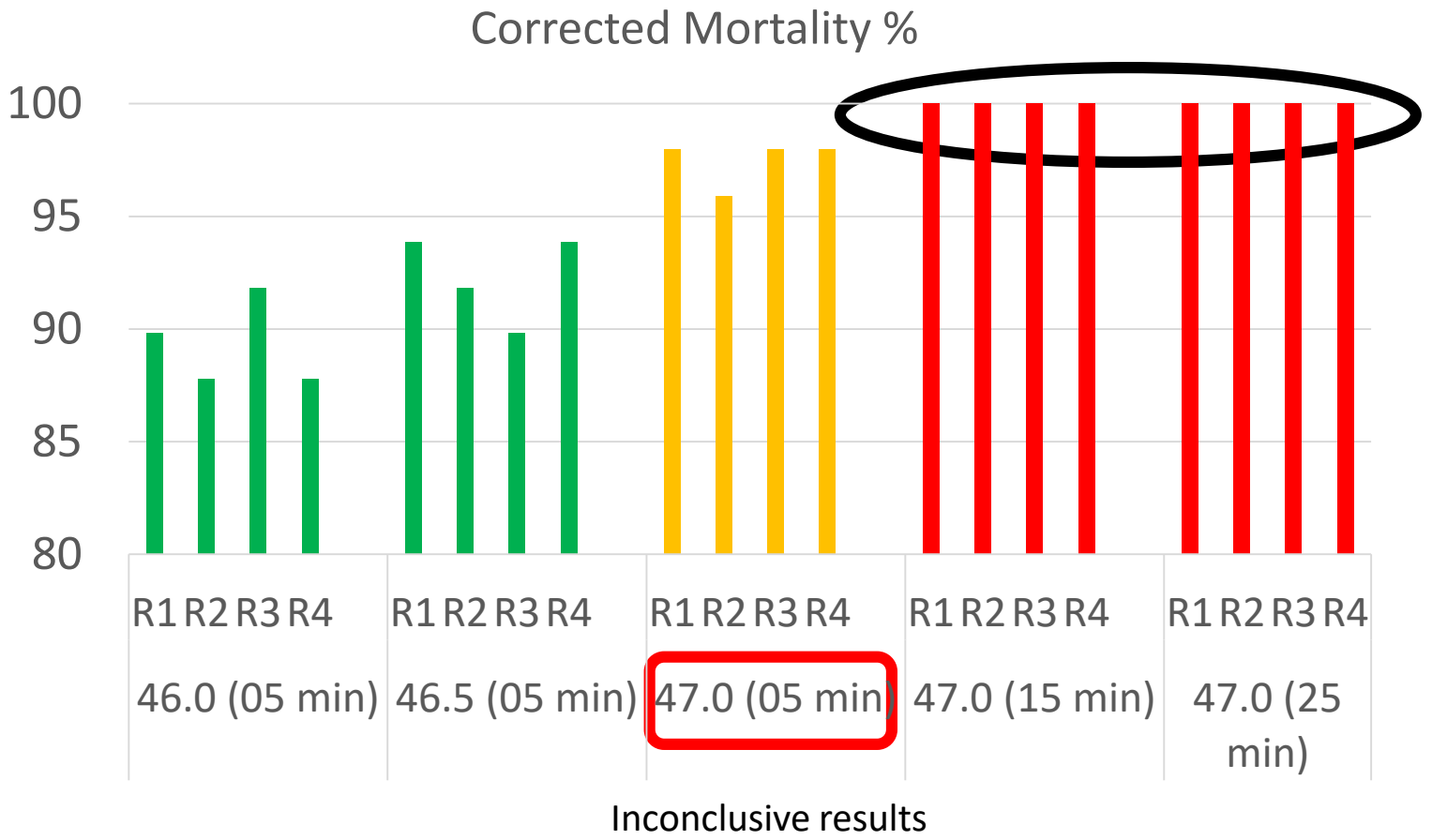
Fruit Injury Test

Small-scale mortality test by VHT

- A total of 36 TJC mango were used for the experiment and among them 6 mangos were infected with 1st instar (50 instar per mango)
- Six un-infested mangos were kept as control and remaining 24 mangos were used to evaluate the fruit quality
- Treatment was conducted by applying different temperature-time intervals at 95% R.H

Temperature (Time)
46.0 ^{0}C (05)
46.5 ^{0}C (05)
47.0 ^{0}C (05)
47.0 ^{0}C (15)
47.0 ^{0}C (25)

Results of small-scale mortality test



Result :

47°C for 15 & 25 min were found to be effective for eradication of *B. dorsalis*

Test on Consumer Preference

47.0^{0}C (15min)

	Median	S/NS
Color	2.0	S
Odour	1.5	S
Texture	2.0	S
Taste	1.5	S
Overall Acceptance	15	S

(Wilcoxon Signed Rank Test)

Conclusion is consumer preference is high for the all the attributes with compared to control

Fruit injury test

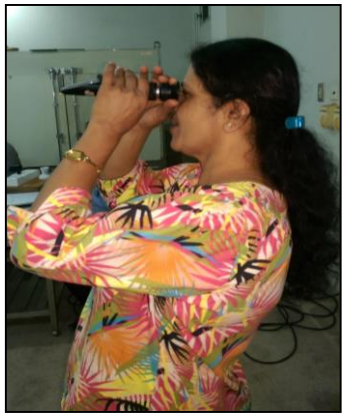
47.0^{0}C (15min)

Treatment level	Avg. pH value		Avg. Brix value		Avg. Hardness value	
	Just after	72 h	Just after	72 h	Just after	72 h
1	4.03^a	5.4^a	12.7^a	22.3^a	2.6^a	1.8^a
2	4.07^a	5.5^a	11.0^a	21.7^a	2.4^a	1.7^a
3	4.10^a	5.6^a	13.7^a	22.0^a	2.6^a	1.9^a
4	4.06^a	5.5^a	15.3^a	22.3^a	2.4^a	1.8^a
Control	4.00^a	5.6^a	14.7^a	22.3^a	2.5^a	1.8^a
P-value	**0.936**	**0.648**	**0.069**	**0.989**	**0.435**	**0.943**

*The numbers which was followed by the same letter on the same column is not significantly different based on Tukey-test (α = 5%)

Hardness test

pH test



Brix test

Conclusion

- **Due to the inconclusive data obtained for 47.0^{0}C (05 min), 47.0^{0}C (15min) was selected as the effective VHT treatment standard to eradicate fruit fly in TomEJC mango**

Trade Negotiations for the exportation of Sri Lankan fresh fruits

- On going negotiations with Japan, Republic of China, Republic of Korea and USA to export Sri Lankan fresh mangoes
- Exportation of fresh mangoes (Tom EJC) was permitted to Jordan after the certification of VHT facility at NPPO Sri Lanka by Jordanian Technical Team

Large Scale Tom EJC Mango Orchards in Sri Lanka

Thank You !

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Department of Agriculture

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