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PP 1/242 (3) Taint tests

Specific scope: This Standard provides general guidance on the requirements for testing whether treated plant produce are tainted by plant protection products (PPP). It explains the circumstances under which taint tests are necessary, where to obtain samples for the tests, how to collect and handle them and how to have them evaluated by tasting assessors. This Standard does not apply to food produce which are so transformed that they are totally different in nature from the raw crop (e.g. bread, beer, wine), which are covered by EPPO Standards PP 1/243 *Effects of plant protection products on transformation processes* and PP 1/268 *Study of unintentional effects of plant protection products on fermentation processes and characteristics of wine*.

Specific approval and amendment: First approved in 2005-09. Revision to add new references approved in 2014-09. Revision in 2025-09.

1 | BACKGROUND

For certain types of treatments with plant protection products (PPP), it may be necessary to provide evidence that the use of the PPP does not give a taint (unpleasant taste or smell – subsequently taste and smell are grouped together and just referred to as taste or flavour) to the harvested or processed plant produce. A large number of factors can influence whether a PPP causes taint including the crop, climate, soil type, method of application, the interval from application to harvest and the method of processing. Due to the impracticality of investigating all of these, only factors which have been shown to be important are examined. These tests will demonstrate whether the food produce from a crop treated with a PPP (the test product) is different in flavour from a food product coming from the same crop treated with a reference product, or untreated. For some pests, the comparison with an untreated control may cause inconsistencies for taint testing, because pests can affect the quality of the harvested material, and lead to differences in taste. Comparison to an untreated control is acceptable if the samples are of equivalent quality.

In most cases, it is likely that no difference in taste will be found and the result may be taken to show the absence of taint coming from the treatment. Where some difference is demonstrated, it may be possible to assess the taint on the basis of descriptions given by assessors. For definitions of this and other terms, see ISO 5492 (2008 version, or latest update if any).

Historically, taint testing has often been targeted almost entirely at crops which subsequently undergo commercial processing, and most commonly those undergoing heating processes or quick freezing. This is because of the potential of such processes to concentrate or enhance any tainting effect. Information suggests that fungicides are the most likely group of PPP to cause taint. Certain PPP have a high propensity to cause taint, and a high occurrence of taint is more likely if they are used near to harvest or as post-harvest treatments. In general, applications near the harvest are more likely to cause taint, but this should always be considered along with the properties of the active substance or the PPP. Indeed, repeated use or persistence of the substance on the plant or in the soil, systemicity, root uptake (etc.) may result in taint, even if applications are performed a long time before harvest. For example, for nematicides and insecticides, even certain soil-applied treatments at or before planting, have been associated with the occurrence of taint.

There is always a possibility of taint, even in freshly harvested produce. However, it is not practical to require routine taint testing of all fresh produce. Taint tests on fresh produce are advisable in specific cases where a risk is identified based on the active substance or PPP properties and depending on the treated crop.

2 | NEED FOR TAINT TESTS

In preparing the biological dossier, the applicant should consider whether there is a need for data on possible effects of the test product on taint, or whether a reasoned case can be presented to justify not supplying such data. There are no simple rules or cut-off criteria, to decide whether or not taint tests should be conducted, but the following generalizations may be made:

- The length of time between application and harvest is an important factor. However, some PPP or active substance properties (long-lasting formulations, repeated use, systemicity, root uptake, etc.) can have an impact on the propensity for taint even a long time after treatment.

– If an active substance or product, or a similar type of product/substance has caused taint in one crop, it will have a higher potential for taint in other crops.

Step 1: In which situations is there a risk of taint?

The need for taint tests should be considered in the following situations:

a. In the case of residue levels higher than the limit of quantification (LOQ) in the plant parts intended for consumption;
b. In the absence of available residue tests or in the case of a high aroma formulation (caused by the active substance or a major co-formulant):
   1. for products applied close to harvest, and applied in the presence of harvestable plant parts (e.g. fruits, leaves for leafy vegetables, inflorescence for some brassica crops),
   2. for a product applied post-harvest, on plant parts intended to human consumption;
c. In case of an active substance absorbed by the plant (systemicity or root uptake).
d. For products based on micro-organism species expected to proliferate in situ on the plant parts, and that are applied close to harvest or post-harvest, with an application on harvestable plant parts expected to be eaten as fresh (i.e. uncooked) produce.

A decision tree for step 1 is illustrated in Figure 1.

Step 2: For which kind of product are taint tests normally required?

Taint tests are usually required for an active substance, or association of substances, for which little is known or which is developed on new crops.

In case an active substance or PPP is already known to cause taint, it is possible to add a label warning or to specify conditions of use that will enable those using the product to limit or avoid the effects.

Taint tests are usually not required for a known active substance that is already registered on a range of crops, without taint issues (except if conditions of use can give a higher risk of taint). A reasoned case should be presented.

If it is decided that taint testing is necessary, guidance is provided (in Table 1 and in the text below) on the principal crops which might be tested, the main processing methods for these crops and if tests on fresh produce are advisable. In particular, if no effects were observed with crops/processes which are usually sensitive to taint, no further crops need to be tested.

If it is decided that taint testing is not necessary, arguments in support of this decision should be provided (e.g. mode of action, method of uptake in the plant, long time interval to harvest, use of directed sprays, no contact with crop foliage, no root uptake). If no taint data is provided and a risk of taint is considered possible, then it may be appropriate to give advice or warnings on the PPP label, for example 'The possibility of taint has not been studied/cannot be excluded'. To remove such a warning, data would need to be provided.

Taint may be caused not only by the active substance but also by the formulants used in the PPP. Therefore, tests with the active substance alone are not acceptable. However, it is not required to test all formulations. Where there is a significant change of formulation, additional testing may be required if this change is likely to lead to taint. If a PPP is a new formulation of a well-known active substance that has never been associated with taint, it may be argued that further taint testing is unnecessary.

Step 3: Which are the main crops and processes concerned?

Table 1 presents the list of main crops and main processed produce (or fresh produce) that can be assessed for taint.

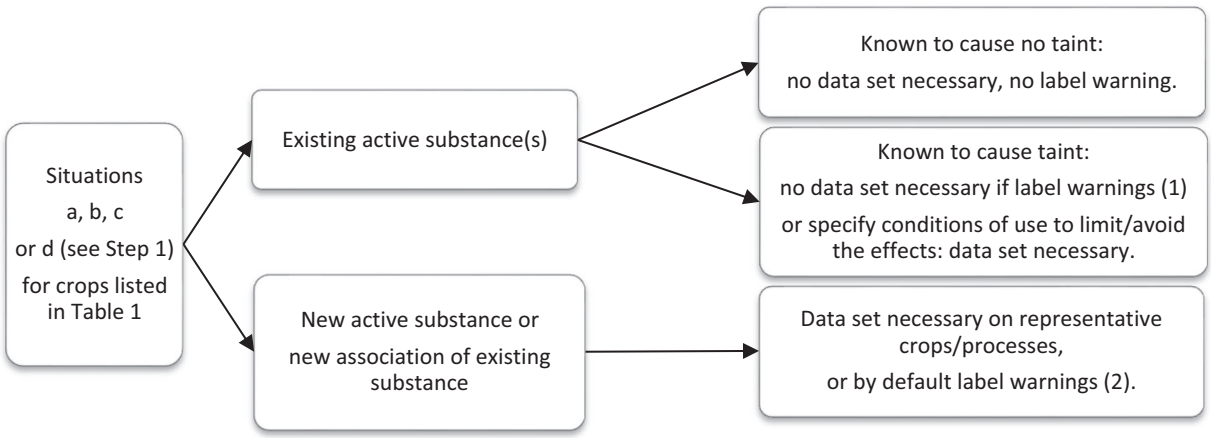

FIGURE 1 Decision tree.
(1) For example: 'There is a known risk of taint on….' (2) For example: 'Caution: Taint effects have not been studied on ….' or 'A risk of taint cannot be excluded on …'

TABLE 1 List of crops and processed produce (or fresh produce).

Crop group	Harvested produce	Processed produce	Fresh produce
Solanaceae fruit	Tomato	Puree, concentrate, juice, canned	Fresh
Legumes	Vining pea, dwarf French bean	Canned	–
Brassicas	Cabbage	Cooked[a]	–
	Broccoli	Cooked[a]	–
Leafy vegetables	Spinach	Canned or cooked[a]	=
	Lettuce or other salad leaves	=	Fresh
Bulb vegetables	Bulb onion	Cooked[a]	–
Tuber vegetables	Potato	Steamed or boiled potatoes, chips	=
Cucurbits	Cucumber	–	Fresh
	Courgette	Cooked[a]	–
Soft fruit	Strawberry, raspberry, other soft fruits.	Jam, juice	Fresh
Pome fruits	Apple	Puree, juice	Fresh
	Pear	Puree, juice	Fresh
Stone fruit	Peach, apricot	Juice, puree	Fresh
	Plum	Dried	–
	Cherry	Canned	–
Grape	Table grape	Dried, juice	Fresh
Citrus	Orange, lemon	Juice, marmalade	–
Olive	Olive	Oil	=

[a]Can be frozen after the cooking phase, if necessary (for conservation).

Other processing methods and other crop produce may also be considered.

Step 4: Selection of representative crop/processed (or fresh) produce combinations.

There is no requirement to perform taint tests for all the process methods and fresh produce listed in Table 1. The crops and processed produce selected combinations should represent those that are more likely to express taint effects. Taint studies performed on a number of representatives 'crops/processed or fresh produce' are sufficient to cover all situations, provided that the tests are performed on situations with higher likelihood of taint between the intended crops. From these situations, absence of taint in the studies can be extrapolated to cover other situations.

Regarding processing methods, Table 1 gives a list of the main produce that are usually assessed and/or those with a higher risk of taint. The choice of the crops and processes tested should be justified based on the substance and PPP properties, the requested uses and the conditions of use of the PPP (number of applications, crop stages, pre-harvest interval etc.), in order to identify the crop/process combinations that are most likely to express taint effects and to cover the diversity of crops claimed by the PPP. The choice of the process should be justified based on the importance of the processing method (tonnage, ha…), and by selecting the processes that are more susceptible to concentrate residues or to taint.

Taint may also appear on frozen produce, but heat preservation and produce consumed fresh are identified as at higher risk of taint, and therefore the results of the taint tests will cover the case of frozen produce. In case a plant protection product causes taint after a heating process and/or on fresh produce, it is possible to assess if this taint is also present after freezing. Some heat processing methods (e.g. frying) can be preceded by a freezing step before the cooking phase.

Taint tests on fresh produce are only advisable in cases where likelihood of taint is high for the fresh produce compared to the processed produce (e.g. fresh products consumed with their peel), or when the produce is mainly consumed fresh (e.g. lettuce).

In other cases, the taint studies performed on the processed produce can cover the risk of taint for fresh produce. Table 1 provides a list of fresh crops where taint tests are advisable; it is sufficient to perform the tests on representative crops/fresh produce.

2.1 | Number of tests

Two to three trials per representative crop/process (or fresh produce) should be performed using raw material from representative growing areas and if possible

covering roughly the geographical area where registration is sought.

If taint is not found, no further testing is required.

If taint is found or some doubt exists, further testing may be necessary to define the conditions of use (see Appendix 2). In such situations, additional tests will generally be required. Other testing may be required also on other crops/processes (or fresh produce). Another option for the applicant is to propose recommendations or conditions of use that will reduce the likelihood of taint.

3 | FIELD TRIALS AND PPP APPLICATION

3.1 | Field trial design and site

Ideally, specific trials could be set up for taint purposes alone. Trials design, recording and management should then comply with the principles laid down by EPPO Standard PP 1/181 *Conduct and reporting of efficacy evaluation trials, including good experimental practice*. Alternatively, for the field part of the experiment, selectivity or effectiveness trials (in the case pest damage does not interfere with the quality of samples) may be used but it should be ensured that the harvest quantity and quality will be sufficient, and the cultivar is adapted for the process to be tested.

The cultivars chosen should be representative of those used commercially for processing (e.g. apple juice cultivars for the juicing process). The system of cultivation, picking, transport and storage etc., should be uniform for any one trial.

Test crops should be grown under a range of soil and climatic conditions, in areas representative of the commercial crops. Due consideration should be given to the fitness of the harvested produce for processing and tasting (Appendix 1). To avoid deterioration of harvested produce, the place of testing and the time period from harvest to testing should be considered when deciding where to grow the crop.

Results from taint testing trials conducted in other areas or regions where registration is sought may also be taken into consideration, provided that agronomic, cultural and climatic conditions are broadly comparable between those regions. A justification of their relevance should normally be made.

The test methods given in Appendix 2 require equal quantities of harvested material for the untreated or reference plot and the plot treated with the test product, that is, the amount of harvested material from the untreated or reference plot should be at least equal to that of the total of all test product plots. In designing trials, account should be taken of the requirements for taint and other intended purposes of the trial (e.g. selectivity) to ensure that there is sufficient material available to allow representative sampling.

Trials should be as free as possible from pests that can have an impact on the harvested samples. Records should be kept of all treatments, including fertilizers, so that the source of any interactions with any previous treatment can be traced.

3.2 | Test product

Applications should be made as stated on the product label or with the maximum dose, the maximum number of treatments and the latest time of application. In particular, the last application of the test product should be performed at the pre-harvest interval. If a PPP is applied post-harvest, then the interval between treatment and preparation of the harvested produce should comply with the minimum duration indicated on the label or if any, the minimum duration of usual commercial practice.

The method of application, and water volumes used, should be appropriate for the use of the product and as recommended on the product label. Where the label recommends use of the product with an adjuvant, for example, wetting agent, this should be included in the treatment.

3.3 | Plot used for comparison: an untreated control or reference product(s) plot

It is possible to compare the test product sample to a sample coming from an untreated plot (according to the explanations in EPPO PP 1/152 *Design and analysis of efficacy evaluation trials*), provided that the samples are of equivalent quality and sufficient quantity for testing. Some pests alter the quality of the harvest (induce difference of maturity, sugar and acid content, taint due to the pathogen itself etc.). In such cases, the plot used for comparison should be treated with a reference product or a program of treatment (if necessary).

The reference product(s), or any other maintenance products used, are products already registered on the crop and they should be known to not cause taint effects.[1] The aim of the reference product is to ensure a good quality of the harvest. When possible, mode of action, time of application and method of application of the reference product(s) should be as close as possible to that of the test product. Reference product(s) and test product should be applied according to their specified use.

[1]Absence of taint can be documented though literature or asking advice of specialists. The ECOACS database available at http://e-phy.agriculture.gouv.fr/ (in French) constitutes a useful reference..

3.4 | Sampling, handling and storage of the crop

In all cases, it should be ensured that the harvested material is healthy and similar in all aspects (e.g. maturity). Detailed guidance is given in Appendix 1.

3.5 | Tasting tests

Detailed guidance on taint testing is given in Appendix 2. Any required authorization (safety certificate) should be obtained before any treated product is consumed (when the PPP is not yet registered for this crop, under similar conditions of use).

REFERENCES

ASTM (2020) *Manual 26 Sensory Testing Methods*, 2nd edn. American Society for Testing and Materials. http://www.astm.org. [Accessed on 1 June 2014].

ISO (2008) *ISO 5492 Sensory Analysis - Vocabulary*. International Standards Organization, Genève (CH).

ISO (2021) *ISO 4120: Sensory analysis – Methodology - Triangle Test*. International Standards Organization, Genève (CH).

APPENDIX 1 - SAMPLING, HANDLING AND STORAGE OF THE CROP

SAMPLING OF RAW MATERIALS

A reliable objective random sampling procedure should be used to eliminate subjective effects on the part of the sampler, prevent cross contamination between samples from different unit plots, and reduce to a minimum the effects of variations inherent in growing crops. Although the methods rely basically on random procedures, it may be necessary to use a stratified, rather than a simple, random pattern of sampling, the stratification being on the basis of, for instance, row, compass orientation or aspect (e.g. fruit trees), height of produce on the plant in relation to maturity (e.g. tomatoes which mature from the bottom upwards), prevailing wind or slope of ground. There may also be variations due to, for example, uneven distribution of chemicals both within and over the plant and over the crop as a whole.

The order in which plots are sampled is often important in minimizing the effects of time over the period in which the samples are taken. For instance, a sudden change in light intensity may radically alter the sugar composition of a vegetable such as spinach or tomatoes. The method of sampling should ensure that variation *within* blocks is minimized, by sampling one completed block at a time. In practice, it may be desirable to deal with the control or reference product plot(s) within a block first, to eliminate as far as possible any risks of contamination. Trials should not be sampled or harvested treatment by treatment. In general, samples should not be collected when they are wet with dew or rain. Samples taken should be representative of the plot in terms of size, maturity and other physical characteristics.

For the test method recommended in Appendix 2, the requirement of equal amounts of harvested material coming from the untreated or reference plot and the test product plot will give rise to a proportionately large bulk of untreated control or reference plot material when several test treatments are included in a trial. This should be obtained by taking the required number of control or reference product samples in a standard manner rather than by obtaining a large and atypical sample.

Each crop, cultivar and site may require different sampling procedures, and specialist advice may be needed on the most appropriate procedure to ensure that samples are not atypical of commercial produce.

Hands, containers, tools, machinery, etc. should always be thoroughly cleaned before sampling or handling material and between taking each sample from the treated plots. For example, treatments applied as a dust may easily be transferred in dry weather from one plot to another. Adequate cleaning facilities should, therefore, be provided.

All samples from a trial should be handled in an identical manner and should at all times be shaded from direct sunlight.

HANDLING OF RAW MATERIALS

Packing

The packing method should give adequate physical protection. If necessary, easily damaged fruits or vegetables such as some tomato cultivars should be individually packed. Containers should be free from contamination, i.e. thoroughly cleaned to remove the risk of chemical, physical and bacteriological contamination, particularly if the test material is to be stored in an unprocessed form. The packing material should not contaminate the samples either physically or chemically. The formation of harmful micro-climates should be avoided, e.g. some types of plastic containers can lead to sweating of the samples. Samples in containers with high thermal insulation properties can reach excessive temperatures. In general, packing in shallow layers is preferable to bulk packing, for both physical protection and regulation of temperature and humidity.

Transport

Time in transit should be kept to a minimum. During transport, the samples should be under the personal supervision of a responsible person, and should not be exposed to any risk of external contamination, extremes of heat, etc. Transport should be equivalent to the best practice of the food industry and chilled refrigerated transport should be used where possible.

Storage

All raw materials for taint tests should be processed as soon as possible after harvesting. This is particularly important for highly perishable materials such as vined peas, strawberries, etc. Some materials such as potatoes and apples may have to be stored for varying periods before taint testing or processing. In such cases, the storage conditions should be in accordance with the best commercial practice. In some cases, it is commercial practice to store raw material in a frozen condition (e.g. -18°C) before manufacture into jam or canned products. Where the practice is a commercially based one, frozen storage is suitable for storing material prior to taint testing.

Processing

Raw material for taint tests should be treated in a manner comparable with recommended commercial practice. For example, strawberries for jam making are generally washed before processing, unlike raspberries and black currants which are processed unwashed. Potatoes should be peeled in a manner which simulates commercial conditions as closely as possible. It is important that all equipment is thoroughly cleaned between handling different samples. Processing (canning, juicing etc.) should be carried out in a standard manner and should reflect commercial process operations. The food produce concerned should conform to any legal standards applicable.

Storage of processed material

Processed materials should be stored under conditions closely similar to those used in commercial practice. Even if the length of time of storage will probably vary for practical reasons, the storage time should be in line with the usual storage period of the considered crop. The minimum period of storage of the processed product, before the taint test is performed, is one month for heat-processed products (e.g. canned) and one week for frozen products. The maximum storage period is the same as the normal commercial shelf-life for the product. This will vary with the crop and processing method.

APPENDIX 2 - TASTING TESTS METHOD OF TASTING

The basic method of tasting should be as simple as possible but should also be as accurate as the conditions of the test allow. It is important that proper care be taken to avoid possible sources of bias in carrying out these tests (ASTM, 2020), For these reasons, the triangle test is suggested as the standard method for simple taint test work (ISO 4120, 2021). In the triangle test, the assessor is presented with three coded samples, two of which are the same (either control or reference material A or test product material B) and one which is different (B or A, respectively). Samples should be presented equally often in each of the six possible orders, ABB, BAB, BBA, AAB, ABA and BAA. The assessor is asked to pick out the odd sample of the three, distinguishing by flavour (including odour) only. At any tasting session, two triangle tests may be carried out by each assessor (ISO 4120, 2021).

The triangle test permits a decision only on whether or not the control or reference plot samples and test product samples differ. When they do, good methods of determining whether or not a taint has been introduced do not exist, mainly because of the difficulty of defining 'taint' without recourse to hedonic aspects (ISO 5492) of flavour which demand for their adequate investigation large panels of assessors fairly representative of the consuming public. Trained selected assessors, as recommended here, are more aware of the variations that exist in the natural flavours of crops and food produce and are generally better able to express their sensory responses. For these reasons, triangle tests are supplemented by asking the assessors at the time of the triangle test to describe any difference in flavour they may find, and to note the presence of any 'taint'. A treated sample may be 'preferred' to the control or reference sample. Also, minority reports of unexpected flavours are important, even when the overall result is of no significant difference. Differences between individuals in sensitivity to particular flavours are not uncommon and if such minority reports occur the test should be repeated.

In most cases, an unequivocal result will be obtained. In cases of doubt, repeat testing will help to clarify the issue. Although clear cases of taint will be readily distinguished by the descriptions or reactions of individual assessors, there is an intermediate area in which the distinction between 'change of flavour', 'foreign flavour', 'off flavour' and 'taint' is unclear. It is not possible to recommend a procedure which will distinguish clearly between these conditions in marginal cases. However, it is also possible for a subtle change of flavour, not in itself detrimental, to be an early indication of a more serious change that might develop during storage or manufacture of a derived product.

Suitability of assessors

Because the possible flavours or taints arising from the use of new substances are not known, the selection of a panel on the basis of their sensitivity to a taint is not possible. The panel should, therefore, be composed of persons who, from experience, have shown their ability to discriminate consistently between flavours of the produce under test. An assessor whose sense of taste is temporarily impaired, e.g. by a cold, should be excluded.

Number of assessors

The number of persons required for tasting tests, and the number of times they are required to taste each set of samples will vary according to the type of test. The number of assessors required for triangle tests, which are dealing with a wide range of products and flavours, should not be fewer than 10 and should preferably be more. With a low number of assessors, some differences may be missed, and some differences that do not exist may be incorrectly perceived.

This standard proposes that the test objective is to differentiate samples of produce that have been treated with a test PPP and a reference PPP (or an untreated control). The range of 10-18 assessors is given in the Standard ISO 4120 (2021) for testing for difference (more precise guidance is given in the Standard regarding the number of assessors).

The statistical analysis is based on a triangular test to confirm there is no difference with a probability α of 0.05 to detect a perceptible difference when there is not (ISO 4120, 2021).

Preparation of samples

Canned fruits and vegetables should be macerated with the cooking liquor (where applicable) and tasted at room temperature or after warming. Jams should be tasted either at room temperature or after warming. The jam should be stirred or mashed to ensure that the sample is reasonably homogenous. Fruit juices should be mixed thoroughly by shaking or stirring. They should be tasted either at room temperature or after warming. Fresh produce that can be eaten with or without their peel should be tasted with their peel.