

**EFSA CEF Panel (EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids), 2014. Scientific Opinion on Flavouring Group Evaluation 73, Revision 3 (FGE.73Rev3): Consideration of alicyclic alcohols, aldehydes, acids and related esters evaluated by JECFA (59th and 63rd meeting) structurally related to primary saturated or unsaturated alicyclic alcohols, aldehydes, acids and esters evaluated by EFSA in FGE.12Rev4 (2013)**

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## SCIENTIFIC OPINION

### **Scientific Opinion on Flavouring Group Evaluation 73, Revision 3 (FGE.73Rev3): Consideration of alicyclic alcohols, aldehydes, acids and related esters evaluated by JECFA (59<sup>th</sup> and 63<sup>rd</sup> meeting) structurally related to primary saturated or unsaturated alicyclic alcohols, aldehydes, acids and esters evaluated by EFSA in FGE.12Rev4 (2013)<sup>1</sup>**

**EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF)<sup>2, 3</sup>**

European Food Safety Authority (EFSA), Parma, Italy

#### ABSTRACT

The Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids of the European Food Safety Authority was requested to consider evaluations of flavouring substances assessed since 2000 by the Joint FAO/WHO Expert Committee on Food Additives (the JECFA), and to decide whether further evaluation is necessary, as laid down in Commission Regulation (EC) No 1565/2000. The present consideration concerns a group of 18 alicyclic alcohols, aldehydes, acids and related esters and one phenethyl ester evaluated by the JECFA at their 59<sup>th</sup> and 63<sup>rd</sup> meetings. This revision is made due to consideration of one additional substance, beta-ionyl acetate [FL-no: 09.305] cleared for genotoxicity concern in FGE.213Rev1. The substances were evaluated through a stepwise approach that integrates information on structure-activity relationships, intake from current uses, toxicological threshold of concern, and available data on metabolism and toxicity. The Panel agrees with the application of the Procedure as performed by the JECFA for all 19 substances [FL-no: 02.114, 02.141, 05.098, 05.104, 05.112, 05.119, 05.123, 08.034, 08.060, 08.067, 09.028, 09.034, 09.289, 09.305, 09.488, 09.534, 09.536, 09.615 and 09.712] considered in this FGE and agrees with the JECFA conclusion, “No safety concern at estimated levels of intake as flavouring substances” based on the MSDI approach. Besides the safety assessment of these flavouring substances, the specifications for the materials of commerce have also been considered and for all substances, the information is adequate.

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#### KEY WORDS

alicyclic, alcohols, aldehydes and esters, JECFA, 59<sup>th</sup> meeting, FGE.12, FGE.73, FGE.213

<sup>1</sup> On request from the European Commission, Question No EFSA-Q-2014-00347, adopted on 24 September 2014.

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<sup>3</sup> Acknowledgement: The Panel wishes to thank the members of the Working Group on Flavourings: Ulla Beckman Sundh, Leon Brimer, Angelo Carere, Karl-Heinz Engel, Henrik Frandsen, Rainer Gürtler, Trine Husøy, Wim Mennes, Gerard Mulder and Harriet Wallin for the preparatory work on this scientific opinion and the hearing experts: Vibe Beltoft, Pia Lund and Karin Nørby and EFSA staff: Maria Carfí, Annamaria Rossi and Kim Rygaard Nielsen for the support provided to this scientific opinion.

## SUMMARY

Following a request from the European Commission, the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF Panel) was asked to deliver scientific advice to the Commission on the implications for human health of chemically defined flavouring substances used in or on foodstuffs in the Member States. In particular, the CEF Panel was requested to consider the Joint FAO/WHO Expert Committee on Food Additives (the JECFA) evaluations of flavouring substances assessed since 2000, and to decide whether no further evaluation is necessary, as laid down in Commission Regulation (EC) No 1565/2000. These flavouring substances are listed in the Register, which was adopted by Commission Decision 1999/217/EC and its consecutive amendments.

In the previous version of Flavouring Group Evaluation 73 (FGE.73Rev2), EFSA considered 17 alicyclic primary alcohols, aldehydes, acids and related esters and one phenylethyl alcohol evaluated by the JECFA at their 59th meeting.

This revision is made due to consideration of one additional substance, beta-ionyl acetate [FL-no: 09.305], compared to the previous version of FGE.73 (FGE.73Rev2). This substance has been evaluated in FGE.213Rev1 due to structural concern for genotoxicity, and has been cleared from this concern and thus may be evaluated through the Procedure.

The present consideration therefore concerns 18 alicyclic alcohols, aldehydes, acids and related esters and one phenethyl alcohol evaluated by the JECFA (59<sup>th</sup> and 63<sup>rd</sup> meeting) which will be considered in relation to the European Food Safety Authority (EFSA) evaluation of 12 primary saturated or unsaturated alicyclic alcohol, aldehyde, and esters evaluated in the Flavouring Group Evaluation 12, Revision 4 (FGE.12Rev4).

The Panel agrees with the application of the Procedure as performed by the JECFA for the 19 substances considered in this FGE.

For all 19 substances evaluated through the Procedure use levels are needed to calculate the modified Theoretical Added Maximum Daily Intake (mTAMDI) in order to identify those flavouring substances that need more refined exposure assessment and to finalise the evaluation.

In order to determine whether the conclusion for the 19 JECFA evaluated substances can be applied to the materials of commerce, it is necessary to consider the available specifications. Adequate specifications including complete purity criteria and identity tests are available for all JECFA evaluated substances.

Thus, for all 19 substances [FL-no: 02.114, 02.141, 05.098, 05.104, 05.112, 05.119, 05.123, 08.034, 08.060, 08.067, 09.028, 09.034, 09.289, 09.305, 09.488, 09.534, 09.536, 09.615 and 09.712] the Panel agrees with the JECFA conclusion “No safety concern at estimated levels of intake as flavouring substances” based on the MSDI approach.

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## BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The use of flavourings is regulated under Regulation (EC) No 1334/2008 of the European Parliament and Council of 16 December 2008<sup>4</sup> on flavourings and certain food ingredients with flavouring properties for use in and on foods. On the basis of Article 9(a) of this Regulation, an evaluation and approval are required for flavouring substances.

The Union list of flavourings and source materials was established by Commission Implementing Regulation (EC) No 872/2012<sup>5</sup>. The list contains flavouring substances for which the scientific evaluation should be completed in accordance with Commission Regulation (EC) No 1565/2000<sup>6</sup>.

EFSA concluded that a genotoxic potential of the  $\alpha,\beta$ -unsaturated precursor, beta-ionyl acetate [FL-no: 09.305] in FGE.213 could not be ruled out.

Information on four representative materials has now been submitted by the European Flavour Association. These are beta-ionone [FL-no: 07.008], maltol [FL-no: 07.014], nootkatone [FL-no: 07.089] and 2,6,6-trimethylcyclohex-2-en-1,4-dione [FL-no: 07.109].

This information is intended to cover also the re-evaluation of the following 8 substances from FGE.19 subgroup 2.7:

- 4-(2,2,6-Trimethyl-1-cyclohexenyl)but-3-en-2-ol [FL-no: 02.106]
- Methyl-beta-ionone [FL-no: 07.010]
- Beta-Isomethylionone [FL-no: 07.041]
- P-Mentha-1,4(8)-dien-3-one [FL-no: 07.127]
- 4,4a,5,6-Tetrahydro-7-methylnaphthalen-2(3H)-one [FL-no: 07.136]
- 4-(2,5,6,6-Tetramethyl-1-cyclohexenyl)but-3-en-2-one [FL-no: 07.200]
- beta-Ionyl acetate [FL-no: 09.305]
- Maltol isobutyrate [FL-no: 09.525]

The Commission asks EFSA to evaluate this new information and depending on the outcome proceed to the full evaluation of the flavouring substance.

## TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

The European Commission requests the European Food Safety Authority to carry out a safety assessment on the following 12 flavouring substances: 4-(2,2,6-trimethyl-1-cyclohexenyl)but-3-en-2-ol [FL-no: 02.106], beta-ionone [FL-no: 07.008], methyl-beta-ionone [FL-no: 07.010], maltol [FL-no: 07.014], beta-isomethylionone [FL-no: 07.041], nootkatone [FL-no: 07.089], 2,6,6-trimethylcyclohex-2-en-1,4-dione [FL-no: 07.109], p-mentha-1,4(8)-dien-3-one [FL-no: 07.127], 4,4a,5,6-tetrahydro-7-methylnaphthalen-2(3H)-one [FL-no: 07.136], 4-(2,5,6,6-tetramethyl-1-cyclohexenyl)but-3-en-2-one [FL-no: 07.200], beta-ionyl acetate [FL-no: 09.305], maltol isobutyrate [FL-no: 09.525] in accordance with Commission Regulation (EC) No 1565/2000.

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<sup>4</sup> Regulation (EC) No 1334/2008 of the European Parliament and of the Council of 16 December 2008 on flavourings and certain food ingredients with flavouring properties for use in and on foods and amending Council Regulation (EEC) No 1601/91, Regulations (EC) No 2232/96 and (EC) No 110/2008 and Directive 2000/13/EC. OJ L 354, 31.12.2008, p. 34-50.

<sup>5</sup> Commission implementing Regulation (EU) No 872/2012 of 1 October 2012 adopting the list of flavouring substances provided for by Regulation (EC) No 2232/96 of the European Parliament and of the Council, introducing it in Annex I to Regulation (EC) No 1334/2008 of the European Parliament and of the Council and repealing Commission Regulation (EC) No 1565/2000 and Commission Decision 1999/217/EC. OJ L 267, 2.10.2012, p. 1-161.

<sup>6</sup> Commission Regulation No 1565/2000 of 18 July 2000 laying down the measures necessary for the adoption of an evaluation programme in application of Regulation (EC) No 2232/96. OJ L 180, 19.7.2000, p. 8-16.

## **INTERPRETATION OF THE TERMS OF REFERENCE**

beta-Ionyl acetate [FL-no: 09.305] was first allocated to FGE.213Rev1 for evaluation with respect to genotoxicity. Based on the new genotoxicity data submitted, the Panel concluded that [FL-no: 09.305] does not give rise to concern with respect to genotoxicity and can accordingly now be evaluated through the Procedure in FGE.73Rev3.

## ASSESSMENT

The approach used by EFSA for safety evaluation of flavouring substances is referred to in Commission Regulation (EC) No 1565/2000, hereafter named the “EFSA Procedure”. This Procedure is based on the Opinion of the Scientific Committee on Food (SCF, 1999), which has been derived from the evaluation procedure developed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA, 1995; JECFA, 1996; JECFA, 1997; JECFA, 1999), hereafter named the “JECFA Procedure”. The Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (the Panel) compares the JECFA evaluation of structurally related substances with the result of a corresponding EFSA evaluation, focussing on specifications, intake estimations and toxicity data, especially genotoxicity data. The evaluations by EFSA will conclude whether the flavouring substances are of no safety concern at their estimated levels of intake, whether additional data are required or whether certain substances should not be evaluated through the EFSA Procedure.

The following issues are of special importance.

### *Intake*

In its evaluation, the Panel as a default uses the Maximised Survey-derived Daily Intake (MSDI) approach to estimate the *per capita* intakes of the flavouring substances in Europe.

In its evaluation, the JECFA includes intake estimates based on the MSDI approach derived from both European and USA production figures. The higher of the two MSDI figures is used in the evaluation by the JECFA. It is noted that in several cases, only the MSDI figures from the USA were available, meaning that certain flavouring substances have been evaluated by the JECFA only on the basis of these figures. For Register substances for which this is the case the Panel will need EU production figures in order to finalise the evaluation.

When the Panel examined the information provided by the European Flavour Industry on the use levels in various foods, it appeared obvious that the MSDI approach in a number of cases would grossly underestimate the intake by regular consumers of products flavoured at the use level reported by the Industry, especially in those cases where the annual production values were reported to be small. In consequence, the Panel had reservations about the data on use and use levels provided and the intake estimates obtained by the MSDI approach. It is noted that the JECFA, at its 65<sup>th</sup> meeting considered “how to improve the identification and assessment of flavouring agents, for which the MSDI estimates may be substantially lower than the dietary exposures that would be estimated from the anticipated average use levels in foods” (JECFA, 2006).

In the absence of more accurate information that would enable the Panel to make a more realistic estimate of the intakes of the flavouring substances, the Panel has decided also to perform an estimate of the daily intakes per person using a modified Theoretical Added Maximum Daily Intake (mTAMDI) approach based on the normal use levels reported by Industry.

As information on use levels for the flavouring substances has not been requested by the JECFA or has not otherwise been provided to the Panel, it is not possible to estimate the daily intakes using the mTAMDI approach for the substances evaluated by the JECFA. The Panel will need information on use levels in order to finalise the evaluation.

### *Threshold of 1.5 Microgram/Person/Day (Step B5) Used by the JECFA*

The JECFA uses the threshold of concern of 1.5 microgram ( $\mu\text{g}$ )/person/day as part of the evaluation procedure:

“The Committee noted that this value was based on a risk analysis of known carcinogens which involved several conservative assumptions. The use of this value was supported by additional information on developmental toxicity, neurotoxicity and immunotoxicity. In the judgement of the

Committee, flavouring substances for which insufficient data are available for them to be evaluated using earlier steps in the Procedure, but for which the intake would not exceed 1.5 µg per person per day would not be expected to present a safety concern. The Committee recommended that the Procedure for the Safety Evaluation of Flavouring Agents used at the forty-sixth meeting be amended to include the last step on the right-hand side of the original procedure (“Do the conditions of use result in an intake greater than 1.5 µg per day?”) (JECFA, 1999).

In line with the Opinion expressed by the Scientific Committee on Food (SCF, 1999), the Panel does not make use of this threshold of 1.5 µg per person per day.

### *Genotoxicity*

As reflected in the Opinion of SCF (SCF, 1999), the Panel has in its evaluation focussed on a possible genotoxic potential of the flavouring substances or of structurally related substances. Generally, substances for which the Panel has concluded that there is an indication of genotoxic potential *in vitro*, will not be evaluated using the EFSA Procedure until further genotoxicity data are provided. Substances for which a genotoxic potential *in vivo* has been concluded, will not be evaluated through the Procedure.

### *Specifications*

Regarding specifications, the evaluation by the Panel could lead to a different opinion than that of JECFA, since the Panel requests information on e.g. isomerism.

### *Structural Relationship*

In the consideration of the JECFA evaluated substances, the Panel will examine the structural relationship and metabolism features of the substances within the flavouring group and compare this with the corresponding FGE.

## **1. HISTORY OF THE EVALUATION OF THE SUBSTANCES IN THE PRESENT FGE**

The JECFA has evaluated a group of 26 flavouring substances consisting of alicyclic primary alcohols, aldehydes, acids and related esters (JECFA, 2002a).

In FGE.73, which covered a group of 15 of the 26 JECFA-evaluated substances, the Panel considered that, for nine substances [FL-no: 02.114, 02.141, 05.098, 05.112, 08.067, 09.289, 09.488, 09.534 and 09.615] additional data were needed (no European production volumes available, preventing them to be evaluated using the Procedure, and/or missing data on isomerism/composition). For the remaining six of the 15 JECFA evaluated substances [FL-no: 05.119, 05.123, 08.034, 08.060, 09.028 and 09.536] the Panel agreed with the JECFA conclusion “no safety concern at estimated levels of intake as flavouring substances” based on the MSDI approach.

The first Revision of FGE.73, FGE.73Rev1, included the assessment of one additional candidate substance, 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104]. No toxicity or metabolism data were provided for the substance. Furthermore, EU production volumes were provided for three substances, [FL-no: 02.141, 09.488 and 09.534] (EFFA, 2010b). After the publication of FGE.73, the following information was received and included in Revision 1: stereoisomeric composition for six substances [FL-no: 02.114, 02.141, 05.098, 08.067, 09.289 and 09.615], and the composition for one substance [FL-no: 05.112] were received (EFFA, 2010a).

The second Revision of FGE.73, FGE.73Rev2, included the assessment of two additional flavouring substances, santalyl acetate [FL-no: 09.034] and santalyl phenylacetate [FL-no: 09.712]. These two substances have been considered with respect to genotoxicity in FGE.207 (EFSA CEF Panel, 2013a) and the Panel concluded that the data available did rule out the concern for genotoxicity and thus concluded that the substances could be evaluated through the Procedure.



Santalyl phenylacetate [FL-no: 09.712] was evaluated by the JECFA at its 59<sup>th</sup> meeting together with other phenethyl substances. With the exception of santalyl phenylacetate [FL-no: 09.712], these phenethyl substances were not  $\alpha,\beta$ -unsaturated substances and were considered by EFSA in FGE.53 with the conclusion “No safety concern at estimated levels of intake as flavouring substances” based on the MSDI approach. As the phenethyl part of the molecules was considered not to raise concern, the Panel concluded that after santalyl phenylacetate [FL-no: 09.712] was cleared from genotoxic concern in FGE.207, it could be included FGE.73Rev2 together with the other santalyl substance (santalyl acetate [FL-no: 09.034]) from FGE.207.

FGE	Opinion adopted	Link	No. of substances
FGE.73	6 March 2008	<a href="http://www.efsa.europa.eu/en/efsajournal/pub/868.htm">http://www.efsa.europa.eu/en/efsajournal/pub/868.htm</a>	15
FGE.73Rev1	22 March 2012	<a href="http://www.efsa.europa.eu/en/efsajournal/pub/2638.htm">http://www.efsa.europa.eu/en/efsajournal/pub/2638.htm</a>	16
FGE.73Rev2	25 September 2013	<a href="http://www.efsa.europa.eu/en/efsajournal/doc/2638.pdf">http://www.efsa.europa.eu/en/efsajournal/doc/2638.pdf</a>	18
FGE.73Rev3	24 September 2014		19

The present revision of FGE.73 (FGE.73Rev3) concerns the consideration of one JECFA-evaluated substance beta-ionyl acetate [FL-no: 09.305].

beta-Ionyl acetate [FL-no: 09.305] was evaluated by the JECFA at its 63<sup>rd</sup> meeting together with other monocyclic and bicyclic secondary alcohols, ketones and related esters. beta-Ionyl acetate [FL-no: 09.305] may be hydrolysed to beta-ionol which is considered as a precursor for an  $\alpha,\beta$ -unsaturated ketone, and was originally allocated to and evaluated in FGE.213Rev1 (EFSA CEF Panel, 2014) in which it was considered not to be of concern with respect to genotoxicity. The Panel concluded that the substance could be included in the present FGE.73Rev3.

## 2. PRESENTATION OF THE SUBSTANCES IN THE JECFA FLAVOURING GROUP

### 2.1. Description

#### 2.1.1. JECFA Status

The JECFA has at the 59<sup>th</sup> meeting evaluated a group of 26 flavouring substances consisting of alicyclic primary alcohols, aldehydes, acids and related esters (JECFA, 2002a, 2003).

#### 2.1.2. EFSA Considerations

One of the 26 JECFA evaluated substances is not in the Register [Mixture of 2-methyl-5-(2,3-dimethyltricyclo[2.2.1.0(2,6)]hept-3-yl)pent-2-en-1-ol and 2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]hept-2-yl)pent-2-en-1-ol] (JECFA-no: 984).

Ten substances [FL-no: 02.060, 02.091, 05.104, 05.106, 05.117, 05.121, 09.034, 09.272, 09.278 and 09.302] are  $\alpha,\beta$ -unsaturated aldehydes or may be metabolised to  $\alpha,\beta$ -unsaturated aldehydes and have been considered together with other  $\alpha,\beta$ -unsaturated aldehydes and ketones. One of these  $\alpha,\beta$ -unsaturated substances, 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104], has been considered with respect to genotoxicity in FGE.209 (EFSA CEF Panel, 2011) and was evaluated through the Procedure in FGE.73Rev1. One additional substance, santalyl acetate [FL-no: 09.034] has been considered with respect to genotoxicity in FGE.207 (EFSA CEF Panel, 2013a), and was evaluated through the Procedure in FGE.73Rev2. The genotoxic properties of the remaining eight of these 10  $\alpha,\beta$ -unsaturated carbonyl substances were considered together with other  $\alpha,\beta$ -unsaturated aldehydes and ketones in FGE.208 (EFSA CEF Panel, 2013b) for which it was concluded that additional genotoxicity data were required for all eight substances.

The Panel also concluded that santalyl phenylacetate [FL-no: 09.712], evaluated by the JECFA at its 59<sup>th</sup> meeting together with other phenethyl substances, cleared for genotoxicity concern in FGE.207, should be included in FGE.73Rev2.

Furthermore, the Panel concluded that beta-ionyl acetate [FL-no: 09.305], evaluated by the JECFA at its 63<sup>rd</sup> meeting together with other monocyclic and bicyclic secondary alcohols, ketones and related esters, was cleared for genotoxicity concern in FGE.213Rev1 and should be included in this Revision of FGE.73.

The Panel concluded that all 19 substances in this FGE are structurally related to the group of primary saturated or unsaturated alicyclic alcohol, aldehyde and esters evaluated by EFSA in the Flavouring Group Evaluation 12, Revision 4 (FGE.12Rev4).

## **2.2. Isomers**

### **2.2.1. Status**

Eleven substances in the group of the JECFA evaluated substances have one or more chiral centres [FL-no: 02.114, 02.141, 05.098, 05.119, 05.123, 08.067, 09.034, 09.289, 09.305, 09.615 and 09.712]. Three substances [FL-no: 09.034, 09.305 and 09.712] can exist as geometrical isomers.

### **2.2.2. EFSA Considerations**

For the two stereoisomeric substances [FL-no: 05.119 and 05.123], the CAS register number (CASrn) is considered to specify the enantiomeric composition (Table 1).

## **3. SPECIFICATIONS**

### **3.1.1. Status**

The JECFA specifications are available for all 19 substances (JECFA, 2002b; JECFA, 2005a). See Table 1.

### **3.1.2. EFSA Considerations**

The available specifications are considered adequate for all substances.

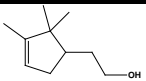
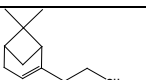
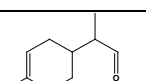
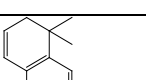
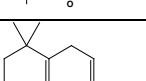
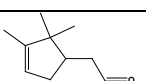
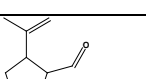
## **4. INTAKE ESTIMATION**

### **4.1. Status**

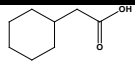
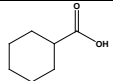
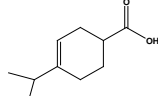
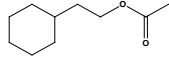
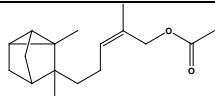
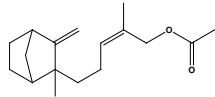
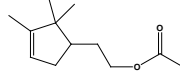
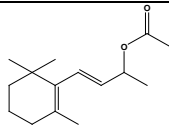
For all 19 substances evaluated through the JECFA Procedure production volumes, based on which MSDI values can be calculated, are available for the EU, see Table 5.

SUMMARY OF SPECIFICATION DATA

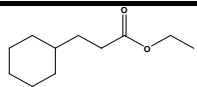
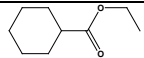
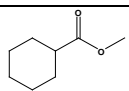
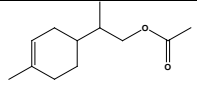
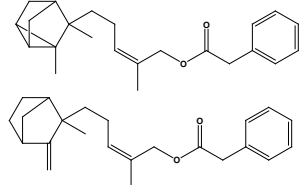
**Table 1:** Specification Summary of the Substances in the JECFA Flavouring Group (JECFA, 2002b)

FL-no JECFA -no	EU Register name	Structural formula	FEMA no CoE no CAS no	Phys.form Mol.formula Mol.weight	Solubility <sup>(a)</sup> Solubility in ethanol <sup>(b)</sup>	Boiling point, °C <sup>(c)</sup> Melting point, °C ID test Assay minimum	Refrac. Index <sup>(d)</sup> Spec.gravity <sup>(e)</sup>	EFSA comments
02.114 970	2-(2,2,3-Trimethylcyclopent-3-enyl)ethan-1-ol		3741 1901-38-8	Liquid C <sub>10</sub> H <sub>18</sub> O 154.25	Slightly soluble Miscible	74 (0.8 hPa) NMR 96 %	1.470-1.478 0.882-0.894 (20°)	Racemate (EFFA, 2010a). Synonym (+/-)-campholene alcohol (EFFA, 2010a).
02.141 986	2-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethan-1-ol		3938 128-50-7	Liquid C <sub>11</sub> H <sub>18</sub> O 166.26	Insoluble Miscible	230 IR NMR 95 %	1.490-1.500 0.965-0.973	Racemate (EFFA, 2010a).
05.098 971	p-Menth-1-en-9-al		3178 10347 29548-14-9	Liquid C <sub>10</sub> H <sub>16</sub> O 152.23	Insoluble Miscible	95 (13 hPa) NMR 99 %	1.458-1.466 0.904-0.916 (20°)	Racemate (EFFA, 2010a).
05.104 977	2,6,6-Trimethylcyclohexa-1,3-diene-1-carbaldehyde		3389 10383 116-26-7	Liquid C <sub>10</sub> H <sub>14</sub> O 150.22	Insoluble Miscible	70 (1 hPa) NMR 96 %	1.525-1.533 0.968-0.980 (20°)	
05.112 978	2,6,6-Trimethylcyclohex-1-en-1-acetaldehyde		3474 10338 472-66-2	Liquid C <sub>11</sub> H <sub>18</sub> O 166.26	Insoluble Miscible	58 (0.5 hPa) IR NMR 92 %	1.480-1.487 0.873-0.885 (20°)	Min. assay (92 %) secondary components β-cyclocitral (2-3 %), β-ionone (0.5-1 %), methyl β-homocyclogerane (2-4 %), ethyl β-homocyclogerane (0.6-1 %) (EFFA, 2010a).
05.119 967	2,2,3-Trimethylcyclopent-3-en-1-yl acetaldehyde		3592 10325 4501-58-0	Liquid C <sub>10</sub> H <sub>16</sub> O 152.23	Insoluble Miscible	75 (137 hPa) NMR 99 %	1.462-1.469 0.918-0.924	CASrn in Register refers to (R)-isomer. Register name to be changed to (1R,2R,3S)-Trimethylcyclopent-3-en-1-yl acetaldehyde.
05.123 968	5-Isopropenyl-2-methylcyclopentanecarboxaldehyde		3645 55253-28-6	Liquid C <sub>10</sub> H <sub>16</sub> O 152.23	Insoluble Miscible	80 (14 hPa) IR 95 %	1.501-1.508 0.940-0.952 (20°)	CASrn in Register refers to (1R,2R,5S)-isomer. Register name to be changed to (1R,2R,5S) 5-Isopropenyl-2-methylcyclopentanecarboxaldehyde.

**Table 1:** Specification Summary of the Substances in the JECFA Flavouring Group (JECFA, 2002b)

FL-no JECFA -no	EU Register name	Structural formula	FEMA no CoE no CAS no	Phys.form Mol.formula Mol.weight	Solubility <sup>(a)</sup> Solubility in ethanol <sup>(b)</sup>	Boiling point, °C <sup>(c)</sup> Melting point, °C ID test Assay minimum	Refrac. Index <sup>(d)</sup> Spec.gravity <sup>(e)</sup>	EFSA comments
08.034 965	Cyclohexylacetic acid		2347 34 5292-21-7	Solid C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> 142.20	Slightly soluble Miscible	242 28-33 NMR 98 %	1.459-1.467 1.001-1.009	
08.060 961	Cyclohexanecarboxylic acid		3531 11911 98-89-5	Solid C <sub>7</sub> H <sub>12</sub> O <sub>2</sub> 128.17	Slightly soluble Miscible	232-233 28-32 IR NMR 98 %	1.516-1.520 1.029-1.037	
08.067 976	1,2,5,6-Tetrahydrocuminic acid		3731 71298-42-5	Solid C <sub>10</sub> H <sub>16</sub> O <sub>2</sub> 168.24	Slightly soluble Soluble	n.a. 61 NMR 95 %	n.a. n.a.	Racemate (EFFA, 2010a).
09.028 964	2-Cyclohexylethyl acetate		2348 218 21722-83-8	Liquid C <sub>10</sub> H <sub>18</sub> O <sub>2</sub> 170.25	Insoluble Miscible	211 (996 hPa) NMR 98 %	1.442-1.450 0.945-0.948	
09.034 985	Santalyl acetate	 	3007 224 1323-00-8	Liquid C <sub>17</sub> H <sub>26</sub> O <sub>2</sub> 262.40	Insoluble Miscible	20.8 (4 hPa) IR 95 %	1.485-1.493 0.980-0.986	CASrn in Register refers to incompletely defined substance. "60-65 % alpha, 30-35 % beta form". 80-85 % Z versus 15-20 % E (for the alpha) and 75-80 % Z versus 20-25 % E (for the beta) (EFFA, 2013).
09.289 969	alpha-Campholene acetate		3657 36789-59-0	Liquid C <sub>12</sub> H <sub>20</sub> O <sub>2</sub> 196.29	Insoluble Miscible	96 (7 hPa) IR NMR 98 %	1.453-1.460 0.943-0.949	Commercial product (S)-enantiomer (EFFA, 2010a). Register name to be changed to (-)-campholenyl acetate or (S)-campholenyl acetate (EFFA, 2010a).
09.305 1409	beta-Ionyl acetate		3844 10702 22030-19-9	Liquid C <sub>15</sub> H <sub>24</sub> O <sub>2</sub> 236.35	Insoluble Soluble	120 (3 hPa) NMR 92 %	1.474-1.484 0.934-0.944	Acc. to JECFA: Min. assay value is "92 %" and secondary components "2-3 % acetic acid; 1-2 % beta-ionol". Racemate, the double bond is mainly E-isomer: E/Z ratio about 50-70%/30-50%. (EFFA, 2014).

**Table 1:** Specification Summary of the Substances in the JECFA Flavouring Group (JECFA, 2002b)

FL-no JECFA -no	EU Register name	Structural formula	FEMA no CoE no CAS no	Phys.form Mol.formula Mol.weight	Solubility <sup>(a)</sup> Solubility in ethanol <sup>(b)</sup>	Boiling point, °C <sup>(c)</sup> Melting point, °C ID test Assay minimum	Refrac. Index <sup>(d)</sup> Spec.gravity <sup>(e)</sup>	EFSA comments
09.488 966	Ethyl cyclohexanepropionate		2431 2095 10094-36-7	Liquid C <sub>11</sub> H <sub>20</sub> O <sub>2</sub> 184.28	Insoluble Miscible	91 (10 hPa)  NMR 98 %	1.444-1.452 0.926-0.932	
09.534 963	Ethyl cyclohexanecarboxylate		3544 11916 3289-28-9	Liquid C <sub>9</sub> H <sub>16</sub> O <sub>2</sub> 156.22	Insoluble Miscible	82 (16 hPa)  IR NMR 99 %	1.447-1.454 0.966-0.978 (20°)	
09.536 962	Methyl cyclohexanecarboxylate		3568 11920 4630-82-4	Liquid C <sub>8</sub> H <sub>14</sub> O <sub>2</sub> 142.19	Insoluble Miscible	183  IR NMR 98 %	1.439-1.447 0.990-0.999	
09.615 972	p-Menth-1-en-9-yl acetate		3566 10748 28839-13-6	Liquid C <sub>12</sub> H <sub>20</sub> O <sub>2</sub> 196.28	Insoluble Miscible	228-232  NMR 97 %	1.441-1.448 0.931-0.937	Racemate (EFFA, 2010a).
09.712 1022	Santalyl phenylacetate		3008 239 1323-75-7	Liquid C <sub>23</sub> H <sub>30</sub> O <sub>2</sub> 338.49	Insoluble Miscible	328  NMR 98 %	1.525-1.576 1.022-1.029	CASrn in Register refers to incompletely defined substance. 60-65 % alpha-, 30-35 % beta- form. 80-85 % Z versus 15-20 % E (for the alpha) and 75-80 % Z versus 20-25 % E (for the beta) (EFFA, 2013).

(a): Solubility in water, if not otherwise stated.

(b): Solubility in 95 % ethanol, if not otherwise stated.

(c): At 1013.25 hPa, if not otherwise stated.

(d): At 20°C, if not otherwise stated.

(e): At 25°C, if not otherwise stated.

## 5. GENOTOXICITY DATA

### 5.1. Genotoxicity Studies – Text Taken<sup>7</sup> from the JECFA Report (JECFA, 2003)

No data on genotoxicity were available for the JECFA-evaluated substances. As these substances are rapidly metabolised *in vivo* to compounds of lower toxicological potential, the Committee concluded that the monocyclic and bicyclic terpenes with alkyl ring substituents and containing an alcohol, aldehyde or carboxylic acid group would have little genotoxic potential *in vivo*.

### 5.2. Genotoxicity Studies – Text Taken<sup>8</sup> from EFSA FGE.12Rev4 (EFSA CEF Panel, 2013c)

Data are available for the supporting substance 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931], but no studies on genotoxicity are available for the 12 candidate substances. The genotoxic potential of the remaining flavouring substances cannot be fully assessed as the data are limited. However, this does not preclude evaluation of the candidate substances in the present group using the Procedure.

### 5.3. Genotoxicity Studies – Text Taken<sup>9</sup> from EFSA FGE.209 (EFSA CEF Panel, 2011)

The Industry has submitted data concerning genotoxicity studies for 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] (safranal), which is the only substance considered in FGE.209.

#### *In Vitro Data*

*In vitro* genotoxicity assays have been performed on the  $\alpha,\beta$ -unsaturated aldehyde safranal [FL-no: 05.104].

#### *Bacterial Reverse Mutation Assay*

Safranal has been tested for its ability to induce gene mutations in the bacterial reverse mutation assay according to OECD Guideline 471 (Beevers, 2010) (for details see Table 2). The concentrations used in the different experiments were based on concentrations observed to give toxic effects in previous experiments. Positive and negative controls were included in all experiments according to current guidelines.

There were some increases in revertant numbers in TA102 in the absence and presence of S9 in the first experiment, but these were of insufficient magnitude to be considered as evidence of mutagenicity, they were not concentration-related, and were not reproducible in the other experiments. In all other strains there was no evidence of mutagenic activity either in the absence or presence of S9 in any of the experiments.

It is concluded that under the test conditions applied safranal did not induce gene mutations in bacteria.

#### *Micronucleus Assays*

Safranal was evaluated in an *in vitro* micronucleus assay in human peripheral blood lymphocytes for its ability to induce chromosomal damage or aneuploidy in the presence and absence of S9 (Whitwell, 2010). The maximum soluble concentration of 1250  $\mu\text{g/ml}$  was selected as the maximum concentration for the cytotoxicity range finder test. The concentrations in the main tests were based on toxicity shown in this range finding study (for details, see Table 2).

<sup>7</sup> The text is taken verbatim from the indicated reference source, but text related to substances not included in the present FGE has been removed.

<sup>8</sup> The text is taken verbatim from the indicated reference source, but text related to subgroups not included in the present FGE has been removed.

<sup>9</sup> The text is taken verbatim from the indicated reference source, but text related to substances not included in the present FGE has been removed.

At the highest concentration used in the 3 + 21 hours treatment in the presence of S9, a small statistical increase in the frequency of micronucleated binucleate cells (MNBN) was observed, but this was set against a low mean concurrent vehicle control response. This concentration induced 62 % cytotoxicity, and there was no statistically significant increase in MNBN at the next lowest concentration, which induced 42 % cytotoxicity. Therefore, this isolated increase was not considered to be of biological importance. Outside of this isolated observation at a high level of toxicity, no evidence of chromosomal damage or aneuploidy was observed in terms of any increase in the frequency of MNBN in the presence or absence of S9.

It is concluded that under the conditions of this study, safranal did not induce micronuclei in cultured human lymphocytes.

#### *In Vivo Data*

Based on the *in vitro* data available, no *in vivo* data are needed.

#### *Discussion of Mutagenicity/Genotoxicity Data*

2,6,6-Trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] was tested for all three genetic endpoints, gene mutations, structural and numerical chromosomal aberrations. The substance did not induce gene mutations in bacteria and was not clastogenic and/or aneugenic in mammalian cells *in vitro*.

Although this flavouring substance showed evidence of cytotoxicity at high concentrations, it did not induce biologically significant genotoxic responses

For validation and study results, see Table 2.

#### *Conclusion on Genotoxicity and Carcinogenicity*

The *in vitro* genotoxicity data on 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] do not indicate genotoxic potential. 2,6,6-Trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] was evaluated through the Procedure in FGE.73Rev1.

#### **5.4. Genotoxicity Studies – Text Taken<sup>10</sup> from EFSA FGE.207 (EFSA CEF Panel, 2013a)**

The Industry has submitted data concerning genotoxicity studies (EFFA, 2012) for one substance 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] of FGE.19 subgroup 1.1.2 (FGE.201). These data will cover four substances [FL-no: 02.216, 02.217, 09.034 and 09.712] from FGE.19 subgroup 2.1, evaluated in FGE.207.

The new data submitted for 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] covers *in vitro* assays in bacteria and mammalian cell systems.

#### *In Vitro Data*

##### *Bacterial Reverse Mutation Assay*

An Ames assay was conducted in *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA102 to assess the mutagenicity of 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931], both in the absence and in the presence of metabolic activation by S9-mix (from livers of rats induced with Aroclor 1254), in three experiments (King, 2000). An initial experiment was carried out in the absence and presence of S9-mix in the five strains, using final concentrations of 2,6-dimethyl-2,5,7-

<sup>10</sup> The text is taken verbatim from the indicated reference source, but text related to substances not included in the present FGE has been removed.

octatriene-1-ol acetate at 5 - 5000 µg/plate in the presence of S9-mix activation and 5 - 1500 µg/plate in the absence of S9-mix, plus negative (solvent) and positive controls. The standard plate incorporation assay was used. Evidence of toxicity, in terms of a decrease in revertant count, was apparent on all plates treated at 500 µg/plate and above in the absence of S9-mix. In the presence of S9-mix, the test article was toxic at concentrations of 1500 µg/plate and above for strains TA1537 and TA102, and at 5000 µg/plate for strains TA98, TA100, and TA1535. In all cases revertant counts were obtained from at least four different concentrations, and so these data were considered valid for mutation assessment. In the absence of S9-mix activation, no statistically significant increases in revertant numbers were observed in any of the test strains. In the presence of S9-mix activation no statistically significant increases in revertant numbers were observed for strains TA98, TA100, TA1535 or TA1537, but very small increases in revertant numbers were observed in strain TA102 at 15 and 50 µg/plate which, although statistically significant ( $p \leq 0.05$ ), amounted to only 1.17-fold and 1.18-fold increases over background, respectively. Furthermore, no increases were observed at the higher test concentrations of 150 and 500 µg/plate.

In a second confirmatory experiment using the same conditions, no statistically significant increases in revertant numbers were observed at any concentration in any of the strains, either in the presence or absence of S9-mix activation. To further investigate the potential mutagenic effect in strain TA102 in the presence of S9-mix activation, a third experiment was conducted in that strain only. No statistically significant increases in revertant numbers were observed at any concentration tested.

On this basis, the very small increases seen in only a single experiment at the two lower test concentrations in the presence of S9-mix activation in strain TA102 were not reproducible or concentration-related, and were therefore considered to be chance occurrences and not related to treatment with 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] (King, 2000). It was concluded that 2,6-dimethyl-2,5,7-octatriene-1-ol acetate did not induce mutation in five histidine-requiring strains (TA98, TA100, TA1535, TA1537 and TA102) of *S. typhimurium* when tested under the conditions of this study. These conditions included treatments at concentrations up to either the limit of toxicity or 5000 µg/plate (the maximum recommended concentration, according to current regulatory guidelines), in the absence and in the presence of a rat liver metabolic activation system (S9-mix).

### *Micronucleus Assays*

2,6-Dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] was assayed for the induction of chromosome damage and potential aneugenicity in mammalian cells *in vitro* by examining the effect of compound treatment on the frequency of micronuclei in cultured human peripheral blood lymphocytes (whole blood cultures pooled from two healthy male volunteers in two separate experiments) treated in the absence and presence of a metabolising system (S9-mix) from livers of rats induced with Aroclor 1254 (Whitwell, 2012).

2,6-Dimethyl-2,5,7-octatriene-1-ol acetate was added at 48 hours following culture initiation (stimulation by phytohaemagglutinin) either for 3 hours treatment in the absence or presence of S9-mix plus 21 hours recovery, or for 24 hours treatment in the absence of S9-mix without recovery. Cytochalasin B (6 µg/ml) was added at the start of the 24-hour continuous treatment, or at the start of the 21-hour recovery periods following the 3-hour treatments, in order to block cytokinesis and generate binucleate cells for analysis. It remained in the cultures until they were harvested 24 hours after the start of treatment. A preliminary range-finding experiment had been conducted with and without S9-mix treatment in order to determine the effect of treatment upon Replication Index (RI), which was used as a basis for choosing a range of concentrations to be evaluated in Experiments 1 and 2.

In all of the different treatment conditions and separate experiments, frequencies of micronucleated binucleate cells (MNBN) were normal in negative controls and were significantly increased by treatment with the positive control chemical.



In Experiment 1, all three different treatment conditions described above were investigated. In the first treatment condition, 2,6-dimethyl-2,5,7-octatriene-1-ol acetate was added for 3 hours in the absence of S9-mix at concentrations of 70, 85, 100 or 120 µg/mL along with positive and negative controls, followed by 21 hours recovery. No significant increases in the frequency of MNBN were observed relative to concurrent vehicle controls at any of the concentrations analysed. Furthermore, the MNBN cell frequencies in all treated cultures under this treatment condition fell within the 95<sup>th</sup> percentile of the normal range.

In the second treatment condition, following 24 hours continuous treatment at 20, 40 or 60 µg/mL in the absence of S9-mix without recovery, no increases in the frequency of MNBN cells were obtained that were significantly higher ( $p \leq 0.05$ ) than those observed in concurrent controls. Furthermore, the MNBN cell frequencies in all treated cultures under this treatment condition fell within the 95<sup>th</sup> percentile of the normal range.

In the third treatment condition, following 3 hours treatment with 2,6-dimethyl-2,5,7-octatriene-1-ol acetate at concentrations of 120, 140, 180 or 225 µg/mL in the presence of S9-mix, followed by 21 hours recovery, the frequency of MNBN cells were significantly higher ( $p \leq 0.05$ ) than concurrent controls at the top concentration analysed. This concentration induced a 57 % mean level of cytotoxicity, which is close to the recommended upper limit for this test procedure. Furthermore, increases in the frequency of MNBN cells were only seen in one replicate (A) where only 394 binucleate cells could be analysed for this test concentration, where cytotoxicity actually exceeded 60 %, and where examination of the slides indicated a concentration-related effect on cells without intact cytoplasm. This may have resulted in an underestimation of the cytotoxicity, but it was not observed in the other replicate culture (B).

In Experiment 2, the weak induction of micronuclei that was observed in Experiment 1 in the presence of S9-mix was further investigated. Following treatment for 3 hours followed by 21 hours recovery in the presence of S9-mix with 2,6-dimethyl-2,5,7-octatriene-1-ol acetate at concentrations of 119.2, 180, 250 or 290 µg/mL, which induced 5 %, 19 %, 39 % and 54 % cytotoxicity, respectively, small but statistically significant ( $p \leq 0.05$ ) increases in MNBN cell frequencies were observed at the lowest and highest concentrations analysed. At the highest concentration analysed only a single replicate culture gave MNBN cell frequencies that exceeded normal historical control values, and it is also noteworthy that the vehicle control frequency was quite low for this particular experiment which might have contributed to the test outcome. Furthermore, additional analysis of spare slides from the replicate cultures at the lowest and highest concentrations analysed resulted in the overall micronucleus frequencies falling within normal ranges. On this basis, the weak statistical significance observed in the first experiment was not reproduced at higher concentrations and similar levels of toxicity, and was therefore not considered to be of biological relevance.

In conclusion, 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] was not considered to demonstrate induction of micronuclei in a robust study that achieved required levels of toxicity (Whitwell, 2012).

### Conclusion

2,6-Dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931] did not induce any biologically significant increases in bacterial mutation when evaluated in an Ames test in the presence and absence of S9 metabolic activation. It did induce weak genotoxic effects in the *in vitro* micronucleus assay in an initial experiment in the presence of S9-mix at the highest concentration only. In a second experiment, although statistically significant increases were observed at the lowest and highest concentrations tested, these increases fell within the historical control range for the testing laboratory, and were not considered to be biologically important. The Panel therefore concluded that 2,6-dimethyl-2,5,7-octatriene-1-ol acetate [FL-no: 09.931], from subgroup 1.1.2 of FGE.19 (FGE.201), does not give rise to concern with respect to genotoxicity and can accordingly be evaluated through the Procedure. Furthermore, as 2,6-dimethyl-2,5,7-octatriene-1-ol acetate is considered representative for the four

precursors for  $\alpha,\beta$ -unsaturated alicyclic aldehydes [FL-no: 02.216, 02.217, 09.034 and 09.712] from subgroup 2.1 of FGE.19 (FGE.207), the genotoxicity concern can also be lifted for these four substances and accordingly they can also be evaluated through the Procedure as well (in FGE.12Rev4 and FGE.73Rev2).

For a summary of *in vitro* genotoxicity data considered by the EFSA in FGE.207 see Table 3.

### 5.5. Genotoxicity Studies – Text Taken<sup>11</sup> from EFSA FGE.213Rev1 (EFSA CEF Panel, 2014)

The substance [FL-no: 09.305] is a precursor of the ketone beta-ionone [FL-no: 07.008] and the conclusion for the precursor has been based in FGE.213Rev1 on the conclusions drawn for the corresponding ketone [FL-no: 07.008].

#### *Bacterial Reverse Mutation Assay*

beta-Ionone [FL-no: 07.008] was tested in *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537 and TA102 in the absence and presence of S9-mix (Ballantyne, 2011). In the first experiment, the concentrations were 0.32, 1.6, 8, 40, 200, 1000 and 5000  $\mu\text{g}/\text{plate}$  of beta-ionone and the plate incorporation methodology was used. Toxicity ranging from slight thinning of the background lawn to complete killing of the tester strains was observed at 1000 and/or 5000  $\mu\text{g}/\text{plate}$  for all tester strains in the absence and presence of S9-mix. In the second experiment, the concentrations were 10.24, 25.6, 64, 160, 400 and 1000  $\mu\text{g}/\text{plate}$  and the treatments in the presence of S9-mix used the pre-incubation method. Toxicity ranging from thinning of the background lawn and/or reduction in revertant numbers to complete killing of the tester bacteria occurred in all strains at 1000  $\mu\text{g}/\text{plate}$  in the absence and presence of S9-mix and was also seen down to 160 and/or 400  $\mu\text{g}/\text{plate}$  for some individual strains. The study design complied with current recommendations and an acceptable top concentration was achieved. There was clearly no evidence of any mutagenic effect induced by beta-ionone in any of the strains, either in the absence or presence of S9-mix.

#### *Micronucleus Assay*

beta-Ionone [FL-no: 07.008] was evaluated in an *in vitro* micronucleus assay in human peripheral blood lymphocytes for its ability to induce chromosomal damage or aneuploidy in the presence and absence of rat liver S9-mix fraction as an *in vitro* metabolising system. Cells were stimulated for 48 hours with phytohaemagglutinin to produce exponentially growing cells, and then treated for 3 hours (followed by 21 hours recovery) with 0, 30, 50 or 60  $\mu\text{g}/\text{ml}$  of beta-ionone in the absence of S9-mix and 0, 80, 100 or 120  $\mu\text{g}/\text{ml}$  in the presence of S9-mix. The levels of cytotoxicity (reduction in replication index) at the top concentrations were 52 and 59 %, respectively. In a parallel assay, cells were treated for 24 hours with 0, 5, 15, and 17.50  $\mu\text{g}/\text{ml}$  of beta-ionone in the absence of S9-mix with no recovery period. The top concentration induced 58 % cytotoxicity. There were 2 replicate cultures per treatment and 1000 binucleate cells per replicate were scored for micronuclei. Thus, the study design complies with current recommendations (OECD Guideline 487), and acceptable levels of cytotoxicity were achieved at the top concentrations used in all parts of the study. Treatment of cells with beta-ionone for 3 hours with a 21 hours recovery period showed an increase in the frequency of MNBN cells in one single replicate at the concentration of 30 and 120  $\mu\text{g}/\text{ml}$  (0.9 % and 1.5 % respectively) in the absence and presence of S9-mix, respectively. At 30  $\mu\text{g}/\text{ml}$ , the lowest concentration tested in the absence of S9-mix, the increase in the frequency of MNBN cells was slightly above the 95 % confidence interval of the historical control range (0.2 - 0.8 %). Also in the presence of S9-mix, one replicate of the lowest concentration tested (80  $\mu\text{g}/\text{ml}$ ) had an increase in the frequency of MNBN cells at the upper limit of the 95 % confidence interval of the historical control range (0.10 - 1.10 %) but did not reach statistical significance. To ensure that these single occurrences are random an additional 1000 binucleate cells were scored from the concurrent controls, 80 and 120

<sup>11</sup> The text is taken verbatim from the indicated reference source, but text related to substances not included in the present FGE has been removed.

µg/ml cultures. The scoring of further cells resulted in overall mean frequencies of MNBN cells that were not significantly different from concurrent controls and fell below the upper 95 % confidence interval of the normal control range (re-calculated due to change of stain), and therefore showed that the earlier increases were due to chance. It was concluded that beta-ionone [FL-no: 07.008] did not induce micronuclei up to toxic concentrations when assayed in cultured human peripheral lymphocytes for 3 + 21 hours in the absence and presence of S9-mix or when incubated for 24 + 0 hours in the absence of S9-mix (Stone, 2011).

### Conclusion

The evidence from *in vitro* genotoxicity data for the substance, beta-ionone [FL-no: 07.008] does not indicate a genotoxic potential. Therefore, the substance [FL-no: 09.305] can be evaluated through the Procedure.

For a summary of *in vitro* genotoxicity data considered by the EFSA in FGE.213Rev1, see Table 4.

## 5.6. EFSA Considerations

The present revision of FGE.73, FGE.73Rev 3, contains 19 substances, which includes the assessment of one additional flavouring substance, beta-ionyl acetate [FL-no: 09.305]. This substance has a structural alert for genotoxicity, but this concern has been alleviated as described in FGE.213Rev1 (EFSA CEF Panel, 2014), where the Panel based on submitted data on the representative substance beta-ionone [FL-no: 07.008] concluded that it does not give rise to concern with respect to genotoxicity. Therefore, beta-ionyl acetate [FL-no: 09.305] can be evaluated through the Procedure in this FGE.73Rev3. In revision 2 of FGE.73, santalyl acetate [FL-no: 09.034] and santalyl phenylacetate [FL-no: 09.712] were evaluated through the Procedure, due to that concern for genotoxicity for these two substances had been evaluated and ruled out in FGE.207. No genotoxicity data are available for the remaining 16 JECFA evaluated substances. However, this will not preclude the evaluation of these substances using the Procedure, and the Panel agreed with the JECFA that these 16 substances also can be evaluated using the Procedure.

## 6. APPLICATION OF THE PROCEDURE

### 6.1. Application of the Procedure to 17 Alicyclic Primary Alcohols, Aldehydes, Acids and Related Esters, One Ester of a Phenethyl Derivative and One Ester of a Monocyclic Alcohol by the JECFA (JECFA, 2002a; JECFA, 2005b)

According to the JECFA all 19 substances belong to structural class I using the decision tree approach presented by Cramer et al. (Cramer et al., 1978).

The JECFA concluded for 16 of the alicyclic primary alcohols, aldehydes, acids and related esters, and for santalyl phenylacetate [FL-no: 09.712], an ester of the phenethyl derivatives, and for beta-ionyl acetate [FL-no: 09.305] at step A3 in the JECFA Procedure – i.e. the substances are expected to be metabolised to innocuous products (step 2) and the intakes for all substances are below the thresholds for their structural class I (step A3).

The JECFA concluded for 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] (safranal) at step B4 in the JECFA Procedure – i.e. the substance cannot be expected to be metabolised to innocuous products (step 2) and an adequate NOAEL exists to provide a margin of safety (step B4). This evaluation was reached by the following procedure: Step B3. The daily per capita intake of the monocyclic substance with two endocyclic double-bonds evaluated at this step, 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104], was below the threshold for daily human intake of compounds of structural class I, and its evaluation therefore proceeded to step B4.

Step B4. As the agent evaluated at this step, 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] (safranal), is structurally related to perillyl alcohol [FL-no: 02.060], data on the toxicity of

perillyl alcohol were used to evaluate its safety. Perillyl alcohol given by intragastric gavage changed the weights of several organs in female rats when given at 400 mg/kg bw per day, but not at 120 mg/kg bw per day, in a 90-day study; changes in organ weights were not reported in male rats. Doses of 40, 120 and 400 mg/kg bw per day produced hyperexcitability and salivation, which the authors considered may have been due to its irritating properties (National Cancer Institute, 1996). A daily dose of 120 mg/kg bw was well tolerated by dogs in a 90-day study (National Cancer Institute, 1996). The daily intake of 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] (safranal) is 0.058 microg/kg bw in Europe and 0.001 microg/kg bw in the USA. The margin of safety between these intakes and 120 mg/kg bw per day is > 2000000. The compound also shares structural similarities with alpha-ionone and beta-ionone [FL-no: 07.007] and [FL-no: 07.008], which were evaluated by the Committee at its fifty-first meeting (JECFA, 2000). The NOELs for these compounds were 10 mg/kg bw per day in a 90-day study in rats, providing a margin of safety of about 200000. Therefore, 2,6,6-trimethylcyclohexa-1,3-diene-1-carbaldehyde [FL-no: 05.104] (safranal) would not be a safety concern.

In conclusion, the JECFA evaluated all 19 substances as to be of no safety concern at the estimated levels of intake as flavouring substances based on the MSDI approach.

The evaluations of the 19 alicyclic alcohols, aldehydes, acids and related esters are summarised in Table 5.

## **6.2. Application of the Procedure to Ten Primary Saturated or Unsaturated Alicyclic Alcohol, Aldehyde, and Esters by EFSA in FGE.12Rev4 (EFSA CEF Panel, 2013c)**

Twelve candidate substances were evaluated in FGE.12Rev4. All 12 substances were classified into structural class I, using the decision tree approach presented by Cramer et al. (Cramer et al., 1978).

It was anticipated that all 12 substances will be metabolised to innocuous products at the estimated levels of intake and accordingly proceed via the A-side of the Procedure. The estimated daily *per capita* intakes of the 12 substances range from 0.011 to 43 µg, which is below the threshold of concern of 1800 µg/person/day for structural class I.

The Panel concluded all substances in FGE.12Rev4 at step A3 as to be of no safety concern at the estimated levels of intake as flavouring substances based on the MSDI approach.

The stepwise evaluations of the 12 substances are summarised in Table 6.

## **6.3. EFSA Considerations**

The Panel agrees with the application of the Procedure as performed by the JECFA for the 19 substances in the groups of alicyclic alcohols, aldehydes, acids and related esters.

The Panel noted that one substance [FL-no: 05.123] has a terminal double bond. Although theoretically, the double bond may be oxidised to give reactive epoxides, it is expected that for this substance, the metabolism via this pathway is negligible, since the terminal double bond is present in a molecule that has an aldehyde function at the end distal from the double bond. The aldehyde function is expected to be readily attacked by oxidation processes, ultimately yielding unsaturated carboxylic acids. Biochemical attack of these carboxylic acids via e.g. beta-oxidation or conjugation with glucuronic acid is expected to be much more efficient and rapid than microsomal oxidation.

## **CONCLUSION**

In Flavouring Group Evaluation 73, Revision 2 (FGE.73Rev2) the EFSA considered 17 flavouring substances from a group of 26 alicyclic primary alcohols, aldehydes, acids and related esters and one phenethyl ester evaluated by the JECFA at the 59<sup>th</sup> meeting in 2002.

The present revision of FGE.73, FGE.73 Rev3, includes the consideration of one additional substance beta-ionyl acetate [FL-no: 09.305] evaluated by JECFA at the 63<sup>rd</sup> meeting. This substance was considered with respect to genotoxicity in FGE.213Rev1, and the Panel concluded that the data available ruled out the concern for genotoxicity and thus concluded that the substances can be evaluated through the Procedure.

Therefore, the present revision of FGE.73Rev3, considers 19 flavouring substances evaluated by the JECFA.

The Panel concluded that the 19 substances are structurally related to the group of 12 primary saturated or unsaturated alicyclic alcohol, aldehyde, and esters evaluated by EFSA in the Flavouring Group Evaluation 12, Revision 4 (FGE.12Rev4).

The Panel agrees with the application of the Procedure as performed by the JECFA for the 19 substances considered in this FGE.

For all 19 substances evaluated through the Procedure use levels are needed to calculate the mTAMDI in order to identify those flavouring substances that need more refined exposure assessment and to finalise the evaluation.

In order to determine whether the conclusion for the JECFA evaluated substances can be applied to the materials of commerce, it is necessary to consider the available specifications.

Adequate specifications including complete purity criteria and identity tests are available for all 19 JECFA evaluated substances.

Thus, for 19 substances [FL-no: 02.114, 02.141, 05.098, 05.104, 05.112, 05.119, 05.123, 08.034, 08.060, 08.067, 09.028, 09.034, 09.289, 09.305, 09.488, 09.534, 09.536, 09.615 and 09.712] the Panel agrees with the JECFA conclusion “No safety concern at estimated levels of intake as flavouring substances” based on the MSDI approach.

## SUMMARY OF GENOTOXICITY DATA

**Table 2:** Genotoxicity Data (*in vitro*) EFSA / FGE.209 (EFSA CEF Panel, 2011)

Chemical Name FL-no	Test System <i>in vitro</i>	Test Object	Concentrations of Test Substance	Result	Reference	Comments
2,6,6-Trimethylcyclohexa- 1,3-diene-1-carbaldehyde [05.104]	Reverse Mutation	<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 and TA102	1.6, 8, 40, 200, 1000, 5000 µg/plate	Negative <sup>(d)</sup>	(Beevers, 2010)	Valid study. First experiment: Standard plate ± S9. Toxicity was observed in all strains with and without S9 at 5000 µg/plate and in TA1537 and TA102 with S9 at 1000 µg/plate.
		<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 and TA102	125, 250, 500, 1000, 2000, 5000 µg/plate	Negative <sup>(d)</sup>	(Beevers, 2010)	Valid study. Second experiment: Standard plate without S9. Toxicity was observed at 2000 µg/plate and above.
		<i>S. typhimurium</i> TA98, TA100 and TA1535	62.5, 125, 250, 500, 1000, 2000, 5000 µg/plate	Negative <sup>(d)</sup>	(Beevers, 2010)	Valid study. Second experiment with S9 and pre-incubation: Toxicity was observed at 500 µg/plate and above.
		<i>S. typhimurium</i> TA1537 and TA102	62.5, 125, 250, 500, 1000, 2000 µg/plate	Negative <sup>(d)</sup>	(Beevers, 2010)	Valid study. Second experiment with S9 and pre-incubation: Toxicity was observed at 500 µg/plate and above.
		<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 and TA102	15.625, 31.25, 62.5, 125, 250, 500 µg/plate	Negative <sup>(d)</sup>	(Beevers, 2010)	Valid study. Third experiment with S9 and pre-incubation: Toxicity was observed at 250 µg/plate and above.
	Micronucleus induction	Human peripheral blood lymphocytes	0, 40, 60, 90 µg/ml <sup>(a)</sup> 0, 80, 100, 120, 140 µg/ml <sup>(b)</sup> 0, 4, 8, 12 µg/ml <sup>(c)</sup>	Negative <sup>(e)</sup>	(Whitwell, 2010)	Valid study.

(a): 3 hours treatment 21 hours recovery without S9.

(b): 3 hours treatment 21 hours recovery with S9.

(c): 24 hours treatment no recovery without S9.

(d): The assays were performed according to OECD Guideline 471 and in compliance with GLP.

(e): This assay is performed in accordance with OECD Guideline 487.

**Table 3:** Summary of Additionally Genotoxicity Data for [FL-no: 09.931] of Subgroup 1.1.2 used in FGE.207 (EFSA CEF Panel, 2013a)

Chemical Name [FL-no:]	Test System <i>in vitro</i>	Test Object	Concentrations of Substance and Test Conditions	Result	Reference	Comments	
2,6-Dimethyl-2,5,7- octatriene-1-ol acetate [09.931]	Reverse Mutation	<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 and TA102	5 - 1500 µg/plate <sup>(a,c)</sup> 5 - 5000 µg/plate <sup>(b,c)</sup>	Negative <sup>(a,c)</sup> Equivocal	(King, 2000)	Reliable without restriction. GLP study in compliance with OECD Guideline 471. A small increase in TA102 revertant numbers was seen at 15 and 50 µg/plate in the presence of S9-mix, but not at higher concentrations.	
		<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 and TA102	5 - 1500 µg/plate <sup>(a,c)</sup> 5 - 5000 µg/plate <sup>(b,c)</sup>	Negative <sup>(a,c)</sup> Negative <sup>(b,c)</sup>			The small increase in TA102 revertant numbers seen in the first experiment at 15 and 50 µg/plate in the presence of S9-mix was not reproduced in the second experiment.
		<i>S. typhimurium</i> TA102	5 - 1500 µg/plate <sup>(b,c)</sup>	Negative			The small increase in TA102 revertant numbers seen in the first experiment at 15 and 50 µg/plate in the presence of S9-mix was not reproduced in the third experiment.
	Micronucleus Assay	Human peripheral blood lymphocytes (Male Donors)	70 - 120 µg/ml <sup>(a,d)</sup> 120 - 225 µg/mL <sup>(b,d)</sup> 20 - 60 µg/mL <sup>(a,e)</sup> 119.2 - 290 µg/mL <sup>(b,d)</sup>	Weak positive +S9; Re-test within normal values	(Whitwell, 2012)	Reliable without restriction. GLP study in compliance with OECD Guideline 487. Weak evidence of inducing micronuclei in the presence of S9-mix in a first experiment (increases only in one culture). A re-test under the same conditions and using a higher top concentration resulted in MNB frequencies within the historical negative control range at 95 <sup>th</sup> percentile, but were statistically significant due to low vehicle control values.	

(a): Without S9-mix metabolic activation.

(b): With S9-mix metabolic activation.

(c): Plate incorporation method.

(d): 3-hour incubation with 21-hour recovery period.

(e): 24-hour incubation with no recovery period.

**Table 4:** Genotoxicity Data (*in vitro*) EFSA / FGE.213Rev1 (EFSA CEF Panel, 2014)

Chemical Name [FL-no:]	Test System <i>in vitro</i>	Test Object	Concentrations of Substance and Test Conditions	Result	Reference	Comments
β-Ionone [07.008]	Gene mutation (preincubation)	<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537	1 - 180 µg/plate	Negative <sup>(a)</sup>	(Mortelmans et al., 1986)	Valid.
	Gene mutation	<i>S. typhimurium</i> TA98, TA100, TA1535, TA1537	3 mmol/plate	Negative <sup>(a)</sup>	(Florin et al., 1980)	Insufficient validity (spot test, not according to OECD Guideline, methods and results insufficiently reported).
	Reverse Mutation	<i>S. typhimurium</i> TA98, TA100, TA102, TA1535 and TA1537	0.32 - 5000 µg/plate <sup>(a,b)</sup>	Negative	(Ballantyne, 2011)	Evidence of toxicity was observed at 1000 and/or 5000 µg/plate in the absence and presence of S9-mix. Study design complied with current recommendations. Acceptable top concentration was achieved.
		<i>S. typhimurium</i> TA98, TA100, TA102, TA1535 and TA1537	10.24 - 1000 µg/plate <sup>(b,d) or (c,e)</sup>	Negative		Evidence of toxicity was observed in all strains at 1000 µg/plate and in strains TA100 and TA102 as low as 160 µg/plate in the absence and presence of S9-mix. Study design complied with current recommendations. Acceptable top concentration was achieved.
Micronucleus Assay	Human peripheral blood lymphocytes	30 - 60 µg/mL <sup>(d,f)</sup> 80 - 120 µg/mL <sup>(e,f)</sup> 5 - 17.5 µg/mL <sup>(d,g)</sup>	Negative	(Stone, 2011)	The top concentrations induced 50-60 % toxicity. The MNBN cell frequencies in all treated cultures fell within the normal range. Complies with draft OECD Guideline 487.	

(a): With and without S-9 metabolic activation.

(b): Plate incorporation method.

(c): Pre-incubation method.

(d): Without S-9 metabolic activation.

(e): With S-9 metabolic activation.

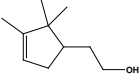
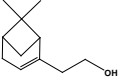
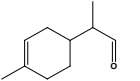
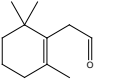
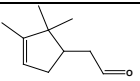
(f): 3-hour incubation with 21-hour recovery period.

(g): 24-hour incubation with no recovery period.

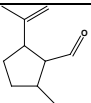
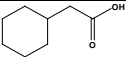
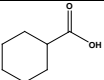
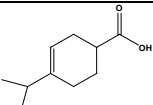
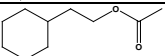


## SUMMARY OF SAFETY EVALUATIONS

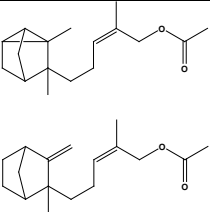
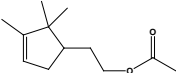
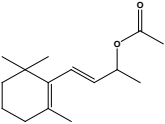
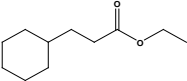
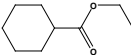
**Table 5:** Summary of Safety Evaluation by the JECFA (JECFA, 2002a; JECFA, 2005b)

FL-no JECFA- no	EU Register name	Structural formula	EU MSDI <sup>(a)</sup> US MSDI ( $\mu\text{g}/\text{capita}/\text{day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	EFSA conclusion on the named compound (Procedure steps, intake estimates, NOAEL, genotoxicity)	EFSA conclusion on the material of commerce
02.114 970	2-(2,2,3-Trimethylcyclopent-3-enyl)ethan-1-ol		0.012 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
02.141 986	2-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethan-1-ol		33 0.01	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
05.098 971	p-Menth-1-en-9-al		0.12 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
05.112 978	2,6,6-Trimethylcyclohex-1-en-1-acetaldehyde		0.24 2	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	According to JECFA: Min. assay value is "92 %". Secondary components $\beta$ -cyclocitral (2-3 %), $\beta$ -ionone (0.5-1 %), methyl $\beta$ -homocyclogeranate (2-4 %), ethyl $\beta$ -homocyclogeranate (0.6-1 %) (EFFA, 2010a). No safety concern at the estimated level of intake based on the MSDI approach.
05.119 967	2,2,3-Trimethylcyclopent-3-en-1-yl acetaldehyde		5 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	CASrn in Register refers to (R)-isomer. Register name to be changed to (1R) 2,2,3-Trimethylcyclopent-3-en-1-yl acetaldehyde. No safety

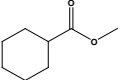
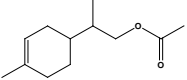
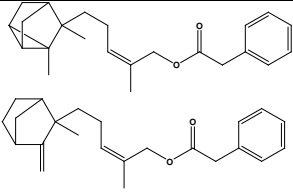

**Table 5:** Summary of Safety Evaluation by the JECFA (JECFA, 2002a; JECFA, 2005b)

FL-no JECFA- no	EU Register name	Structural formula	EU MSDI <sup>(a)</sup> US MSDI ( $\mu\text{g/capita/day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	EFSA conclusion on the named compound (Procedure steps, intake estimates, NOAEL, genotoxicity)	EFSA conclusion on the material of commerce
05.123 968	5-Isopropenyl-2-methylcyclopentanecarboxaldehyde		0.012 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	concern at the estimated level of intake based on the MSDI approach.  CASrn in Register refers to (1R,2R,5S)-isomer. Register name to be changed to (1R,2R,5S) 5-Isopropenyl-2-methylcyclopentanecarboxaldehyde. No safety concern at the estimated level of intake based on the MSDI approach.
08.034 965	Cyclohexylacetic acid		0.12 0.4	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
08.060 961	Cyclohexanecarboxylic acid		0.061 4	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
08.067 976	1,2,5,6-Tetrahydrocuminic acid		0.012 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
09.028 964	2-Cyclohexylethyl acetate		0.97 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.

**Table 5:** Summary of Safety Evaluation by the JECFA (JECFA, 2002a; JECFA, 2005b)

FL-no JECFA- no	EU Register name	Structural formula	EU MSDI <sup>(a)</sup> US MSDI ( $\mu\text{g}/\text{capita}/\text{day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	EFSA conclusion on the named compound (Procedure steps, intake estimates, NOAEL, genotoxicity)	EFSA conclusion on the material of commerce
09.034 985	Santalyl acetate		0.1 0.01	Class I A3: Intake below threshold	d	Evaluated in FGE.207, genotoxicity concern could be ruled out. No safety concern at the estimated level of intake based on the MSDI approach.	CASrn in Register refers to incompletely defined substance According to JECFA: Min. assay value is "95%" and secondary components "60-65% alpha, 30-35% beta form" No safety concern at the estimated level of intake based on the MSDI approach.
09.289 969	alpha-Campholene acetate		0.061 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	Register name to be changed to (-)-campholenyl acetate or (S)-campholenyl acetate. No safety concern at the estimated level of intake based on the MSDI approach.
09.305 1409	beta-Ionyl acetate		3.3 9	Class I A3: Intake below threshold	d	Evaluated in FGE.213Rev1, genotoxicity concern could be ruled out.	Acc. to JECFA: Min. assay value is "92 %" and secondary components "2-3 % acetic acid; 1-2 % beta- ionol". Racemate, the double bond is mainly E-isomer: E/Z ratio about 50-70%/30-50%. (EFFA, 2014). No safety concern at the estimated level of intake based on th
09.488 966	Ethyl cyclohexanepropionat e		0.12 0.1	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
09.534 963	Ethyl cyclohexanecarboxyla		0.24 0.1	Class I A3: Intake below	d	No safety concern at the estimated level of	No safety concern at the estimated level of intake

**Table 5:** Summary of Safety Evaluation by the JECFA (JECFA, 2002a; JECFA, 2005b)

FL-no JECFA- no	EU Register name	Structural formula	EU MSDI <sup>(a)</sup> US MSDI ( $\mu\text{g}/\text{capita}/\text{day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	EFSA conclusion on the named compound (Procedure steps, intake estimates, NOAEL, genotoxicity)	EFSA conclusion on the material of commerce
	te			threshold		intake based on the MSDI approach.	based on the MSDI approach.
09.536 962	Methyl cyclohexanecarboxyla te		0.073 0.01	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
09.615 972	p-Menth-1-en-9-yl acetate		0.85 ND	Class I A3: Intake below threshold	d	No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.
09.712 1022	Santalyl phenylacetate		0.029 1	Class I A3: Intake below threshold	d	Evaluated in FGE.207, genotoxicity concern could be ruled out. No safety concern at the estimated level of intake based on the MSDI approach.	60-65 % alpha-, 30-35 % beta- form. 80-85 % Z versus 15-20 % E (for the alpha) and 75-80 % Z versus 20-25 % E (for the beta) (EFSA, 2013). No safety concern at the estimated level of intake based on the MSDI approach.
05.104 977	2,6,6- Trimethylcyclohexa- 1,3-diene-1- carbaldehyde		3.5 0.07	Class I B3: Intake below threshold, B4: Adequate NOAEL exists	d	Evaluated in FGE.209, genotoxicity concern could be ruled out. No safety concern at the estimated level of intake based on the MSDI approach.	No safety concern at the estimated level of intake based on the MSDI approach.

(a): EU MSDI: Amount added to food as flavour in ( $\text{kg} / \text{year}$ )  $\times 10^9 / (0.1 \times \text{population in Europe} (= 375 \times 10^6) \times 0.6 \times 365) = \mu\text{g}/\text{capita}/\text{day}$ .

(b): Thresholds of concern: Class I = 1800  $\mu\text{g}/\text{person}/\text{day}$ , Class II = 540  $\mu\text{g}/\text{person}/\text{day}$ , Class III = 90  $\mu\text{g}/\text{person}/\text{day}$ .

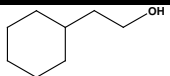
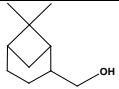
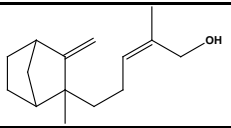
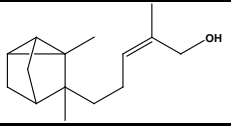
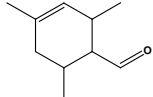
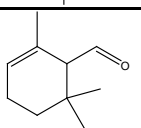
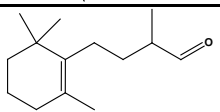
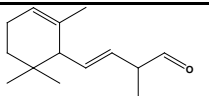
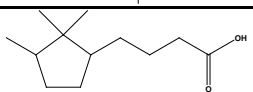
(c): Procedure path A substances can be predicted to be metabolised to innocuous products. Procedure path B substances cannot.

(d): No safety concern based on intake calculated by the MSDI approach of the named compound.

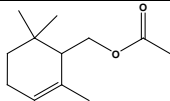
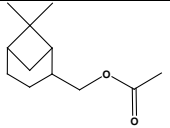
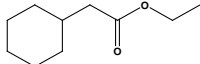
(e): Data must be available on the substance or closely related substances to perform a safety evaluation.

ND: Not determined.

**Table 6:** Summary of Safety Evaluation by the EFSA (FGE.12Rev4) (EFSA CEF Panel, 2013c)

FL-no	EU Register name	Structural formula	MSDI <sup>(a)</sup> ( $\mu\text{g}/\text{capita}/\text{day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	Outcome on the material of commerce [ <sup>(f)</sup> , <sup>(g)</sup> or <sup>(h)</sup> ]	Evaluation remarks
02.134	2-Cyclohexylethan-1-ol		0.011	Class I A3: Intake below threshold	d	f	
02.186	Myrtanol		0.37	Class I A3: Intake below threshold	d	f	
02.216	12-beta-Santalen-14-ol		0.085	Class I A3: Intake below threshold	d	f	
02.217	12-alpha-Santalen-14-ol		0.11	Class I A3: Intake below threshold	d	f	
05.157	Isocyclocitral		0.011	Class I A3: Intake below threshold	d	f	
05.182	2,6,6-Trimethylcyclohex-2-ene-1-carboxaldehyde		0.061	Class I A3: Intake below threshold	d	f	
05.183	4-(2,6,6-Trimethylcyclohexenyl)-2-methylbutanal		0.012	Class I A3: Intake below threshold	d	f	
05.198	alpha-Methyl ional		0.011	Class I A3: Intake below threshold	d	f	
08.135	4-(2,2,3-Trimethylcyclopentyl)butanoic acid		43	Class I A3: Intake below threshold	d	f	

**Table 6:** Summary of Safety Evaluation by the EFSA (FGE.12Rev4) (EFSA CEF Panel, 2013c)

FL-no	EU Register name	Structural formula	MSDI <sup>(a)</sup> ( $\mu\text{g}/\text{capita}/\text{day}$ )	Class <sup>(b)</sup> Evaluation procedure path <sup>(c)</sup>	Outcome on the named compound [ <sup>(d)</sup> or <sup>(e)</sup> ]	Outcome on the material of commerce [ <sup>(f)</sup> , <sup>(g)</sup> or <sup>(h)</sup> ]	Evaluation remarks
09.342	Cyclogeranyl acetate		0.24	Class I A3: Intake below threshold	d	f	
09.670	Myrtanyl acetate		0.58	Class I A3: Intake below threshold	d	f	
09.829	Ethyl cyclohexyl acetate		0.61	Class I A3: Intake below threshold	d	f	

(a): EU MSDI: Amount added to food as flavour in ( $\text{kg} / \text{year}$ )  $\times 10^9 / (0.1 \times \text{population in Europe} (= 375 \times 10^6) \times 0.6 \times 365) = \mu\text{g}/\text{capita}/\text{day}$ .

(b): Thresholds of concern: Class I = 1800  $\mu\text{g}/\text{person}/\text{day}$ , Class II = 540  $\mu\text{g}/\text{person}/\text{day}$ , Class III = 90  $\mu\text{g}/\text{person}/\text{day}$ .

(c): Procedure path A substances can be predicted to be metabolised to innocuous products. Procedure path B substances cannot.

(d): No safety concern based on intake calculated by the MSDI approach of the named compound.

(e): Data must be available on the substance or closely related substances to perform a safety evaluation.

(f): No safety concern at the estimated level of intake of the material of commerce meeting the specification requirement (based on intake calculated by the MSDI approach).

(g): Tentatively regarded as presenting no safety concern (based on intake calculated by the MSDI approach) pending further information on the purity of the material of commerce and/or information on stereoisomerism.

(h): No conclusion can be drawn due to lack of information on the purity of the material of commerce.

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## ABBREVIATIONS

BW	Body Weight
CAS	Chemical Abstract Service
CEF	Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids
CoE	Council of Europe
EFFA	European Flavour and Fragrance Association
EFSA	The European Food Safety Authority
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FEMA	Flavor and Extract Manufacturers Association
FGE	Flavouring Group Evaluation
FLAVIS (FL)	Flavour Information System (database)
GLP	Good laboratory practice
ID	Identity
IR	Infrared spectroscopy
JECFA	The Joint FAO/WHO Expert Committee on Food Additives
MNBN	Micronucleated Binucleate cells
MSDI	Maximised Survey-derived Daily Intake
mTAMDI	Modified Theoretical Added Maximum Daily Intake
No	Number
NOAEL	No Observed Adverse Effect Level
OECD	Organization for Economic Cooperation and Development
PCE	Polychromatic erythrocyte
RI	Replication Index
SCF	Scientific Committee on Food
WHO	World Health Organization