



Food and Agriculture
Organization of the
United Nations

**REGIONAL STANDARDS
FOR PHYTOSANITARY MEASURES**

***INTERNATIONAL MOVEMENT OF FRESH MANGO
(MANGIFERA INDICA) FRUIT***

APPPC RSPM No. 11

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INTRODUCTION

Scope

- [1] This standard provides guidance to assist national plant protection organizations (NPPOs) in managing risk of introduction of specific pests associated with the international movement of fresh mango (*Mangifera indica*) fruit intended for consumption or processing.
- [2] This standard applies to all varieties of mango fruit with or without a small section of fruit stalk (pedicel) attached but without leaves or stem.
- [3] Some major pests of mango fruit, and measures to manage them, are included in this standard. These measures include those that have been adopted as International Standards for Phytosanitary Measures (ISPMs) as well as those that are used in trade by APPPC countries.
- [4] This standard does not address issues related to living modified organisms, food safety, climate change, quality of mango fruit, or diversion from intended use.

Definitions

- [5] Definitions of phytosanitary terms used in this standard can be found in ISPM 5 (*Glossary of phytosanitary terms*).

OUTLINE OF REQUIREMENTS

- [6] Pest risk may vary within and between countries and importing NPPOs should use pest risk analysis (PRA) (as described in ISPM 2, *Framework for pest risk analysis*; ISPM 11, *Pest risk analysis for quarantine pests*) to identify quarantine pests and provide the technical justification¹ for phytosanitary import requirements.
- [7] This standard provides guidance on procedures to establish phytosanitary import requirements. It identifies and describes specific phytosanitary measures that may be used to reduce pest risk and provides guidance on sampling, inspection and phytosanitary certification of mango fruit for export.

BACKGROUND

- [8] Mango fruit has the potential to host pests that can be introduced into an importing country and potentially cause negative economic impacts. Pests that have been shown historically to move with fresh mango fruit include fruit flies, fruit boring moths and beetles, scales and mealybugs. This standard lists major pests associated with mango fruit in trade and where at least one contracting party has required measures to manage these pests.
- [9] The intention of this standard is to enable trade by providing a harmonised suite of measures that may be applied to manage pest risk identified through PRA. Where appropriate, pests are grouped according to measures that effectively manage pest risk.

REQUIREMENTS

Pest Risk Analysis

- [10] The NPPO of the importing country should conduct PRA associated with fresh mango fruits in accordance with ISPM 2, *Framework for pest risk analysis* and ISPM 11, *Pest risk analysis for quarantine pests* to determine the regulatory status of the pests for the area.
- [11] Table 1 is a list of pests associated with fresh mango fruit that may be identified as regulated pests that require phytosanitary measures by the PRA process. Measures in Table 3 should be used for the management of these quarantine pests. Alternative measures may be considered where technically justified.

Table 1: Pest groups associated with fresh mango fruit (if no measures applied)

Pest Group	Family	Example species
Weevils	Curculionidae	<i>Sternochetus frigidus</i> [syn. <i>Sternochetus gravis</i>] <i>Sternochetus mangiferae</i> <i>Sternochetus olivieri</i>
Fruit flies	Tephritidae	<i>Anastrepha</i> spp. <i>Bactrocera</i> spp. <i>Ceratitis capitata</i>
Moths	Pyralidae	<i>Deanolis sublimbalis</i> ¹
Scales and mealybugs	Coccidae	<i>Ceroplastes rubens</i> <i>Coccus viridis</i>
	Pseudococcidae	<i>Dysmicoccus neobrevipes</i> <i>Paracoccus marginatus</i> <i>Planococcus lilacinus</i> <i>Planococcus minor</i> <i>Pseudococcus cryptus</i> <i>Pseudococcus jackbeardsleyi</i> <i>Rastrococcus iceryoides</i> <i>Rastrococcus invadens</i> <i>Rastrococcus rubellus</i> <i>Rastrococcus spinosus</i>
	Diaspididae	<i>Aonidiella</i> spp. <i>Aulacaspis tubercularis</i> <i>Chrysomphalus aonidum</i> <i>Parlatoria crypta</i> <i>Pseudaonidia trilobitiformis</i>
Fungi	Unclassified	<i>Cytosphaera mangiferae</i>

¹ Associated with mature fruit

Pest Group	Family	Example species
Bacteria	Xanthomonadaceae	<i>Xanthomonas campestris</i> pv. <i>mangiferaeindicae</i>

[12] Phytosanitary measures may be difficult to evaluate if significant uncertainty is identified in the pest risk assessment. Even where uncertainty is identified, measures should not be applied unless information indicates a pest is likely to be introduced and cause negative economic impacts in the PRA area.

[13] Table 2 identifies examples of pests where there is uncertainty in the region as to their association with mango fruit in trade and a description of the uncertainty.

Table 2: Pests with uncertain association with mango fruit in trade

Pest Group	Family	Pest	Description
Moths	Pyralidae	<i>Conogethes punctiferalis</i>	These pests may not follow the pathway if infestation results in fruit damage causing fruit to drop before harvest or renders fruit unsuitable for export.
		<i>Cryptoblabes gnidiella</i>	

General Procedures

General procedures include the following if technically justified:

[14] Production:

- registration of commercial production orchards
- orchard hygiene practices such as GAP
- monitoring for pests
- pest management

[15] Packing and grading:

- registration of packing houses
- pest management in the packing house
- packing in clean and either new or refurbished material
- storage prior to export and transportation in a secure manner to prevent contamination and re-infestation, e.g., insect-proof packaging
- grading to assure fruits are suitable for export including freedom from damage, symptoms of pests, contamination (soil, plant debris etc.)

[16] Treatment facilities:

- registration and approval of treatment facilities

- secure management to prevent contamination and re-infestation

Phytosanitary Measures

[17] Information on pests associated with mango fruit and measures considered effective in managing each pest group is provided below.

Table 3: Phytosanitary measures considered effective in managing the risk from specified pest groups

Pest Group	Phytosanitary measure(s)
Weevils	PFA, PFPP, systems approach, irradiation treatment
Fruit flies	PFA, treatment e.g. heat (VHT, hot water immersion treatment, high temperature forced air treatment) or irradiation treatment
Moths	PFA, PFPP, systems approach, treatment e.g. irradiation
Scales and mealybugs	Pre-harvest, harvest management, post-harvest washing and brushing, visual examination, treatment (e.g. fumigation, irradiation treatment)
Fungi, Bacteria	PFA, PFPP, systems approach, post-harvest treatment e.g. dipping
Arthropods	Irradiation treatment (IAEA)

[18] Treatments that are used in trade in the region and technically justified through PRA are provided as reference in this standard. NPPOs of importing countries should recognise the effectiveness of these treatments to manage the target pest/pests or, provide technical justification to support alternative measures. Tables 4, 5, 6 and 7 are intended to clearly separate those treatments that are accepted as international standards (Annex to ISPM 28) and those that are not, but are used in regional trade. In some cases, phytosanitary measures applied to manage risk from one pest will also reduce the pest risk from other pests.

[19] Phytosanitary import requirements should be required only for pests identified as regulated pests requiring phytosanitary measures by PRA for the area endangered. Phytosanitary measures applied to a pest or pest group where the association with the pathway is uncertain, should be justified through PRA.

Pest Free Areas (PFA)

[20] Relevant guidance on pest free areas is presented in ISPM 4 (*Requirements for the establishment of pest free areas*) and ISPM 8 (*Determination of pest status in an area*).

Pest Free Places of Production (PFPP) and Areas of Low Pest Prevalence (ALPP)

[21] Relevant guidance on pest free places of production and areas of low pest prevalence is presented in ISPM 10 (*Requirements for the establishment of pest free places of production and pest free production sites*) and ISPM 22 (*Requirements for the establishment of areas of low pest prevalence*). The use of these measures may be limited by the biological characteristics of pests, such as dispersal mechanisms.

Pre-harvest and Harvest Management

- [22] Pre-harvest pest management programmes (chemical, biological and cultural) to reduce pest incidence and removal of infested fruit at harvest are practices consistent with good cultural and handling practices employed in the production and marketing of mango fruit.

Post-harvest Handling and Treatments

Washing and brushing

- [23] High pressure washing and brushing of mango fruit is likely to reduce but not eliminate the presence of quarantine pests from the surface of fruit. Pest groups likely to be reduced in number by washing and brushing include mealybugs, scales, and surface contaminating fungi.
- [24] Washing and brushing should be supported by inspection in the packing house to determine effectiveness at removing pests. Fruit infested with quarantine pests following washing and brushing should be discarded or remedial actions applied.
- [25] Water used for washing should be clean.

Dipping

Dipping with chemicals may be used as a phytosanitary measure against some pest groups (Table 3). Chemicals for dipping are to be applied at manufacturers label requirements or according to technical justification.

Fumigation treatment

- [27] Scientific data to support effective fumigation (e.g. with methyl bromide) treatment for Tephritidae fruit flies and other internally feeding arthropod pests in mango fresh fruits is not currently available.

Heat treatment

- [28] The application of heat treatments and systems to support the treatments should follow the requirements set out in ISPM 42, *Requirements for the use of temperature treatments as phytosanitary measures*.

Hot Water Immersion Treatment

- [29] Hot water immersion treatments should be applied in accordance with ISPM 42, *Requirements for the use of temperature treatments as phytosanitary measures*. The following treatments are either recognised as effective through an international standard or, are used by an APPPC country in trade and technically justified by PRA.

Table 4: Hot water immersion treatment specifications

[30] Pest	[31] Specification	[32] Reference
<i>[33] Anastrepha fraterculus</i> <i>[34] Anastrepha distincta</i> <i>[35] Anastrepha ludens</i> <i>[36] Anastrepha obliqua</i> <i>[37] Anastrepha serpentine</i> <i>[38] Anastrepha striata</i> <i>[39] Ceratitis capitata</i>	<i>[40]</i> Fruit core temperature of 46.0 °C for 5 minutes	<i>[41]</i> Used in trade (by Republic of Korea)
<i>[42] Bactrocera dorsalis</i> <i>[43] Bactrocera carambola</i> <i>[44] Bactrocera correcta</i> <i>[45] Bactrocera curcubitae</i> <i>[46] Bactrocera zonata</i>	<i>[47]</i> Fruit immersed in water at a temperature of 48°C for 60 minutes for mango fruit up to 500 grams	<i>[48]</i> Used in trade (by Australia, Pakistan, Korea, China, Iran)

Vapour Heat Treatment and High Temperature Forced Air

[49] Vapour heat and high temperature forced air treatments should be applied in accordance with ISPM 42, *Requirements for the use of temperature treatments as phytosanitary measures*. The following treatments are either recognised as effective through an international standard or are used by an APPPC country in trade and technically justified by PRA.

Table 5: Vapour heat treatment specifications

Pest	Specification	Reference
[51] <i>Bactrocera tryoni</i>	[52] Vapour heat treatment at a fruit core (largest fruit) temperature of 47.0°C for 15 minutes at 95% relative humidity.	[53] International Standard [54] ISPM 28, PT31: Vapour heat treatment for <i>Bactrocera tryoni</i> on <i>Mangifera indica</i>
[55] <i>Ceratitis capitata</i>	[56] Vapour heat treatment at a fruit core (largest fruit) temperature of 46.5°C for 10 minutes at 95% relative humidity.	[57] International Standard [58] ISPM 28, PT30: Vapour heat treatment for <i>Ceratitis capitata</i> on <i>Mangifera indica</i> .
[59] <i>Bactrocera carambolae</i> [60] <i>Bactrocera correcta</i> [61] <i>Bactrocera cucurbitae</i> [62] <i>Bactrocera dorsalis</i> [63] <i>Bactrocera tau</i> [64] <i>Bactrocera tuberculata</i> [65] <i>Bactrocera zonata</i>	[66] Vapour heat treatment at a fruit core (largest fruit) temperature of 46.5°C for 30 minutes at 95% relative humidity [67] Vapour heat treatment at a fruit core (of largest fruit) temperature of 47.0°C for 20 minutes at 95% relative humidity. [68] Vapour heat treatment at a fruit core (of largest fruit) temperature of 47.5°C for 20 minutes at 95% relative humidity.	[69] Used in trade (by New Zealand, China (Taiwan)) [70] Used in trade (by New Zealand, Thailand, Vietnam) [71] Used in trade (by Japan, India)

Table 6: High temperature forced air treatment specifications

[72] Pest	[73] Specification	[74] Reference
[75] <i>Bactrocera curvipennis</i> [76] <i>Bactrocera facialis</i> [77] <i>Bactrocera kirki</i> [78] <i>Bactrocera melanotus</i> [79] <i>Bactrocera passiflorae</i> [80] <i>Bactrocera psidii</i> [81] <i>Bactrocera tryoni</i> [82] <i>Bactrocera xanthodes</i>	[83] High temperature forced air where temperature raised from ambient to 47.2°C and then held for a minimum of 20 minutes.	[84] Used in trade (by New Zealand) [85] (Allwood & Vueti 1996)

Irradiation

[86] Irradiation treatments should be applied in accordance with ISPM 18, *Guidelines for the use of irradiation as a phytosanitary measure*. The following treatments are either recognised as effective through an international standard or are used by an APPPC country in trade and technically justified by PRA.

[87] **Table 7: Irradiation treatment specifications**

Pest	Minimum absorbed dose (Gy)	Reference
[88] All Tephritidae	[89] 150 Gy	[90] International Standard [91] ISPM 28, PT7: Irradiation treatment for fruit fly of the family Tephritidae (generic).
[92] <i>Bactrocera jarvisi</i>	[93] 100 Gy	[94] International Standard [95] ISPM 28, PT4: Irradiation treatment for <i>Bactrocera jarvisi</i> .
[96] <i>Bactrocera tryoni</i>	[97] 100 Gy	[98] International Standard [99] ISPM 28, PT5: Irradiation treatment for <i>Bactrocera tryoni</i> .
[100] <i>Ceratitis capitata</i>	[101] 100 Gy	[102] International Standard [103] ISPM 28, PT14: Irradiation treatment for <i>Ceratitis capitata</i> .
[104] <i>Dysmicoccus neobrevipes</i>	[105] 231 Gy	[106] International Standard [107] ISPM 28, PT19: Irradiation treatment for <i>Dysmicoccus neobrevipes</i> , <i>Planococcus lilacinus</i> and <i>Planococcus minor</i> .
[108] <i>Planococcus lilacinus</i>	[109] 231 Gy	[110] International Standard [111] ISPM 28, PT19: Irradiation treatment for <i>Dysmicoccus neobrevipes</i> , <i>Planococcus lilacinus</i> and <i>Planococcus minor</i> .
[112] <i>Planococcus minor</i>	[113] 231 Gy	[114] International Standard [115] ISPM 28, PT19: Irradiation treatment for <i>Dysmicoccus neobrevipes</i> , <i>Planococcus lilacinus</i> and <i>Planococcus minor</i> .
[116] Mites	[117] 400 Gy for Tetranychidae [118] 500 Gy for all other Acari	Used in trade (by Australia, New Zealand)

Pest	Minimum absorbed dose (Gy)	Reference
[119] <i>Sternochetus frigidus</i>	[120]165 Gy	[121]Used in trade (by USA) [122]Obra <i>et al.</i> 2014 [123]USDA treatment manual 2019
[124]Plant pests of the class Insecta except pupae and adults of the order Lepidoptera	[125]400 Gy	[126]Used in trade (by USA)

Systems Approaches

[127] Guidelines for the development and evaluation of integrated measures in a systems approach is given in ISPM 14 *The use of integrated measures in a systems approach for pest risk management*.

[128] At least two measures that are independent of each other may be used to manage specific quarantine pests and any uncertainty.

[129] ISPM 14 *The use of integrated measures in a systems approach for pest risk management* provides examples of independent measures that can be applied during pre-harvest, harvest, post-harvest, transport and distribution that are applicable to international trade in mango fruit. Independent measures for specific pests should be negotiated with the importing country NPPO and may include:

Table 8: Measures that may be used as components in a systems approach

[130]Pre-harvesting	[131]Harvesting	[132]Post-harvesting
<ul style="list-style-type: none"> - Field management (chemical, biological and cultural controls) - Protected conditions (e.g. fruit bagging) - Area of low pest prevalence - Pest free place of production 	<ul style="list-style-type: none"> - Removal of infested products 	<ul style="list-style-type: none"> - Washing and brushing - Treatment (e.g. dipping, heat, irradiation) - Fruit cutting - Inspection

Verification of Compliance

[133] Sampling and inspection should be undertaken to verify compliance of consignments of mango fruit with phytosanitary import requirements.

[134] NPPOs may authorize entities to perform phytosanitary activities such as sampling, inspection and testing in accordance with ISPM xx, *Authorization of entities to perform phytosanitary actions*.

Sampling and Phytosanitary Inspection

[135] Guidance for official phytosanitary sampling of consignments is given in ISPM 31, *Methodologies for sampling of consignments* and inspection in ISPM 23, *Guidelines for inspection*.

[136] Following official procedures, the NPPO of the exporting country should sample and inspect each consignment of fresh mango fruit to verify conformity with importing requirements and freedom from quarantine pests. Where infield controls require the registration of the orchard, then sampling and inspection should be of each homogenous grower lot.

[137] Where live pests are found, the exporting country NPPO should determine whether additional actions are necessary to meet the requirements of the importing country NPPO.

[138] The minimum sample size for inspection should be based on a 95% confidence level that not more than 0.5% of the fruit are infested as set out in ISPM 31, *Methodologies for sampling of consignments*, or as specified by the NPPO of the importing country with technical justification. For example, for inspection lots of 1000 pieces of fruit, this equates to a sample size of 450 pieces of fruit.

Phytosanitary Certification

[139] A phytosanitary certificate should only be issued when the requirements of the importing country have been verified as being met as attested in the certifying statement.

Phytosanitary Security

[140] One or more methods to safeguard fruit against re-infestation after the application of a phytosanitary measure should be applied. The safeguarding method should take into account the biological characteristics of pests and the strength of phytosanitary measures applied.

Audit and Compliance of the Export Pathway

[141] In accordance with ISPM 20 *Guidelines for a phytosanitary import regulatory system*, the NPPO of the importing country may ask to audit particular elements of the mango export system, specifically export registered entities and records relating to exported consignments or may ask verification of compliance of consignment by the importing country in the exporting country.

REFERENCES

- [142] The present standard refers to ISPMs. ISPMs are available on the International Phytosanitary Portal (IPP) at <https://www.ippc.int/core-activities/standards-setting/ispms>.
- [143] **Allwood, A., Vueti, E.T.** 1996. *Report on the confirmatory tests to demonstrate the efficacy of commercial forced hot air as a quarantine treatment for eggs of Bactrocera passiflorae, artificially infested into five varieties of mangoes in Fiji.* Official report, MAFF, Fiji.
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