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SCIENTIFIC OPINION

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Safety and efficacy of a feed additive consisting of an essential oil obtained from the fruit of *Carum carvi* L. (caraway oil) for all animal species (FEFANA asbl)

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Abstract

Following a request from the European Commission, EFSA was asked to deliver a scientific opinion on the safety and efficacy of an essential oil obtained from the fruit of *Carum carvi* L. (caraway oil), when used as a sensory additive in feed and water for drinking for all animal species. The EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) Panel concluded that the use of caraway oil is of no concern up to the following concentrations in complete feed: 9 mg/kg for chickens for fattening, 13 mg/kg for laying hens, 12 mg/kg for turkeys for fattening, 16 mg/kg for piglets, 19 mg/kg for pigs for fattening, 24 mg/kg for sows, 35 mg/kg for veal calves (milk replacer), 11 mg/kg for cattle for fattening, 10 mg/kg for dairy cows, sheep, goats, horses and rabbits, 25 mg/kg for salmonids and dogs. These conclusions were extrapolated to other physiologically related species. For cats, ornamental fish and other species, no conclusion can be drawn. The use of caraway oil in animal feed under the proposed conditions of use is safe for the consumer and the environment. The additive under assessment should be considered as an irritant to skin and eyes, and as a respiratory and skin sensitiser. When handling the essential oil, exposure of unprotected users to perillaldehyde may occur. Therefore, to reduce the risk, the exposure of the users should be minimised. Since *C. carvi* and its preparations were recognised to flavour food and its function in feed would be essentially the same as that in food, no further demonstration of efficacy was considered necessary.

KEYWORDS

caraway oil, *Carum carvi* L., *d*-carvone, *d*-limonene, flavouring compounds, perillaldehyde, safety, sensory additives

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1 | INTRODUCTION

1.1 | Background and Terms of Reference

Regulation (EC) No 1831/2003[1] establishes the rules governing the Community authorisation of additives for use in animal nutrition. In particular, Article 4(1) of that Regulation lays down that any person-seeking authorisation for a feed additive or for a new use of feed additive shall submit an application in accordance with Article 7. In addition, Article 10(2) of that Regulation specifies that for existing products within the meaning of Article 10(1), an application shall be submitted in accordance with Article 7, within a maximum of 7 years after the entry into force of this Regulation.

The European Commission received a request from Feed Flavourings Authorisation Consortium European Economic Interest Grouping (FFAC EEIG)[2] for authorisation/re-evaluation of 29 additives (namely dill herb oil, dill seed extract, dill tincture, dong quai tincture, celery seed oil, celery seed extract (oleoresin), celery tincture, hares ear tincture, caraway seed oil, caraway oleoresin/extract, coriander oil, cumin oil, taiga root extract (solvent-based, sb), taiga root tincture, fennel oil, fennel tincture, common ivy extract (sb), opoponax oil, ginseng tincture, parsley oil, parsley tincture, anise oil, anise tincture, ajowan oil, *Ferula assa-foetida* oil, anise star oil, anise star tincture, anise star terpenes and omicha tincture) belonging to botanically defined group (BDG) 02 – Apiales/Austrobaileyales when used as feed additives for all animal species (category: sensory additives; functional group: flavourings). During the assessment, the applicant withdrew the application for nine additives.[3] These additives were deleted from the register of feed additives.[4] During the course of the assessment, this application was split and the present opinion covers only one out of the 20 remaining additives under application: caraway oil from the dried fruit of *Carum carvi* L. for all animal species.

The remaining 19 additives belonging to botanically defined group (BDG) 02 – Apiales/Austrobaileyales under application are assessed in separate opinions.

According to Article 7(1) of Regulation (EC) No 1831/2003, the Commission forwarded the application to the European Food Safety Authority (EFSA) as an application under Article 4(1) (authorisation of a feed additive or new use of a feed additive) and under Article 10(2) (re-evaluation of an authorised feed additive). EFSA received directly from the applicant the technical dossier in support of this application. The particulars and documents in support of the application were considered valid by EFSA as of 24 June 2019.

According to Article 8 of Regulation (EC) No 1831/2003, EFSA, after verifying the particulars and documents submitted by the applicant, shall undertake an assessment in order to determine whether the feed additive complies with the conditions laid down in Article 5. EFSA shall deliver an opinion on the safety for the target animals, consumer, user and the environment and on the efficacy of the feed additive consisting of an essential oil from the dried fruit of *Carvum carvi* L. (caraway oil), when used under the proposed conditions of use (see **Section 3.3.3**).

1.2 | Additional information

An essential oil from the dried fruit of *Carum carvi* L. (caraway oil) is currently authorised as a feed additive according to the entry in the European Union Register of Feed Additives pursuant to Regulation (EC) No 1831/2003 (2b natural products – botanically defined). It has not been assessed as a feed additive in the European Union.

2 | DATA AND METHODOLOGIES

2.1 | Data

The present assessment is based on data submitted by the applicant in the form of a technical dossier[5] in support of the authorisation request for the use of an essential oil from the dried fruit of *Carum carvi* L. (caraway oil), as a feed additive. The dossier was received on 22 May 2024 and the general information and supporting documentation are available at https://open.efsa.europa.eu/questions/EFSA-Q-2024-00305.[6]

The FEEDAP Panel used the data provided by the applicant together with data from other sources, such as previous risk assessments by EFSA or other expert bodies, peer-reviewed scientific papers, other scientific reports and experts' knowledge, to deliver the present output.

[1]Regulation (EC) No 1831/2003 of the European Parliament and of the council of 22 September 2003 on the additives for use in animal nutrition. OJ L 268, 18.10.2003, p. 29.
[2]On 13/03/2013, EFSA was informed by the applicant that the applicant company changed to FEFANA asbl, Avenue Louise 130 A, Box 1, 1050 Brussels, Belgium.
[3]Dill seed extract, celery seed extract (oleoresin), caraway oleoresin/extract, opoponax oil (27 February 2019); parsley oil, hares ear tincture, taiga root extract (sb), ajowan oil (2 April 2020); celery tincture (9 December 2020).
[4]Register of feed additives, Annex II, withdrawn by OJ L162, 10.05.2021, p. 5.
[5]Dossier reference: FAD-2010-0221.
[6]The original application EFSA-Q-2010-01286 was split on 22/05/2024 and a new EFSA-Q-2024-00305 was generated.

Many of the components of the essential oil under assessment have been already evaluated by the FEEDAP Panel as chemically defined flavourings (CDGs). The applicant submitted a written agreement to use the data submitted for the assessment of chemically defined flavourings (dossiers, publications and unpublished reports) for the risk assessment of preparations belonging to BDG 2, including the one under assessment.[7]

EFSA has verified the European Union Reference Laboratory (EURL) report as it relates to the methods used for the control of the active substance/agent in the additive. The evaluation report is related to the methods of analysis for each feed additive included in BDG 02 (Apiales and Austrobaileyales).[8] During the assessment, the EURL issued a partial report[9] and an addendum of the report.[10] In particular, for the characterisation of *caraway seed oil*, the EURL report recommended a method based on gas chromatography coupled with flame ionisation detection (GC-FID) for the quantification of the phytochemical markers *carvone* and *limonene* in *caraway seed oil*.

2.2 | Methodologies

The approach followed by the FEEDAP Panel to assess the safety and the efficacy of caraway oil from *C. carvi* is in line with the principles laid down in Regulation (EC) No 429/2008[11] and the relevant guidance documents: Guidance on safety assessment of botanicals and botanical preparations intended for use as ingredients in food supplements (EFSA Scientific Committee, 2009), Compendium of botanicals that have been reported to contain toxic, addictive, psychotropic or other substances of concern (EFSA, 2012), Guidance on the identity, characterisation and conditions of use of feed additives (EFSA FEEDAP Panel, 2017a), Guidance on the safety of feed additives for the target species (EFSA FEEDAP Panel, 2017b), Guidance on the assessment of the safety of feed additives for the consumer (EFSA FEEDAP Panel, 2017c), Guidance on the assessment of the safety of feed additives for the environment (EFSA FEEDAP Panel, 2019a, 2019b), Guidance on the assessment of the efficacy of feed additives (EFSA FEEDAP Panel, 2018), Guidance on the assessment of the safety of feed additives for the users (EFSA FEEDAP Panel, 2023a), Guidance document on harmonised methodologies for human health, animal health and ecological risk assessment of combined exposure to multiple chemicals (EFSA Scientific Committee, 2019a), Statement on the genotoxicity assessment of chemical mixtures (EFSA Scientific Committee, 2019b), Guidance on the use of the Threshold of Toxicological Concern approach in food safety assessment (EFSA Scientific Committee, 2019c), General approach to assess the safety for the target species of botanical preparations which contain compounds that are genotoxic and/or carcinogenic (EFSA FEEDAP Panel, 2021a).[12]

3 | ASSESSMENT

The additive under assessment, caraway oil, is an essential oil obtained from the fruit of *Carum carvi* L., intended for use as a sensory additive (functional group: flavouring compounds) in feed and in water for drinking for all animal species.

3.1 | Origin and extraction

Carum carvi L., commonly known as caraway, is an annual or biennial herbaceous plant belonging to the Apiaceae family and native to much of Europe and Asia. In common with most other members of the Apiaceae, flowers are produced in compound umbrils each giving rise to small fruits annually or in the second year in biennial varieties (2–3 mm, often misleadingly referred to as seeds). The dried fruits are used in cooking, particularly in baked goods, in the production of liquors and as an ingredient in traditional medicinal products. The fresh leaves may also be used as a salad leaf and the roots consumed as a vegetable. Fruits are distilled to produce an essential oil (caraway oil). Caraway oil is usually produced from biennial varieties because of the higher yield.

The essential oil is obtained from the dried, ripe fruit of *C. carvi* by steam distillation. The volatile constituents are condensed and then separated from the aqueous phase by decantation.

[7]Technical dossier/Supplementary information/Letter dated 29/04/2021.

[8]The full report is available on the EURL website: https://joint-research-centre.ec.europa.eu/publications/fad-2010-0221_en

[9]Additives included in the partial report: dill herb oil, dill tincture, dong quai tincture, cumin oil, fennel tincture, parsley tincture, anise tincture, star anise tincture and ferula assa-foetida oil.

[10]Additives included in the addendum: celery seed oil, caraway seed oil, coriander oil, taiga root tincture, fennel oil, common ivy extract (sb), ginseng tincture, anise oil, anise star oil, anise star terpenes and omicha tincture.

[11]Commission Regulation (EC) No 429/2008 of 25 April 2008 on detailed rules for the implementation of Regulation (EC) No 1831/2003 of the European Parliament and of the Council as regards the preparation and the presentation of applications and the assessment and the authorisation of feed additives. OJ L 133, 22.5.2008, p. 1.

[12]https://www.efsa.europa.eu/sites/default/files/2021-05/general-approach-assessment-botanical-preparations-containing-genotoxic-carcinogenic-compounds.pdf.

3.2 | Uses other than feed flavouring

There is no specific EU authorisation for any *Carum carvi* L. preparation when used to provide flavour in food. However, according to Regulation (EC) No 1334/2008[13] flavouring preparations produced from food, may be used without an evaluation and approval as long as 'they do not, on the basis of the scientific evidence available, pose a safety risk to the health of the consumer, and their use does not mislead the consumer'.

'Caraway fruit (Carvi fructus)' and 'Caraway oil (Carvi aetheroleum)' are described in monographs of the European Pharmacopoeia 11.0 (PhEur, 2022a, 2022b) for medicinal uses. The European Medicines Agency (EMA) issued a monograph each for *Carum carvi* L., fructus and *Carum carvi* L., aetheroleum (EMA, 2015a, 2015b) and corresponding opinions (EMA, 2015c, 2015d) and an assessment report with an addendum common to both *Carum carvi* L., fructus and *Carum carvi* L., aetheroleum (EMA, 2015e, 2020).

3.3 | Characterisation

3.3.1 | Characterisation of caraway oil

Caraway oil is a light-yellow liquid with a characteristic odour. In six batches of the additive (of Chinese or Indian origin), the density (20°C) ranged between 899 and 910 kg/m^3 (specification: 896–918 kg/m^3), the refractive index (20°C) between 1.485 and 1.487 (specification: 1.477–1.497) and the specific optical rotation (at 20°C) between +72.4° and + 80.0° (specification; +70.0°–+81.3°).[14] Caraway oil is identified with the single Chemical Abstracts Service (CAS) number 8000-42-8, the European Inventory of Existing Chemical Substances (EINECS) number 288–921-6, the Flavor Extract Manufacturers Association (FEMA) number 2238 and the Council of Europe (CoE) number 112.

For caraway oil, the specifications used by the applicant are based on the standard developed by the International Organisation for Standardization (ISO) 8896:2016 for essential oil of caraway (*C. carvi*),[15] adapted to reflect the concentrations of selected volatile components. Three components contribute to the specifications as shown in Table 1, with carvone[16] and limonene[17] selected as phytochemical markers. The FEEDAP Panel notes that the main components of caraway oil are *d*-carvone and *d*-limonene (EMA, 2015e; PhEur Commentary, 2020). Therefore, the current assessment will refer to these enantiomers. The applicant set a specification of ≤ 0.5% for the maximum content of perillaldehyde in caraway oil. Analysis of three batches of the additive showed compliance with the specifications, when analysed by GC-FID and expressed as percentage of gas chromatographic peak area (% GC area).

TABLE 1 Major constituents of the essential oil from the fruit of *Carum carvi* L. as defined by specifications and batch to batch variation based on the analysis of three batches by gas chromatography with flame ionisation detector (GC-FID).

Constituent			% GC area		
EU register name	**CAS no**	**FLAVIS no**	**Specification[a]**	**Mean**	**Range**
d-Carvone	2244-16-8	07.146	45–65	52.2	47.3–55.7
d-Limonene	5989-27-5	01.045	30–50	44.6	41.2–49.7
Perillaldehyde	2111-75-3	05.117	≤ 0.5	0.25	0.21–0.28
Total				97.1	96.7– 97.2[b]

Note: The content of each constituent is expressed as the area per cent of the corresponding chromatographic peak (% GC area), assuming the sum of chromatographic areas of all detected peaks as 100%.

Abbreviations: EU, European Union; CAS no., Chemical Abstracts Service number; FLAVIS number, EU Flavour Information System numbers.

[a]Specifications defined based on GC-FID analysis.

[b]The values given for the total are the lowest and the highest values of the sum of the components in the three batches analysed.

The applicant provided the full characterisation of the volatile constituents in six batches obtained by gas chromatography–mass spectrometry (GC–MS).[18] In total, 62 peaks were identified and accounted on average for 99.6% (99.3%–99.9%) of the % GC area. The three compounds indicated in the product specifications account for about 95.8% on average (range

[13]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 Regulation (EC) No 1601/91 of the Council, Regulations (EC) No 2232/96 and (EC) No 110/2008 and Directive 2000/13/EC. OJ L 354, 31.12.2008, p. 34.

[14]Technical dossier/Supplementary information February 2024/Conf_Annex_II_SIn_Reply_caraway_seed_oil_COA_chrom_1–3 and Conf_Annex_II_SIn_Reply_caraway_seed_oil_COA_chrom_4–6.

[15]Technical dossier/Supplementary information February 2024/Annex_IV_SIn_reply_caraway_seed_oil_ ISO_8896_2016(en).

[16]Carvone [07.012] is a mixture of *d*-carvone and*l*-carvone. According to the PhEur Commentary (2020) and EMA (2015c) the main components of caraway oil is S-(+)-carvone (=*d*-carvone = L-carvone).

[17]Limonene [01.001] is a mixture of *d*- and *l*-limonene. According to the PhEur Commentary (2020) and EMA (2015c), R-(+)-limonene (=*d*-limonene = D-limonene) is one of the main components of caraway oil.

[18]Technical dossier/Supplementary information February 2024/ Conf_Annex_II_SIn_Reply_caraway_seed_oil_COA_chrom_1–3 and Conf_Annex_II_SIn_Reply_caraway_seed_oil_COA_chrom_4–6.

92.4%–98.6%) of % GC area. Besides the three compounds indicated in the product specifications, 17 other compounds were detected at individual levels > 0.1% and are listed in Table 2. The 20 compounds together account on average for 99.0% (97.9%–99.9%) of the % GC area. The remaining 42 compounds (ranging between 0.1% and 0.003%) and accounting for 0.65% are listed in the footnote.[19] Based on the available data on the characterisation, caraway oil is considered a fully defined mixture (EFSA Scientific Committee, 2019a).

TABLE 2 Constituents of the essential oil from the fruit of *Carum carvi* L. accounting for > 0.1% of the composition (based on the analysis of six batches by gas chromatography–mass spectrometry).

Constituent			% GC area	
EU register name	**CAS no**	**FLAVIS no**	**Mean**	**Range**
d-Carvone	2244-16-8	07.146	55.9	52.9–57.0
d-Limonene	5989-27-5	01.045	39.6	36.3–42.1
Perillaldehyde	2111-75-3	05.117	0.56	0.46–0.63
Myrcene	123-35-3	01.008	0.59	0.50–0.68
trans-Dihydrocarvone	5948-04-9	–	0.58	0.47–0.69
cis-p-2,8-Menthadien-1-ol	3886-78-0	–	0.47	0.33–0.59
cis-Dihydrocarvone	3792-53-8	–	0.40	0.09–0.72
trans-1-methyl-4-(1-methylvinyl)cyclohex-2-en-1-ol	7212-40-0	–	0.38	0.31–0.50
β-Caryophyllene	87-44-5	01.007	0.32	0.22–0.38
1-Methoxy-4-(1-propenyl)benzene (anethole)	104-46-1	04.088	0.29	0.16–0.40
Carveol[a]	99-48-9	02.062	0.29	0.07–0.52
α-Terpineol	98-55-5	02.014	0.26	0.06–0.33
d-8-p-Menthene-1,2-epoxide	1195-92-2	–	0.25	0.19–0.35
Neodihydrocarveol	18675-34-8	–	0.24	0.02–0.55
Dihydrocarveol	619-01-2	02.061	0.14	0.06–0.25
Linalool	78-70-6	02.013	0.14	0.03–0.18
1-Isopropyl-4-methylbenzene (*p*-cymene)	99-87-6	01.002	0.11	0.07–0.13
Octanal	124-13-0	05.009	0.11	0.07–0.12
4(10)-Thujene (sabinene)	3387-41-5	01.059	0.11	0.04–0.15
Pin-2(3)-ene (α-Pinene)	80-56-8	01.004	0.11	0.05–0.15
Total			99.0	97.9–99.9[b]

Note: The content of each constituent is expressed as the area per cent of the corresponding chromatographic peak (% GC area), assuming the sum of chromatographic areas of all detected peaks as 100%.

Abbreviations: CAS no., Chemical Abstracts Service number; EU, European Union; FLAVIS number, EU Flavour Information System numbers.

[a]Present in the additive as a mixture of isomers (*cis,trans*-carveol), the ratio between *cis*- and *trans*-isomers not given.

[b]The values given for the total are the lowest and the highest values of the sum of the components in the six batches analysed.

The applicant performed a literature search (see Section 3.4) for information on the chemical composition of *C. carvi* and its preparations and the presence of any recognised substances of concern.[20] The EFSA Compendium reported the occurrence of carvone (up to 65%) in the essential oil from the fruit of *C. carvi* (EFSA, 2012).[21] The applicant identified 39 references on the composition of caraway oil. Eleven publications (Bitterling et al., 2021; Simic et al., 2008; Laribi et al., 2010; Jiang et al., 2011; Raal et al., 2012; Baananou et al., 2013; Laribi et al., 2013; Solberg et al., 2016; Trifan et al., 2016; Ben Salha et al., 2019; Lasram et al., 2019) consistently reported the presence of low concentrations of perillaldehyde (< 0.5%). Other publications reported the presence of *p*-allylalkoxybenzenes, i.e. myristicin (0.05%–1.87%, Jalali-Heravi et al., 2007; Razzaghi-Abyaneh et al., 2009; Fang et al., 2010), elemicin (traces-3.54%, Jalali-Heravi et al., 2007; Razzaghi-Abyaneh et al., 2009; Fang et al., 2010; Jiang et al., 2011), apiole (0.41%–15.1%, Fang et al., 2010; Jiang et al., 2011), dillapiole (0.16%–1.39%, Razzaghi-Abyaneh et al., 2009), methyleugenol (0.93%, Fang et al., 2010), estragole (traces–0.1%, Jiang et al., 2011) and safrole (1.44%, Simic et al., 2008).

Perillaldehyde was detected in three batches of one of the two essential oils used as examples of the oil under assessment in concentration ranging from 0.21% to 0.28%, when analysed by GC-FID. In the other oil, perillaldehyde was below

[19]Additional constituents: constituents ($n = 11$) between < 0.1 and ≥0.05%: 6-camphenone, isocarveol, (–)-*trans*-isopiperitenol, *(2R,4R)-p*-mentha-6,8-diene 2-hydroperoxide, methyl geranate, 6-methylhept-5-en-2-one, heptanal, *trans*-3,7-dimethyl-1,3,6-octatriene, *(1R,4R)-p*-mentha-2,8-diene 1-hydroperoxide, isopiperitenone, β-caryophyllene epoxide, constituents ($n = 31$) between < 0.05% and ≥0.003%: *trans*-β-farnesene, 8-*p*-menthene-1,2-diol, *cis*-isocarveol, 4-hydroxy-2-pentanone, γ-terpinene, *trans*-menthone, β-bourbonene, octanoic acid, *trans*-2-nonenal, carvyl acetate, 1,5,8-*p*-menthatriene, hexanoic acid, 1-isopropenyl-4-methylbenzene, α-copaene, hexanal, *p*-mentha-1,8-dien-7-ol, germacra-1(10),4(14),5-triene, 1-(4-methylcyclohex-3-en-1-yl)ethenone, *cis*-3,7-dimethyl-1,3,6-octatriene, β-pinene, octan-1-ol, 3,7,10-humulatriene, 4-terpinenol, heptan-1-ol, hexan-1-ol, nonan-2-one, thymol, 2-pentylfuran, spathulenol, α-thujene, benzaldehyde.

[20]Technical dossier/Supplementary information February 2024/Literature search_caraway_seed_oil.

[21]https://www.efsa.europa.eu/en/microstrategy/botanical-summary-report.

the limit of detection (LOD, 0.0015%). The compounds belonging to the group of *p*-allylalkoxybenzenes were not detected in caraway oil (LOD, 0.0015%–0.01%).

3.3.1.1 | *Impurities*

The applicant referred to the 'periodic testing' of some representative flavourings premixtures for mercury, cadmium and lead, arsenic, fluoride, dioxins and polychlorinated biphenyls (PCBs), organo-chloride pesticides, organo-phosphorus pesticides, aflatoxins (B1, B2, G1, G2) and ochratoxin A. However, no data have been provided on the presence of these impurities.

3.3.2 | Shelf life

The typical shelf-life of caraway oil is stated to be at least 12 months, when stored in tightly closed containers under standard conditions (in a cool, dry place protected from light). However, no data supporting this statement were provided.

3.3.3 | Conditions of use

Caraway oil is intended to be added to feed and water for drinking for all animal species without a withdrawal period. The maximum use levels in complete feed proposed for all animal species and categories are listed in Table 3. No use level has been proposed by the applicant for the use in water for drinking.

TABLE 3 Conditions of use for the essential oil from the fruit of *Carum carvi* L.: Maximum proposed use levels in complete feed for all animal species and categories.

Animal category	Maximum use level (mg/kg complete feed)
Chickens for fattening	25
Laying hens	25
Turkeys for fattening	25
Piglets	25
Pigs for fattening	25
Sows	25
Veal calves (milk replacer)	35
Cattle for fattening	11
Dairy cows	10
Sheep/goats	10
Horses	10
Rabbits	10
Fish (salmon and other fin fish)	25
Dogs	25
Cats	25
Ornamental fish	10
Other species	10

3.4 | Safety

The assessment of safety of caraway oil is based on the maximum use levels in complete feed proposed by the applicant (Table 3).

No studies to support the safety for target animals, consumers and users were performed with the additive under assessment. The applicant carried out an extensive database search (no time limits) to identify data related to the chemical composition and the safety of preparations obtained from *C. carvi*.[22] Four cumulative databases (LIVIVO, NCBI, OVID and ToxInfo), 13 single databases including PubMed and Web of Science and 12 publishers' search facilities including Elsevier, Ingenta, Springer and Wiley were used. The keywords used covered different aspects of safety and the inclusion and exclusion criteria were provided by the applicant.

[22]Technical dossier/Supplementary information February 2024/Literature_search_ caraway_seed_oil.

Many of the individual components of the essential oil have been already assessed as chemically defined flavourings for use in feed and food by the FEEDAP Panel, the EFSA Panel on Food Additives, Flavourings, Processing Aids and Materials in contact with Food (AFC), the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF), and/or the Joint FAO/WHO Expert Committee on Food Additives (JECFA). The flavouring compounds currently authorised for feed[23] and/or food[24] use, together with the EU Flavour Information System (FLAVIS) number, the chemical group as defined in Commission Regulation (EC) No 1565/2000[25] and the corresponding EFSA opinion are listed in Table 4.

TABLE 4 Flavouring compounds already assessed by EFSA and/or by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) as chemically defined flavourings, grouped according to the chemical group (CG) as defined in Commission Regulation (EC) No 1565/2000, with indication of the EU Flavour Information System (FLAVIS) number and the corresponding EFSA/JECFA opinion.

CG	Chemical group	Product – EU register name (common name)	FLAVIS no	EFSA* or JECFA opinion, year
01	Straight-chain primary aliphatic alcohols/aldehydes/acids, acetals and esters with esters containing saturated alcohols and acetals containing saturated aldehydes	Hexan-1-ol	02.005	2013
		Octan-1-ol	02.006	
		Heptan-1-ol	02.021	
		Hexanal	05.008	
		Octanal	05.009	
		Heptanal	05.031	
		Hexanoic acid	08.009	
		Octanoic acid	08.010	
		Methyl geranate	09.643	2011a CEF
03	α, β-Unsaturated (alkene or alkyne) straight-chain and branched-chain aliphatic primary alcohols/aldehydes/acids, acetals and esters	*trans*-2-Nonenal	05.072	2019
05	Saturated and unsaturated aliphatic secondary alcohols, ketones and esters with esters containing secondary alcohols	6-Methylhept-5-en-2-one	07.015	2015a, 2021b
		Nonan-2-one	07.020	WHO 2000 (JECFA)
06	Aliphatic, alicyclic and aromatic saturated and unsaturated tertiary alcohols and esters with esters containing tertiary alcohols ethers	Linalool	02.013	2012a
		α-Terpineol	02.014	
		4-Terpinenol	02.072	
07	Primary alicyclic saturated and unsaturated alcohols/aldehydes/acids/acetals/esters with esters containing alicyclic alcohols	*p*-Mentha-1,8-dien-7-ol[a] (perillyl alcohol)	02.060	2017, CEF
08	Secondary alicyclic saturated and unsaturated alcohols, ketones, ketals and esters with ketals containing alicyclic alcohols or ketones and esters containing secondary alicyclic alcohols	*trans*-Menthone[b]	07.176	2016a, 2023b
		Carvyl acetate[c]	09.215	2016a
		Dihydrocarveol	02.061	WHO 2000 (JECFA)
		trans-Carveol[a]	02.062	2015a, CEF
		d-Carvone[a]	07.146	2014, SC
14	Furfuryl and furan derivatives with and without additional side-chain substituents and heteroatoms	2-Pentylfuran	13.059	2023c
18	Allylhydroxybenzenes	1-Methoxy-4-(1-propenyl) benzene[a,d] (anethole)	04.088	WHO 2000 (JECFA)
23	Benzyl alcohols/aldehydes/acids/esters/acetals	Benzaldehyde	05.013	2012b
25	Phenol derivatives containing ring-alkyl, ring-alkoxy and side-chains with an oxygenated functional group	Thymol	04.006	2012c
31	Aliphatic and aromatic hydrocarbons and acetals containing saturated aldehydes	1-Isopropyl-4-methylbenzene (*p*-cymene)	01.002	2015b
		1-Isopropenyl-4-methylbenzene	01.010	
		γ-Terpinene	01.020	
		d-Limonene	01.045	

[23]European Union Register of Feed Additives pursuant to Regulation (EC) No 1831/2003. Available online: https://ec.europa.eu/food/sites/food/files/safety/docs/animal-feed-eu-reg-comm_register_feed_additives_1831-03.pdf.

[24]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.

[25]Commission Regulation (EC) 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 of the European Parliament and of the Council. OJ L 1 80, 19.7.2000, p. 8.

TABLE 4 (Continued)

CG	Chemical group	Product – EU register name (common name)	FLAVIS no	EFSA* or JECFA opinion, year
		Pin-2(10)-ene (β-pinene)	01.003	2016b
		Pin-2(3)-ene (α-pinene)	01.004	
		β-Caryophyllene	01.007	
		Myrcene	01.008	
		Germacra-1(10),4(14),5-triene δ-Germacrene[a,e]	01.042	2011b, CEF
		3,7,10-Humulatriene[a,e]	01.043	
		4(10)-Thujene (Sabinene)[a]	01.059	2015b, CEF
		cis-3,7-Dimethyl-1,3,6-octatriene cis-β-Ocimene[a]	01.064	
		β-Bourbonene[a]	01.024	2015c, CEF
32	Epoxides	β-Caryophyllene epoxide	16.043	2014, CEF

*FEEDAP opinion unless otherwise indicated.

[a]Evaluated for use in food only. According to Regulation (EC) 1565/2000, flavourings evaluated by JECFA before 2000 are not required to be re-evaluated by EFSA.

[b]*trans*-Menthone [07.176]: menthone exists only as *trans*-isomer. Referred in the opinion to as menthone.

[c]EFSA evaluated carvyl acetate [09.215] as a mixture of isomers (related to *(1R,5R)*-carvyl acetate or *cis*-l-carvyl acetate).

[d]JECFA and EFSA evaluated 1-methoxy-4-(prop-1(*trans*)-enyl)benzene, *trans*-anethole [04.010] (WHO, 2000). *trans*-Anethole was also evaluated for use in feed (EFSA FEEDAP Panel, 2011).

[e]Evaluated applying the 'Procedure' described in the Guidance on the data required for the risk assessment of flavourings to be used in or on food (EFSA CEF Panel, 2010). No longer authorised for use as flavours in food.

As shown in Table 4, a number of components of caraway oil, accounting on average for 98.7% of the % GC area, have been previously assessed and considered safe for use as flavourings, and are currently authorised for use in food[26] without limitations and for use in feed[27] at individual use levels higher than those resulting from the intended use of the essential oil in feed.

Two compounds listed in Table 4, germacra-1(10),4(14),5-triene [01.042] and 3,7,10-humulatriene [01.043], have been evaluated in Flavouring Group Evaluation 25 Revision 2 (FGE25.Rev2) by applying the procedure described in the Guidance on the data required for the risk assessment of flavourings to be used in or on food (EFSA CEF Panel, 2010). For these compounds, for which there is no concern for genotoxicity, EFSA requested additional subchronic toxicity data (EFSA CEF Panel, 2011b). In the absence of such toxicological data, the EFSA CEF Panel was unable to complete its assessment (EFSA CEF Panel, 2015b). As a result, these compounds are not authorised for use as flavours in food. In the absence of toxicity data, the FEEDAP Panel applies the threshold of toxicological concern (TTC) approach or read-across from structurally related substances, following the approach recommended in the Guidance document on harmonised methodologies for human health, animal health and ecological risk assessment of combined exposure to multiple chemicals (EFSA Scientific Committee, 2019a).

Twenty-two additional components accounting on average for 3.7% of the GC area have not been previously assessed for use as flavourings. The FEEDAP Panel notes that 11 of them[28] are aliphatic monoterpenes or sesquiterpenes structurally related to flavourings already assessed in CG 8 and 31 and a similar metabolic and toxicological profile is expected. These lipophilic compounds are expected to be rapidly absorbed from the gastrointestinal tract, oxidised to polar oxygenated metabolites, conjugated and excreted (EFSA FEEDAP Panel, 2015b, 2016a, 2016b). An additional compound, *d*-8-*p*-menthene-1,2-epoxide is an epoxide structurally related to β-caryophyllene epoxide in CG 32.

Caraway seed oil contains perillaldehyde (average: 0.25%, range: 0.21%–0.28%), a substance for which EFSA identified a concern for genotoxicity (EFSA CEF Panel, 2015d, 2017), which was confirmed by JECFA (WHO, 2018). The applicant submitted a publication on the in vivo and in vitro mutagenicity of perillaldehyde (Honma et al., 2021), which was not available at the time of the previous assessments and is described below.

The following sections focus on the ADME and on the toxicology of perillaldehyde, and the other 10 compounds[29] not assessed for use in food, based on the information provided by the applicant in the form of literature searches and quantitative structure–activity relationship (QSAR) analysis.

[26]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.

[27]European Union Register of Feed Additives pursuant to Regulation (EC) No 1831/2003. https://ec.europa.eu/food/sites/food/files/safety/docs/animal-feed-eu-reg-comm_register_feed_additives_1831-03.pdf.

[28]*trans*-dihydrocarvone, *cis*-dihydrocarvone, neodihydrocarveol, isocarveol, (–)-*trans*-isopiperitenol and *cis*-isocarveol, (CG 8); *trans*-β-farnesene, *trans*-3,7-dimethyl-1,3,6-octatriene, 1,5,8-*p*-menthatriene, α-copaene and α-thujene (CG 31).

[29]*trans*-1-methyl-4-(1-methylvinyl)cyclohex-2-en-1-ol, *cis*-*p*-2,8-menthadien-1-ol, 8-*p*-menthene-1,2-diol, spathulenol, 1-(4-methylcyclohex-3-en-1-yl)ethenone, 6-camphenone, isopiperitenone, *(1R,4R)*-*p*-mentha-2,8-diene, 1-hydroperoxide, *(2R,4R)*-*p*-mentha-6,8-diene, 2-hydroperoxide, 4-hydroxy-2-pentanone.

3.4.1 | Absorption, distribution, metabolism and excretion

Perillaldehyde is rapidly metabolised, largely by oxidation of the side chain to a carboxylic acid, which is excreted unchanged or as its conjugates. Perillaldehyde is also an intermediate metabolite arising from the oxidation of the methyl side chain of *d*-limonene to perillic acid and dihydroperillic acid, which are further conjugated with glucuronic acid and excreted as perillyl-glucuronide and dihydroperillyl-glucuronide (EFSA CEF Panel, 2015c).

3.4.2 | Toxicology

3.4.2.1 | *Genotoxicity*

For fully defined mixtures, the EFSA Scientific Committee (EFSA SC) recommends applying a component-based approach, i.e. assessing all components individually for their genotoxic potential using all available information, including read-across and QSAR considerations about their genotoxic potential (EFSA Scientific Committee, 2019b). Therefore, the potential genotoxicity of identified constituents is first considered.

Perillaldehyde

The EFSA CEF Panel concluded that perillaldehyde raises a concern for genotoxicity based on the positive results observed in vivo with a Comet assay performed in liver of male rats. In the present opinion, the FEEDAP Panel evaluated a publication provided by the applicant (Honma et al., 2021), which was not available at the time the CEF Panel evaluated perillaldehyde (EFSA CEF Panel, 2015d, 2017).

In the publication by Honma et al. (2021), it is reported an Ames test performed with perillaldehyde using Salmonella typhimurium strains TA 98, TA 100, TA 1535, TA 1537 and *Escherichia* coli strain WP2 uvrA in the presence and absence of metabolic activation. According to the applicant, the good laboratory practice (GLP) study followed the Organisation for Economic Co-operation and Development (OECD) Test Guideline (TG) 471 (1997). Eight perillaldehyde concentrations were tested (i.e. 9.77, 19.5, 39.1, 78.1, 156, 313, 625 and 1250 µg/plate) applying the preincubation method. Cytotoxicity was observed at 313 µg/plate and above in the presence and absence of metabolic activation. No increase in the number of revertant colonies was observed at any concentration tested in any strain and experimental condition. The FEEDAP Panel concluded that perillaldehyde did not induce gene mutations in bacterial cells under the experimental conditions applied in the study.

An in vivo mutagenicity study was also performed applying the transgenic rodent somatic cell gene mutation assay in compliance with OECD TG 488 (1997). The study was performed in 9-week-old male Muta™ Mouse (CD2-LacZ80/HazfBR) administered perillaldehyde by oral gavage at 250, 500, 1000 mg/kg per day for 28 consecutive days. Mutation frequency (MF) was estimated via the lacZ positive selection method in liver and glandular stomach. The positive control ethyl nitrosourea (ENU) significantly increased MF in liver and glandular stomach confirming the sensitivity of the test system. MFs were comparable between treated and vehicle control groups (Honma et al., 2021). The FEEDAP Panel concluded that perillaldehyde did not induce gene mutations in vivo in liver and glandular stomach of transgenic rodents under the experimental conditions applied in the study.

The FEEDAP Panel noted the discrepancy between the positive results of the in vivo Comet assay in liver, as reported in the CEF opinions, and the negative outcomes of the TGR assay (Honma et al., 2021) and emphasised that the TGR assay detects gene mutations, while the Comet assay reveals primary DNA lesions such as single and double strand breaks that may give rise to gene mutations as well as to chromosome aberrations. Therefore, a negative TGR assay does not necessarily overrule the results of a positive in vivo Comet assay. On this basis, the FEEDAP Panel concluded that the publication by Honma et al. (2021) does not give reason to modify the conclusion drawn on the genotoxicity of perillaldehyde (*p*-mentha-1,8-dien-7-al) by the CEF Panel (EFSA CEF Panel, 2015d, 2017).

Other compounds

The genotoxic potential for 10 compounds (*trans*-1-methyl-4-(1-methylvinyl)cyclohex-2-en-1-ol, *cis-p*-2,8-menthadien-1-ol, 8-*p*-menthene-1,2-diol, spathulenol, 1-(4-methylcyclohex-3-en-1-yl)ethenone, 6-camphenone, isopiperitenone, *(1R,4R)-p*-mentha-2,8-diene, 1-hydroperoxide, *(2R,4R)-p*-mentha-6,8-diene, 2-hydroperoxide, 4-hydroxy-2-pentanone) was predicted by the applicant using the QSAR Toolbox. No alerts were identified for in vitro mutagenicity (Ames test), for genotoxic and non-genotoxic carcinogenicity and for other toxicity endpoints for spathulenol. Structural alerts for mutagenicity for *trans*-1-methyl-4-(1-methylvinyl)cyclohex-2-en-1-ol and *cis-p*-2,8-menthadien-1-ol were due to the presence of the vinyl/allyl alcohol group, while for 1-(4-methylcyclohex-3-en-1-yl)ethenone, 6-camphenone and isopiperitenone were due to the presence of the ketone group (nucleophilic addition). For the other three compounds, structural alerts were due to the presence of 'H acceptor-path 3-H acceptor' (8-*p*-menthene-1,2-diol and 4-hydroxy-2-pentanone), or of a peroxide group (*(1R,4R)-p*-mentha-2,8-diene, 1-hydroperoxide, predictions considered valid for *(2R,4R)-p*-mentha-6,8-diene, 2-hydroperoxide). For these substances, predictions of Ames mutagenicity (with and without S9) were made by 'read-across' analyses of data available for similar substances to the target compounds (i.e. analogues obtained by categorisation). Read-across-based predictions were found to be consistently negative for all categories of analogues. On this basis, the alerts raised were discounted.[30]

[30]Technical dossier/Supplementary information February 2024/Annex X_SIn_reply_caraway_seed_oil_QSAR.

Genotoxicity studies with caraway oil

The literature search provided by the applicant (see Section 3.4) identified several publications on the genotoxicity of caraway oil. The genotoxicity of caraway oil was reviewed in the FEMA GRAS assessment of natural flavour complexes (Cohen et al., 2020). The FEEDAP Panel notes that the FEMA assessment reporting negative results is based on four studies (Al-Bataina et al., 2003; Higashimoto et al., 1993; Mahmoud et al., 1992; Marcus & Lichtenstein, 1982). However, these studies were not further considered in the safety assessment of caraway oil due to the limitations identified by the FEEDAP Panel in the description of the test item and in the experimental protocol.

3.4.2.2 | *Repeated dose oral toxicity study with caraway oil*

No toxicity studies with the additive under assessment were provided by the applicant; however, a 28-day oral toxicity study in rat performed with an essential oil obtained from the fruit of *Carum carvi* L. similar to the additive under assessment is available from the above-mentioned literature search (Auti & Kulkarni, 2019). Gas chromatography analysis showed that the percentage of *d*-carvone and *d*-limonene in the essential oil tested (A) and in the essential oil under assessment (B) is similar (*d*-carvone: 56.5% in essential oil A and 52.9%–56.9%% in essential oil B; *d*-limonene: 43% in essential oil A and 36.2%–42.1% in essential oil B).

A total of 40 Wistar rats (10 per group, five males and five females) were given 0 (control, vehicle (5% tween 80)), 50, 100 or 200 mg essential oil/kg body weight (bw) per day for 28 days following the OECD TG 407. There were no significant differences in body weight changes as well as in water and food consumption among groups. No abnormal signs of toxicity (e.g. changes in skin, fur, eyes, respiratory pattern, motor activity) were observed in any of the treatment groups. The results of haematology, blood chemistry, renal function parameters, gross pathology and histopathology showed no evidence of any treatment-related adverse effects (Auti & Kulkarni, 2019). From this study, the highest dose tested (200 mg/kg bw per day) is identified as a no observed adverse effect level (NOAEL) for caraway oil in Wistar rats. Because of the short duration of the study, the FEEDAP Panel considers the 28-day study as supporting evidence to the safety assessment of caraway oil.

3.4.3 | Safety for the target species

Tolerance studies with the target species and/or subchronic toxicological studies in laboratory animals conducted with the essential oil under application were not submitted. In the absence of these data, the approach to the safety assessment of a mixture whose individual components are known is based on the safety assessment of each individual component (component-based approach). This approach requires that the mixture is sufficiently characterised and that the individual components can be grouped into assessment groups, based on structural and metabolic similarity. The combined toxicity can be predicted using the dose addition assumption within an assessment group, taking into account the relative toxic potency of each component (EFSA Scientific Committee, 2019a).

As the additive under assessment is a fully defined mixture (the identified components represent about 99% of the % GC area, see Section 3.3.1), the FEEDAP Panel applied a component-based approach to assess the safety for target species of the components of the essential oil, except perillaldehyde, which is assessed separately.

An assessment based on the NOAEL derived from a 28-day study with a caraway oil similar to the additive under assessment (see Section 3.4.2.2) is also presented to support the outcome of the safety assessment based on a component-based approach.

For perillaldehyde, the available data set do not allow to identify a reference point for the risk assessment or to derive a safe level. Therefore, the assessment of the safety for target species is based on the comparison between the intake of perillaldehyde via the consumption of citrus by-products, commonly used as feed material, and that via the use of caraway oil as a feed additive. For citrus by-products, data on the occurrence of perillaldehyde are available and have been evaluated by the FEEDAP Panel (EFSA FEEDAP Panel, 2021b).

3.4.3.1 | *Component-based approach*

Components other than perillaldehyde

Based on considerations related to structural and metabolic similarities, the components were allocated to 11 assessment groups, corresponding to the chemical groups (CGs) 1, 3, 5, 6, 7, 8, 10, 14, 18, 16, 23, 25, 31 and 32, as defined in Annex I of Regulation (EC) No 1565/2000.[31] For chemical group 31 ('aliphatic and aromatic hydrocarbons'), subassessment groups as defined in FGE.25 and FGE.78 were established (EFSA CEF Panel, 2015b, 2015c). The allocation of the components to the (sub-)assessment groups is shown in Table 5 and in the corresponding footnote.

For each component in the assessment group, exposure in target animals was estimated considering the use levels in feed, the percentage of the component in the oil and the default values for feed intake according to the guidance on the safety of feed additives for target species (EFSA FEEDAP Panel, 2017b). Default values on body weight (bw) are used to

[31]Commission Regulation (EC) 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 of the European Parliament and of the Council. OJ L 180, 19.7.2000, p. 8.

express exposure in terms of mg/kg bw. The intake levels of the individual components calculated for chickens for fattening, the species with the highest ratio of feed intake/body weight per day, are shown in Table 5.

For hazard characterisation, each component of an assessment group was first assigned to the structural class according to Cramer classification (Cramer et al., 1978). For some components in the assessment group, toxicological data were available to derive no observed adverse effect levels (NOAELs). Structural and metabolic similarity among the components in the assessment groups were evaluated to explore the application of read-across. If justified, extrapolation from a known NOAEL of components of an assessment group to the other components of the group with no available NOAEL was made. If sufficient evidence is available for the members of a (sub)assessment group, a (sub)assessment group NOAEL was derived.

Toxicological data of subchronic studies, from which NOAEL values could be derived, were available for several compounds in CG 1 (EFSA FEEDAP Panel, 2013), for 6-methylhept-5-en-2-one [07.015] in CG 5 (EFSA FEEDAP Panel, 2021), linalool [02.013] and terpineol [02.230][32] in CG 6 (EFSA FEEDAP Panel, 2012a), *d*-carvone [07.146] in CG 8 (EFSA Scientific Committee, 2014), 2-pentylfuran [13.059] in CG 14 (EFSA FEEDAP Panel, 2023c), thymol [04.006] in CG 25 (EFSA FEEDAP Panel, 2012c), *d*-limonene [01.045], *p*-cymene [01.002], myrcene [01.008] and β-caryophyllene [01.007] in CG 31 (EFSA FEEDAP Panel, 2015b, 2016b) and β-caryophyllene oxide in CG 32 (EFSA CEF Panel, 2014). For benzaldehyde [05.013], a NOAEL of 400 mg/kg bw for benzaldehyde was derived from a 90-day oral toxicity studies with rats (Andersen, 2006).

For CG 1 compounds, a group NOAEL of 120 mg/kg bw was derived from the toxicological data available and applied to CG 1 compounds, i.e. hexan-1ol [02.005], heptan-1-ol [02.021], octan-1-ol [02.006], hexanal [05.008], heptanal [05.031], octanal [05.009], hexanoic acid [08.009], octanoic acid [08.010] and methyl geranate [09.643]. The NOAEL of 80 mg/kg bw per day hex-2(*trans*)-enal [05.073] was extrapolated using read-across to *trans*-2-nonenal [05.072].

For the subgroup of terpinyl derivatives in CG 6, i.e. α-terpineol [02.072] and 4-terpinenol [02.072], the reference point was selected based on the NOAEL of 250 mg/kg bw per day available for terpineol [02.230]. An uncertainty factor (UF) of 2 was applied to the NOAEL of 250 mg/kg bw per day to take into account the short duration (35 days) of the study with terpineol (EFSA FEEDAP Panel, 2012a).

For the subgroup of carvyl derivatives in CG 8, i.e. *trans*- and *cis*-dihydrocarvone, carveol (present in the additive as a mixture of *trans*- and *cis*-isomers), dihydrocarveol, neodihydrocarveol and carvyl acetate [09.215], the reference point was selected based on the benchmark dose (BMD) lower confidence limit for a benchmark response of 10% ($BMDL_{10}$) of 60 mg/kg bw per day available for *d*-carvone [07.146]. The FEEDAP Panel already applied to *d,l*-isomenthone [07.078] and menthone [07.176] the NOAEL of 375 mg/kg bw per day for menthol [02.015]. An UF of 2 was applied to the NOAEL to take into account additional uncertainty in read across (EFSA FEEDAP Panel, 2023b).

The NOAELs of 44, 250 and 222 mg/kg bw per day for the representative compounds of CG 31, myrcene [01.008], *d*-limonene [01.045], *p*-cymene [01.002] and β-caryophyllene [01.007] were applied, respectively, using read-across to the compounds within subassessment groups II (trans-3,7-dimethyl-1,3,6-octatriene and cis-3,7-dimethyl-1,3,6-octatriene), III (γ-terpinene) and V (sabinene, α-pinene, β-bourbonene, α-copaene, β-pinene and α-thujene) (EFSA CEF Panel, 2015b, 2015c). Read-across was also applied from β-caryophyllene [01.007] to 3,7,10-humulatriene [01.043] in CG 31, VI. An uncertainty factor (UF) of 2 was applied to the NOAEL of 222 mg/kg bw per day for β-caryophyllene [01.007] to take into account the uncertainty in read-across (EFSA FEEDAP Panel, 2023d).

The NOAEL of 109 mg/kg bw per day for β-caryophyllene epoxide [16.043] was extrapolated to d-8-*p*-menthene-1,2-epoxide in CG 32.

For the remaining compounds,[33] toxicity studies performed with the compounds under assessment and NOAEL values derived from toxicity studies were not available and read-across was not possible. Therefore, the threshold of toxicological concern (TTC) approach was applied (EFSA FEEDAP Panel, 2017b).

As the result of the hazard characterisation, a reference point was identified for each component in the assessment group based on the toxicity data available (NOAEL from in vivo toxicity study or read across) or from the 5th percentile of the distribution of NOAELs of the corresponding Cramer Class (i.e. 3, 0.91 and 0.15 mg/kg bw per day, respectively, for Cramer Class I, II and III compounds, Munro et al., 1996). Reference points selected for each compound are shown in Table 5.

For risk characterisation, the margin of exposure (MOE) was calculated for each component as the ratio between the reference point and the exposure. For each assessment group, the combined (total) margin of exposure (MOET) was calculated as the reciprocal of the sum of the reciprocals of the MOE of the individual substances (EFSA Scientific Committee, 2019a, 2019b, 2019c). An MOE(T) > 100 allowed for interspecies- and intra-individual variability (as in the default 10 × 10 uncertainty factor). The compounds resulting individually in an MOE > 50,000 were not further considered in the assessment group as their contribution to the MOE(T) is negligible. They are listed in the footnote.[34]

[32]Terpineol is a mixture of four structural isomers: α-terpineol [02.014], β-terpineol, γ-terpineol and 4-terpinenol [02.072]. α-terpineol [02.014], is defined as a mixture of *(R)*-(+)-α-terpineol and *(S)*-(−)-α-terpineol. Composition of mixture: 55%–75% α-terpineol, 16%–23% γ-terpineol, 1%–10% cis-β-terpineol, 1%–13% trans-β-terpineol and 0%–1% δ-terpineol (EFSA CEF Panel, 2015c) FGE.18Rev 3.

[33]Nonan-2-one (CG 05); *cis-p*-2,8-menthadien-1-ol, *trans*-1-methyl-4-(1-methylvinyl)cyclohex-2-en-1-ol, 8-*p*-menthene-1,2-diol, spathulenol (CG 06); *p*-mentha-1,8-dien-7-ol (CG 07); 6-camphenone, isocarveol, *(2R,4R)-p*-mentha-6,8-diene, 2-hydroperoxide, *(1R,4R)-p-m*-2,8-diene, 1-hydroperoxide, *cis*-isocarveol, isopiperitenone, 1-(4-methylcyclohex-3-en-1-yl)ethenone (CG 8); 4-hydroxy-2-pentanone (CG 10); 1,5,8-*p*-menthatriene (CG 31,III); 1-isopropenyl-4-methylbenzene (CG 31, IVe); germacra-1(10),4(14),5-triene (CG 31,VI).

[34]Compounds included in the assessment groups but not reported in the table: hexanal, hexan-1-ol, heptanal, heptan-1-ol, hexanoic acid, octan-1-ol, octanoic acid, methyl geranate (CG 1); *trans*-2-nonenal (CG 3); 4-terpinenol (CG 6); (−)−*trans*-isopiperitenol, menthone, carvyl acetate (CG 8); benzaldehyde (CG 23); thymol (CG 25); *trans*-3,7-dimethyl-1,3,6-octatriene, *cis*-3,7-dimethyl-1,3,6-octatriene (CG 31, II); γ-terpinene (CG 31, III); *p*-cymene (CG 31, IVe); sabinene, α-pinene, β-bourbonene, α-copaene, β-pinene, α-thujene (CG 31, V); 3,7,10-humulatriene (CG31, VI); β-caryophyllene oxide II (CG 32).

The approach to the safety assessment of caraway oil for the target species is summarised in Table 5. The calculations were done for chickens for fattening, the species with the highest ratio of feed intake/body weight and represent the worst-case scenario.

TABLE 5 Compositional data, intake values (calculated for chickens for fattening at 25 mg/kg complete feed), reference points and margin of exposure (MOE) for the individual components of caraway oil classified according to assessment groups, and combined margin of exposure (MOET) for each assessment group.

Essential oil composition			Exposure		Hazard characterisation		Risk characterisation	
Assessment group	**FLAVIS-no**	**Highest conc. in the oil**	**Highest feed conc.**	**Daily intake[a]**	**Cramer class[b]**	**NOAEL/ $BMDL_{10}$[c]**	**MOE**	**MOET**
Constituent	–	%	mg/kg	mg/kg bw/day	–	mg/kg bw/day	–	–
CG 01								
Octanal	05.009	0.12	0.031	0.0028	(I)	120	43,120	
CG 05								
6-Methylhept-5-en-2-one	07.015	0.13	0.032	0.0029	(II)	50	17,270	
Nonan-2-one	07.020	0.01	0.003	0.0002	II	*0.91*	3686	
MOET CG 5								3038
CG 6								
cis-p-2,8-Menthadien-1-ol	–	0.59	0.148	0.0132	I	*3*	227	
trans-1-Methyl-4-(1-methyl vinyl) cyclohex-2-en-1-ol	–	0.50	0.124	0.0111	I	*3*	269	
α-Terpineol	02.014	0.33	0.082	0.0074	(I)	125[d]	16,929	
Linalool	02.013	0.18	0.044	0.0039	(I)	**117**	29,790	
8-*p*-Menthene-1,2-diol	–	0.07	0.018	0.0016	II	*0.91*	579	
Spathulenol	–	0.01	0.003	0.0002	I	*3*	13,367	
MOET CG 6								100
CG 7								
p-Mentha-1,8-dien-7-ol	02.060	0.04	0.009	0.0008	I	*3*	3819	
CG 8								
d-Carvone	07.012	57.03	14.258	1.2799	(II)	**60**	47	
trans-Dihydrocarvone	–	0.69	0.172	0.0154	(II)	60	3891	
cis-Dihydrocarvone	–	0.72	0.181	0.0162	(II)	60	3703	
Neodihydrocarveol	–	0.55	0.138	0.0123	(I)	60	4861	
Carveol	02.062	0.52	0.131	0.0117	(I)	60	5121	
Dihydrocarveol	02.061	0.25	0.063	0.0056	(II)	60	10,694	
6-Camphenone	–	0.09	0.023	0.0020	I	*3*	1485	
Isocarveol	–	0.11	0.028	0.0025	I	*3*	1183	
(2R,4R)-*p*-Mentha-6,8-diene, 2-hydroperoxide	02.100	0.10	0.025	0.0023	I	*3*	1323	
(1R,4R)-*p*-Mentha-2,8-diene, 1-hydroperoxide	–	0.08	0.020	0.0018	I	*3*	1692	
cis-Isocarveol	–	0.06	0.016	0.0014	I	*3*	2122	
Isopiperitenone	–	0.06	0.016	0.0014	II	*0.91*	644	
1-(4-Methylcyclohex-3-en-1-yl) ethanone	–	0.03	0.007	0.0006	I	*3*	4774	
MOET CG 8								36
CG 10								
4-Hydroxy-2-pentanone	–	0.04	0.011	0.0010	I	*3*	3819	
CG 14								
2-Pentylfuran	13.059	0.01	0.002	0.0002	(II)	**8.51**	42,131	
CG 18								
Anethole	04.088	0.40	0.100	0.0090	(I)	**300**	33,418	

(Continues)

TABLE 5 (Continued)

Essential oil composition			Exposure		Hazard characterisation		Risk characterisation	
Assessment group	**FLAVIS-no**	**Highest conc. in the oil**	**Highest feed conc.**	**Daily intake[a]**	**Cramer class[b]**	**NOAEL/ $BMDL_{10}$[c]**	**MOE**	**MOET**
CG 31, II (Acyclic alkanes)								
Myrcene	01.008	0.68	0.170	0.0153	(I)	**44**	2883	
(Z)-β-Farnesene	–	0.11	0.026	0.0024	(I)	44	18,671	
MOET CG 31,II								2497
CG 31, III (Cyclohexene hydrocarbons)								
d-Limonene	01.045	42.06	10.515	0.9440	(I)	**250**	265	
1,5,8-*p*-Menthatriene	–	0.05	0.012	0.0011	I	*3*	2728	
								241
CG 31, IVe (Benzene hydrocarbons, alkyl)								
1-Isopropenyl-4-methylbenzene	01.002	0.05	0.012	0.0011	I	*3*	2785	
CG 31, V (Bi-, tricyclic, non-aromatic hydrocarbons)								
β-Caryophyllene	01.007	0.38	0.095	0.0085	(I)	**222**	26,099	
CG 31, VI								
Germacra-1(10),4(14),5-triene	01.042	0.03	0.008	0.0007	I	*3*	4312	
CG 32 (Epoxides)								
d-8-*p*-Menthene-1,2-epoxide	–	0.35	0.087	0.0078	(I)	109	13,956	

[a]Intake calculations for the individual components are based on the use level of 25 mg/kg in feed for chickens for fattening, the species with the highest ratio of feed intake/body weight. The MOE for each component is calculated as the ratio of the reference point (NOAEL) to the intake. The combined margin of exposure (MOET) is calculated for each assessment group as the reciprocal of the sum of the reciprocals of the MOE of the individual substances.

[b]When a NOAEL value is available or read-across is applied, the allocation to the Cramer class is put into parentheses.

[c]Values **in bold** refer to those components for which the NOAEL value was available, values *in italics* are the 5th percentile of the distribution of NOAELs of the corresponding Cramer Class, other values (plain text) are NOAELs extrapolated by using read-across.

[d]An uncertainty factor of 2 was applied to the NOAEL of 250 mg/kg bw per day for terpineol (short duration of the study).

As shown in Table 5, for chickens for fattening at the proposed use level of 25 mg/kg complete feed, an MOET of 36 was calculated for CG 8. From this lowest MOET of 36 for chickens for fattening, the MOE for CG 8 was calculated for the other target species, considering the respective daily feed intake and conditions of use. The results are summarised in Table 6.

TABLE 6 Combined margin of exposure (MOET) for the assessment group CG 8 calculated for the different target animal categories at the proposed use level and maximum safe use levels in feed calculated to ensure an MOET ≥ 100 (500 for cats).

Animal category	Daily feed intake (g DM/kg bw)	Proposed use level (mg/kg complete feed)[a]	Lowest MOET CG 8	Maximum safe use level (mg/kg complete feed)[a,b]
Chickens for fattening	79	25	36	9
Laying hens	53	25	54	13
Turkeys for fattening	59	25	48	12
Pigs for fattening	44	25	65	16
Piglets	37	25	77	19
Sows lactating	30	25	95	24
Veal calves (milk replacer)	19	35	107	–[b]
Cattle for fattening	20	11	347	–
Dairy cows	31	10	229	–
Sheep/goat	20	10	356	–
Horses	20	10	356	–
Rabbits	50	10	142	–
Salmon	18	25	158	–
Dogs	17	25	167	–
Cats[c]	20	25	142	7
Ornamental fish	5	10	1422	–

[a]Complete feed containing 88% DM, milk replacer 94.5% DM.

[b]For the species for which the MOET is > 100, the proposed use level is considered safe.

[c]The MOE for cats is increased to 500 because of the reduced capacity of glucuronidation.

At the proposed use levels in complete feed, the MOET exceeds the value of 100 for veal calves, cattle for fattening, dairy cows, sheep/goats, horses, rabbits, salmon, dogs, cats and ornamental fish indicating that the proposed maximum use levels for these species are safe (without considering perillaldehyde). For the other species, the maximum safe use levels in feed were calculated to ensure an MOET ≥ 100. Because glucuronidation is an important metabolic pathway to facilitate the excretion of the components of the essential oil and considering that cats have an unusually low capacity for glucuronidation (Court & Greenblatt, 1997; Lautz et al., 2021), the use of caraway oil as an additive in cat feed needs a wider margin of exposure. A MOET of 500 is considered adequate. The maximum use levels proposed by the applicant of 10 mg/kg for dairy cows, sheep/goats, horses, rabbits, ornamental fish, 11 mg/kg for cattle for fattening, 25 mg/kg for salmonids and dogs and 35 mg/kg for veal calves are considered safe (without considering perillaldehyde). For the other species/categories, the calculated maximum safe levels are shown in Table 6. These levels are extrapolated to physiologically related minor species. For the other species not considered, the lowest value of 7 mg/kg complete feed is applied.

3.4.3.2 | *Whole mixture approach as supportive evidence*

Because of the similarity of the caraway oil tested by Auti and Kulkarni (2019) (see Section 3.4.2.2) with the additive under assessment, the FEEDAP Panel applied the NOAEL of 200 mg/kg bw per day as the reference point to derive maximum safe feed concentrations of the additive for the target species. Following the EFSA Guidance on the safety of feed additives for the target species (EFSA FEEDAP Panel, 2017b), a UF of 100 was applied to the reference point plus an additional UF of 2 for the short duration for the study. Generally, for cats, an additional UF of 5 is applied, considering their unusually low capacity for glucuronidation of compounds (Court & Greenblatt, 1997; Lautz et al., 2021). The calculated maximum safe feed concentrations of caraway oil (without considering the presence of perillaldehyde) for the target species are shown in Table 7.

TABLE 7 Maximum safe concentrations of caraway oil in feed for the target animal species and categories calculated using the reference point of 200 mg/kg bw per day derived from a 28-day oral toxicity study (Auti & Kulkarni, 2019) and applying an uncertainty factor of 200 (500 for cats).

Animal category	Daily feed intake (kg DM/kg bw)	Proposed use level (mg/kg complete feed)[a]	Maximum safe concentration (mg/kg complete feed)[a]
Chickens for fattening	79	25	11
Laying hens	53	25	17
Turkeys for fattening	59	25	15
Piglets	44	25	20
Pigs for fattening	37	25	24
Sows	30	25	31
Veal calves (milk replacer)	19	35	50
Cattle for fattening	20	11	44
Dairy cows	31	10	29
Sheep/goats	20	10	44
Horses	20	10	44
Rabbits	50	10	18
Salmonids	18	25	50
Dogs	17	25	53
Cats[b]	20	25	18
Ornamental fish	5	10	196

[a]Complete feed containing 88% DM, milk replacer 94.5% DM.

[b]For cats, an additional uncertainty factor of 5 is applied because of the reduced capacity of glucuronidation.

The FEEDAP Panel notes that the safe concentrations in feed (without considering the presence of perillaldehyde) for the target animals calculated by applying the NOAEL from the 28-day study are comparable to those derived by applying the component-based approach, which is considered the preferred approach.

3.4.3.3 | *Perillaldehyde*

Low concentrations of perillaldehyde were detected in three out of six batches of the additive under assessment (average: 0.25%, range: 0.21%–0.28%, Table 1). The highest intake estimates of perillaldehyde for the target species were calculated considering the highest specification of perillaldehyde in the essential oil (0.5%) and the maximum safe use levels for the different target species (without considering perillaldehyde, Table 6). The results are reported in Table 8.

TABLE 8 Target animal intake of perillaldehyde (as µg/kg bw per day) at the maximum safe use levels for the different target species calculated considering the highest proposed specification in caraway oil (0.5%).

Animal category	Daily feed intake (g DM/kg bw)	Maximum safe use level (mg/kg complete feed)[a,b]	Perillaldehyde intake (µg/kg bw per day)[a]
Chickens for fattening	79	9	4.04
Laying hens	53	13	3.91
Turkeys for fattening	59	12	4.00
Piglets	44	16	4.00
Pigs for fattening	37	19	3.96
Sows lactating	30	24	4.11
Veal calves (milk replacer)	19	11	3.50
Cattle for fattening	20	10	1.25
Dairy cows	31	10	1.75
Sheep/goats	20	10	1.14
Horses	20	10	1.14
Rabbits	50	25	2.84
Salmon	18	25	2.49
Dogs	17	25	2.37
Cats	20	7	0.80
Ornamental fish	5	10	0.26

[a]Complete feed containing 88% DM, milk replacer 94.5% DM.
[b]Without considering perillaldehyde.

The use of caraway oil would result in a daily intake of perillaldehyde ranging from 0.26 to 4.11 µg/kg bw.

Perillaldehyde occurs in feed materials rich in *d*-limonene, such as caraway seeds and citrus by-products. For citrus by-products, there is evidence that they are used in diets of most of the target species at different concentrations depending on the target species. As comparable evidence is not available for caraway seeds, the FEEDAP Panel considers that perillaldehyde intake from feed materials can be estimated based on the data available for citrus by-products. According to the information submitted by the applicant and reviewed by the FEEDAP Panel in the assessment of expressed lemon oil and its fractions and on lime oil (EFSA FEEDAP Panel, 2021b), the concentrations of citrus by-products in the diets of target animals range from 5% up to 30% in ruminants. Taking into account an inclusion level of 10% citrus by-products for poultry and 20% for the other species and considering the default values for feed intake according to the guidance on the safety of feed additives for target species (EFSA FEEDAP Panel, 2017b), the daily intake of citrus by-products has been estimated to be 7.9 g dry matter (DM)/kg bw for poultry, 8.8 g DM/kg bw for pigs, 6.2 g DM/kg bw for ruminants, 4 g DM/kg bw for horses, 10 g DM/kg bw for rabbit and 3.6 g DM/kg bw for fish. For the current assessment, the applicant submitted additional evidence showing that citrus by-products are also used in feed for dogs at about 10% (Brambillasca et al., 2013; Pacheco et al., 2021), resulting in a daily intake of citrus by-products of 1.7 g DM/kg bw for dogs.

Considering the literature data provided by the applicant on the occurrence of perillaldehyde in citrus peel[35] and assuming that citrus peel represents 62.5% of citrus by-product[36] (Bampidis and Robinson, 2006), the FEEDAP Panel estimated an average content of 0.0004% perillaldehyde in citrus by-products[37] (EFSA FEEDAP Panel, 2021b). Based on citrus by-product intake (see above), the daily intake of perillaldehyde via feed was calculated to be 32 µg/kg bw for poultry, 36 µg/kg bw for pigs, 24 µg/kg bw for ruminants, 16 µg/kg bw for horses, 40 µg/kg bw for rabbit and 14 µg/kg bw for fish. For dogs, the estimated daily intake of perillaldehyde from citrus by-products is 6.8 µg/kg bw. These concentrations are 3- to 11-fold higher than those resulting from the use of caraway oil at the concentrations in feed considered safe (without considering perillaldehyde) for the different target species (ranging from 7 to 35 mg/kg complete feed, see Section 3.4.3.1). Therefore, based on this comparison (EFSA FEEDAP Panel, 2021b), for these species, the use of caraway oil is considered of no concern.

For the remaining species, cats and ornamental fish not normally exposed to citrus by-products, the FEEDAP Panel applied the threshold of toxicological concern (TTC) concept. The intake of perillaldehyde arising from the use of the additive was compared with the threshold of the TTC of 0.0025 µg/kg bw per day established for potential DNA-reactive mutagens and/or carcinogens in human risk assessment (EFSA Scientific Committee, 2019c).

At the use levels of 7 and 10 mg/kg complete feed for cats and ornamental fish, respectively (see Table 6), the perillaldehyde intake would result in 1.00 and 0.32 µg/kg bw per day. These levels are above the threshold of 0.0025 µg/kg bw

[35]Calculated considering the occurrence of perillaldehyde in citrus peel (e.g. 0.0004% for mandarins and lemons, and 0.001% for oranges according to Qadir et al., 2018, Kamal et al., 2011, Bourgou et al., 2012, as referenced in EFSA FEEDAP Panel, 2021b).

[36]Composition of fresh citrus by-products: 62.5% citrus peel, 32.5% pulp and 5% seeds. Similar proportions are assumed in dried citrus by-products.

[37]Occurrence of perillaldehyde in citrus by-products calculated considering the composition of citrus by-products as 60% oranges, 20% lemon and lime, 30% mandarin: 0.0006% × 0.6 + 0.0002 × 0.3 + 0.0002 × 0.1 = 0.0004%.

per day. Therefore, no conclusion can be drawn on the safety of caraway oil which contains perillaldehyde for cats and ornamental fish.

3.4.3.4 | *Use in water for drinking*

No specific proposals have been made by the applicant for the use level in water for drinking. The FEEDAP Panel considers that the use in water for drinking is of no concern provided that the total daily intake of the additive does not exceed the daily amount that is considered of no concern when consumed via feed.

3.4.3.5 | *Conclusions on safety for the target species*

The FEEDAP Panel concludes that the levels of caraway oil summarised in Table 9 are considered of no concern.

For cats and ornamental fish and other species not mentioned in the table, no conclusion can be drawn.

TABLE 9 Concentrations of caraway oil in complete feed (mg/kg) considered of no concern for the respective target species and categories.

Animal categories	Feed concentration of no concern (mg/kg complete feed)[a]
Turkeys for fattening	12
Chickens for fattening, other poultry for fattening or reared for laying/reproduction, ornamental birds	9
Laying hens and other laying/reproductive birds	13
Pigs for fattening	16
Piglets and other porcine species for meat production or reared for reproduction	19
Sows and other porcine species for reproduction	24
Veal calves (milk replacer)	35
Cattle for fattening, other bovines for fattening or reared for milk production/reproduction, cervids and camelids at the same physiological stage	11
Dairy cows and other bovines, cervids and camelids for milk production or reproduction	10
Sheep/goats	10
Horses and other equines	10
Rabbits and other leporids	10
Salmonids and minor fin fish	25
Dogs	25

[a]Complete feed containing 88% DM, milk replacer 94.5% DM.

3.4.4 | Safety for the consumer

Caraway oil is added to a wide range of food categories for flavouring purposes. Although individual consumption figures for the EU are not available, the Fenaroli's handbook of flavour ingredients (Burdock, 2009) cites values of 1.24 mg/kg bw per day for 'caraway seed' (FEMA 2236) and 0.0019 mg/kg bw per day for 'caraway seed oil' (FEMA 2238).

The majority of the individual constituents of the essential oil under assessment are currently authorised as food flavourings without limitations and have been already assessed for consumer safety when used as feed additives in animal production (see Table 4, Section 3.3).

No data on residues in products of animal origin were made available for any of the constituents of the essential oil. However, the Panel recognises that the constituents of caraway oil are expected to be extensively metabolised and excreted in the target species. Also for perillaldehyde, the available data indicate that it is absorbed, metabolised and rapidly excreted and at the concentrations in feed resulting from the use of the additive is not expected to accumulate in animal tissues and products (see Section 3.3.1). Considering the above and the reported human exposure due to the direct use of caraway oil in food (Burdock, 2009), it is unlikely that the consumption of products from animals given caraway oil would substantially increase human background exposure. The use of caraway oil in animal nutrition under the proposed conditions of use is safe for the consumers.

3.4.5 | Safety for the user

No specific data were provided by the applicant regarding the safety of the additive for users.

No studies relevant to user safety of essential oils obtained from fruit of *C. carvi* were found in the literature review.[38]

The applicant provided a safety data sheet[39] for caraway oil where hazards for users have been identified.

The additive under assessment should be considered as irritant to skin and eyes, and as a skin and respiratory sensitiser.

When handling the essential oil, exposure of unprotected users to perillaldehyde may occur. Therefore, to reduce the risk, the exposure of the users should be minimised.

3.4.6 | Safety for the environment

C. carvi is native to Europe and is grown and consumed worldwide. The use of caraway oil in animal feed under the proposed conditions of use is not expected to pose a risk to the environment.

3.5 | Efficacy

C. carvi, its fruit and their preparations are listed in Fenaroli's Handbook of Flavour Ingredients (Burdock, 2009) and by FEMA with the reference number 2236 (caraway, seed) and 2238 (caraway seed oil).

Since caraway oil and its preparations are recognised to flavour food and its function in feed would be essentially the same as that in food, no further demonstration of efficacy is considered necessary.

4 | CONCLUSIONS

Caraway oil from *Carum carvi* L. may be produced from plants of different geographical origins and by various processes resulting in preparations with different composition and toxicological profiles. Therefore, the following conclusions apply only to caraway oil which contains ≤ 0.50% perillaldehyde and is produced by steam distillation of fruit of *C. carvi*.

The conclusions of the FEEDAP Panel on the concentrations of caraway oil in complete feed (mg/kg), which are considered of no concern for the respective target animal species are summarised as follow:

Animal categories	Feed concentration of no concern (mg/kg complete feed)[a]
Turkeys for fattening	12
Chickens for fattening, other poultry for fattening or reared for laying/reproduction, ornamental birds	9
Laying hens and other laying/reproductive birds	13
Pigs for fattening	16
Piglets and other porcine species for meat production or reared for reproduction	19
Sows and other porcine species for reproduction	24
Veal calves (milk replacer)	35
Sheep/goats	10
Cattle for fattening, other bovines for fattening or reared for milk production/reproduction, cervids and camelids at the same physiological stage	11
Dairy cows and other bovines, cervids and camelids for milk production or reproduction	10
Horses and other equines	10
Rabbits and other leporids	10
Salmonids and minor fin fish	25
Dogs	25

[a] Complete feed containing 88% DM, milk replacer 94.5% DM.

For cats, ornamental fish and other species, no conclusion can be drawn. The FEEDAP Panel considers that the use in water for drinking is of no concern provided that the total daily intake of the additive does not exceed the daily amount that is considered of no concern when consumed via feed.

The use of caraway oil in animal feed under the proposed conditions of use is safe for the consumer and the environment.

[38] Technical dossier/Supplementary Information February 2024/2024-02-19_SIn_Reply_cararway_seed_oil.

[39] Technical dossier/Supplementary Information February 2024/Conf_Annex_XI_SIn reply_caraway_seed_oil_MSDS. Inhalation hazard (H304, may be fatal if swallowed and enters airways), hazards for skin irritation (H315, category 2), skin sensitisation (H317, category 1).

The additive under assessment should be considered as irritant to skin and eyes, and as a skin and respiratory sensitiser. When handling the essential oil, exposure of unprotected users to perillaldehyde may occur. Therefore, to reduce the risk, the exposure of the users should be minimised.

Caraway oil is recognised to flavour food. Since its function in feed would be essentially the same as that in food, no further demonstration of efficacy is considered necessary.

5 | DOCUMENTATION PROVIDED TO EFSA/CHRONOLOGY

Date	Event
28/10/2010	Dossier received by EFSA. Botanically defined flavourings from Botanical Group 02 - Apiales and Austrobaileyales for all animal species and categories. Submitted by Feed Flavourings Authorisation Consortium European Economic Interest Grouping (FFAC EEIG)
09/11/2010	Reception mandate from the European Commission
26/02/2013	EFSA informed the applicant (EFSA ref. 7,150,727) that, in view of the workload, the evaluation of applications on feed flavourings would be re-organised by giving priority to the assessment of the chemically defined feed flavourings, as agreed with the European Commission
24/06/2015	Technical hearing during risk assessment with the applicant according to the "EFSA's Catalogue of support initiatives during the life-cycle of applications for regulated products": data requirement for the risk assessment of botanicals
17/06/2016	Technical hearing during risk assessment with the applicant according to the "EFSA's Catalogue of support initiatives during the life-cycle of applications for regulated products". Discussion on the ongoing work regarding the pilot dossiers BDG08 and BDG 09
27/04/2017	Trilateral meeting organised by the European Commission with EFSA and the applicant FEFANA on the assessment of botanical flavourings: characterisation, substances of toxicological concern present in the botanical extracts, feedback on the pilot dossiers
27/02/2019	Partial withdrawal by applicant (EC was informed) for the following additives: dill seed extract, celery seed extract (oleoresin), caraway oleoresin/extract, and opoponax oil
24/06/2019	Application validated by EFSA – Start of the scientific assessment
03/07/2019	Request of supplementary information to the applicant in line with Article 8(1)(2) of Regulation (EC) No 1831/2003 – Scientific assessment suspended. *Issues: characterisation, safety for the target species, safety for the consumer, safety for the user, safety for the environment*
30/09/2019	Comments received from Member States
31/10/2022	Reception of the Evaluation report of the European Union Reference Laboratory for Feed Additives – partial report related to nine additives *(dill herb oil, dill tincture, dong quai tincture, cumin oil, fennel tincture, parsley tincture, anise tincture, star anise tincture and ferula assa-foetida oil)*
16/12/2022	Reception of an addendum of the Evaluation report of the European Union Reference Laboratory for Feed Additives – final report related to 11 additives *(celery seed oil, caraway seed oil, coriander oil, taiga root tincture, fennel oil, common ivy extract (sb), ginseng tincture, anise oil, anise star oil, anise star terpenes and omicha tincture)*
19/02/2024	Reception of supplementary information from the applicant (partial dataset on caraway seed oil) - Scientific assessment remains suspended
22/05/2024	The application was split and a new EFSA-Q-2024-00305 was assigned to the additive included in the present assessment. Scientific assessment re-started for the additive included in the present assessment
27/06/2024	Opinion adopted by the FEEDAP Panel on celery seed oil (EFSA-Q-2024-00305). End of the Scientific assessment for the additive included in the present assessment. The assessment of other additives belonging to BDG 02 is still ongoing

ABBREVIATIONS

AFC	EFSA Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food
BDG	Botanically defined group
BMD	Benchmark dose
$BMDL_{10}$	Benchmark dose (BMD) lower confidence limit for a benchmark response of 10%
BW	Body Weight
CAS	Chemical Abstracts Service
CD	Commission Decision
CDG	Chemically Defined Group
CEF	EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids
CG	Chemical Group
CoE	Council of Europe
DM	Dry Matter
EEIG	European economic interest grouping
EINECS	European Inventory of Existing Chemical Substances
EMA	European Medicines Agency

EURL	European Union Reference Laboratory
FAF	EFSA Panel on Food Additives and Flavourings
FEEDAP	EFSA Scientific Panel on Additives and Products or Substances used in Animal Feed
FEMA	Flavor Extract Manufacturers Association
FFAC	Feed Flavourings authorisation Consortium of (FEFANA) the EU Association of Specialty Feed Ingredients and their Mixtures
FGE	Flavouring Group Evaluation
FLAVIS	The EU Flavour Information System
FL-No	FLAVIS number
GC	Gas Chromatography
GC-FID	Gas Chromatography with Flame Ionisation Detector
GC–MS	Gas Chromatography–Mass Spectrometry
GLP	Good Laboratory Practice
ISO	International Standard Organization
JECFA	The Joint FAO/WHO Expert Committee on Food Additives
MF	mutation frequency
MOE	Margin of Exposure
MOET	Combined Margin of Exposure (Total)
NOAEL	No Observed Adverse Effect Level
OECD	Organization for Economic Co-operation and Development
QSAR	Quantitative Structure–Activity Relationship
SC	EFSA Scientific Committee
TG	Test Guideline
TGR	transgenic Muta™ Mouse (assay)
TTC	Threshold of Toxicological Concern
WHO	World Health Organization

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CONFLICT OF INTEREST

If you wish to access the declaration of interests of any expert contributing to an EFSA scientific assessment, please contact interestmanagement@efsa.europa.eu.

REQUESTOR

European Commission

QUESTION NUMBER

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