European Food Safety Authority

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## SCIENTIFIC OPINION

# Scientific Opinion on the re-evaluation of paprika extract (E 160c) as a food additive[1]

**EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS)**[2, 3, 4]

European Food Safety Authority (EFSA), Parma, Italy

*This scientific output, published on 5 June 2017, replaces the earlier version published on 10 December 2015*

## ABSTRACT

The EFSA Panel on Food Additives and Nutrient Sources added to Food provides a scientific opinion re-evaluating the safety of paprika extract (E 160c). Paprika extract (E 160c) is a natural dye allowed as a food additive in the EU. The bioavailability of capsanthin and capsorubin from paprika extract is very low. Toxicological data were limited to a 13-week oral toxicity and one chronic toxicity and carcinogenicity study on a specified paprika extract (DN-933), representative of commercially produced paprika extracts used as food colour. Based on the new studies on the specified paprika extract (DN-933), compliant with good laboratory practice (GLP), which fulfil the requirements for genotoxicity assessment according to the EFSA guidelines on food additives, the Panel concluded that paprika extracts used as food colours do not raise a genotoxic concern. No reproductive and developmental toxicity studies are available, but evaluated by read-across. The Panel concluded in the chronic toxicity and carcinogenicity study that for the dose levels tested, paprika extract (E 160c) was not carcinogenic. Based on the lack of genotoxic potential, the Panel considered that the no-observed-adverse-effect level (NOAEL) for histopathological changes from this study could be used for establishing an acceptable daily intake (ADI). On this basis, the Panel established an ADI of 24 mg/kg bw/day for paprika extract (E 160c). Based on the analytical data on paprika extract N1, which is reported to be comparable to the specified paprika extract used in these studies (DN-933), the total carotenoid content was 7.1%. Using this value, the Panel established an ADI of 1.7 mg carotenoids/kg bw/day for paprika extract

[1] On request from the European Commission, Question No EFSA-Q-2011-00353, adopted on 19 November 2015. The Panel noted the corrections during its plenary meeting on 6 April 2017.

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[3] Acknowledgement: The Panel wishes to thank the members of the former Working Group 'B' Food Additives and Nutrient Sources (2011–2014) and the members of the Standing Working Group on the re-evaluation of food colours: Fernando Aguilar, Riccardo Crebelli, Alessandro Di Domenico, Maria Jose Frutos, Pierre Galtier, David Gott, Claude Lambré, Jean-Charles Leblanc, Agneta Oskarsson, Jeanne Stadler, Paul Tobback, Ine Waalkens-Berendsen and Rudolf Antonius Woutersen, for the preparatory work on this scientific opinion and EFSA staff members Ana Maria Rincon, Alexandra Tard and Stavroula Tasiopoulou for the support provided to this scientific opinion. The ANS Panel wishes to acknowledge all European competent institutions, bodies and other organisations that provided data for this scientific output.

[4] Erratum: Some of the values reported in Appendix B of the original publication were erroneous and have been corrected: the affected FCS categories were: 03, 04.2.5.2, 05.2, 06.3, 07.2, 12.5, 12.6, 14.1.4. In addition, entry 14.2.6. of Appendix A has been removed. These errors did not impact on the final outcome of the opinion, however, to avoid confusion the original version has been removed from the EFSA Journal and is available on request, as is a version showing all the changes made.

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(E 160c). Exposures to paprika extract (E 160c) for the refined exposure assessment scenarios were below the ADI established by the Panel.



**KEY WORDS**

Paprika extract, E 160c, CAS Registry Number 465-42-9, CAS Registry Number 470-38-2, capsanthin, capsorubin, food colour

## SUMMARY

*Following a request from the European Commission to the European Food Safety Authority (EFSA), the Scientific Panel on Food Additives and Nutrient Sources added to Food (ANS Panel) was* asked to provide a scientific opinion re-evaluating the safety of paprika extract (E 160c) when used as a food additive.

Paprika extract (E 160c) is a natural dye with capsanthin and capsorubin being the principle colouring compounds. Paprika extract (E 160c) is authorised as a food additive in the European Union (EU), according to Annex II to Regulation (EC) No 1333/2008 on food additives. Specifications for paprika extract (E 160c) are defined in Commission Regulation (EU) No 231/212 laying down specifications for food additives. Paprika extract (E 160c) is permitted *quantum satis* (QS) in food except for meat preparations and processed meat, in which it is allowed up to 10 mg/kg product, and foodstuffs in which the use of colours is specifically prohibited.

Paprika extract (E 160c) has been evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in 1970, 1989, 2000 and 2008, but no acceptable daily intake (ADI) was ever allocated. In the 2008 evaluation, no ADI was allocated, due to concerns as to whether the material tested in the 90-day study and the long-term study was representative of all commercial paprika extracts used as a food colour. Furthermore, JECFA requested information on the concentrations of capsaicin present in the extracts and additional information about the composition of batches of extract produced by a variety of manufacturers. At the 77th JECFA meeting in 2013, following receipt of additional analytical data, the specifications were revised, and the tentative status was removed. At its 79th meeting, JECFA reconsidered the toxicological data and the dietary exposure and established an ADI for paprika extract for use as a food colour of 0–1.51 mg/kg body weight (bw), expressed as total carotenoids.

The use of paprika extract (E 160c) as a food colour has not been evaluated previously by the Scientific Committee on Food (SCF) or EFSA. Capsaicin was evaluated as a flavouring substance by the SCF in 2002. As a limit of 250 mg/kg has been set for the content of capsaicin in paprika extract (E 160c) (Commission Regulation (EU) No 231/2012), studies dealing with capsaicin toxicity are of limited relevance to paprika extracts used as a food colour (E 160c) and are therefore not described in this opinion.

The bioavailability of capsanthin and capsorubin from paprika extract is very low. The Panel agreed with the conclusion of JECFA in 2008, that there are no indications that carotenoids from paprika extract (E 160c) would behave differently from other oxygenated carotenoids with respect to their low bioavailability. When capsanthin is absorbed, it is transported by plasma lipoproteins. The half-life for capsanthin in plasma is approximately 20 hours in man. Capsanthin can be oxidised to capsanthone and its geometrical isomer 11-*cis*-capsanthin in man.

Toxicological data on a paprika extract (E 160c), including capsanthin and capsorubin, were limited to a 13-week oral toxicity study and one chronic toxicity and carcinogenicity study in rats on a specified paprika extract (DN-933). The no-observed-adverse-effect level (NOAEL) in the 13-week oral toxicity study was 5.0% paprika extract/kg bw/day, equivalent to 2948 mg paprika extract/kg bw/day for males and 3197 mg paprika extract/kg bw/day for females.

Paprika extract (E 160c) was not carcinogenic to male and female F344 rats according to a two-year combined chronic toxicity and carcinogenicity study on a specified paprika extract (DN-933). Slight histopathological changes were observed in livers of males exposed to 5% paprika extract in their feed (the highest dose tested, equivalent to approximately 2 500 mg paprika extract/kg bw/day).

Several studies in rats and mice show the carcinogenic or tumour promoting potential of capsaicin or chilli extract, although no carcinogenic effects were observed in other studies. However, as paprika extracts used as a food colour contain a very low amount of capsaicin, the relevance of the studies

using chilli pepper or capsaicin for the assessment of chronic toxicity or carcinogenic effects of paprika extract as a food colour is limited.

Mixed results are reported in the literature from a few, relatively old, limited *in vitro* genotoxicity studies with paprika extracts of different purity and composition. Therefore, upon request of EFSA, two new good laboratory practice (GLP) compliant genotoxicity studies using a specified paprika extract (DN-933), representative of commercially available paprika extracts used as the food additive (E 160c), were submitted by the Natural Food Colours Association (NATCOL) in 2014. These studies, which fulfil the requirements for genotoxicity assessment according to the EFSA guidelines on food additives (EFSA ANS Panel, 2012), were negative and the Panel concluded that there was no evidence of genotoxic potential for paprika extract.

No data on reproductive and developmental toxicity of paprika extract (E 160c) are available. Nevertheless, the Panel noted that in 2014, JECFA based on the results of a dietary, GLP compliant developmental toxicity study that had been performed with lutein, a carotenoid of similar structure to capsanthin, concluded by a read-across, that paprika extracts meeting the specifications for use as a food colour are unlikely to pose a reproductive/developmental hazard. The Panel agreed that this read-across was appropriate and agreed with this conclusion.

Considering the widespread consumption of paprika extract (E 160c) and the absence of reports on allergic and intolerance reactions, the Panel concluded that the food additive paprika extract (E 160c) is unlikely to represent a safety concern as regards allergenicity and immunotoxicity.

Based on the lack of genotoxic potential, the Panel considered that the NOAEL for histopathological changes from the combined chronic toxicity and carcinogenicity study by Inoue et al. (2008) could be used for establishing an ADI. For males, this was equivalent to 2388 mg/kg bw/day, and for females equivalent to 2826 mg/kg bw/day. On this basis and using the default uncertainty factor of 100, the Panel established an ADI of 24 mg/kg bw/day for paprika extract (E 160c).

Based on the analytical data on paprika extract N1, which is reported by NATCOL to be comparable to the specified paprika extract DN-933 used in these studies, the total carotenoid content was 7.1%. Using this value, the NOAELs expressed on a carotenoid basis would be equivalent to 170 mg carotenoids/kg bw/day for males and to 200 mg carotenoids/kg bw/day for females, respectively. On this basis and using the default uncertainty factor of 100, the Panel established an ADI of 1.7 mg carotenoids/kg bw/day for paprika extract (E 160c).

According to the EC specifications, concentrations up to 250 mg capsaicin/kg, i.e. 0.25% are allowed. The paprika extract generally contains less than 0.01% capsaicin.

For the maximum level exposure assessment scenario, mean estimates ranged from 0.1 to 1.8 mg carotenoids/kg bw/day across all population groups. Estimates based on the high percentile (95th percentile) ranged from 0.3 to 2.7 mg carotenoids/kg bw/day across all population groups.

For the refined exposure assessment scenario, in the brand-loyal scenario, mean exposure to paprika extract (E 160c) from its use as a food additive ranged from 0.1 mg carotenoids/kg bw/day to 1.1 mg carotenoids/kg bw/day. The high exposure to paprika extract (E 160c) ranged from 0.2 mg carotenoids/kg bw/day to 1.7 mg carotenoids/kg bw/day. In the non-brand-loyal scenario, mean exposure to paprika extract (E 160c) ranged from < 0.1 mg carotenoids/kg bw/day to 0.5 mg carotenoids/kg bw/day in children. The high exposure ranged from 0.1 mg carotenoids/kg bw/day to 0.8 mg carotenoids/kg bw/day. Dietary exposure from the food additive and the regular diet would lead to a mean intake for children of 0.2 to 0.5 mg/kg bw/day (non-brand-loyal scenario). On average, dietary exposure from the natural diet would represent around 1% of the dietary exposure.

Exposures to paprika extract (E 160c) in the refined exposure assessment scenarios were below the ADI established by the Panel.

## RECOMMENDATIONS

The Panel recommended that:

- In the EC specifications, the term 'paprika oleoresin' as a synonym of 'paprika extract' should not be used.
- Limits for pesticides and mycotoxins could be considered in the specifications to avoid any potential adverse effects.
- The maximum limits for toxic elements (arsenic, lead, mercury and cadmium) present as impurities in the EC specification for paprika extract (E 160c) should be revised to ensure that paprika extract (E 160c) as a food additive will not be a significant source of exposure to these toxic elements in food.
- The EC specifications could be based on total capsaicinoids rather than on capsaicin only.

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## BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Regulation (EC) No 1333/2008[5] of the European Parliament and of the Council on food additives requires that food additives are subject to a safety evaluation by the European Food Safety Authority (EFSA) before they are permitted for use in the European Union. In addition, it is foreseen that food additives must be kept under continuous observation and must be re-evaluated by EFSA.

For this purpose, a programme for the re-evaluation of food additives that were already permitted in the European Union before 20 January 2009 has been set up under Regulation (EU) No 257/2010[6]. This Regulation also foresees that food additives are re-evaluated whenever necessary in light of changing conditions of use and new scientific information. For efficiency and practical purposes, the re-evaluation should, as far as possible, be conducted by group of food additives according to the main functional class to which they belong.

The order of priorities for the re-evaluation of the currently approved food additives should be set on the basis of the following criteria: the time since the last evaluation of a food additive by the Scientific Committee on Food (SCF) or by EFSA, the availability of new scientific evidence, the extent of use of a food additive in food and the human exposure to the food additive taking also into account the outcome of the Report from the Commission on Dietary Food Additive Intake in the EU[7] of 2001. The report 'Food additives in Europe 2000[8]' submitted by the Nordic Council of Ministers to the Commission, provides additional information for the prioritisation of additives for re-evaluation. As colours were among the first additives to be evaluated, these food additives should be re-evaluated with the highest priority.

In 2003, the Commission already requested EFSA to start a systematic re-evaluation of authorised food additives. However, as a result of the adoption of Regulation (EU) 257/2010, the 2003 Terms of Reference are replaced by those below.

## TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

The Commission asks the European Food Safety Authority to re-evaluate the safety of food additives already permitted in the Union before 2009 and to issue scientific opinions on these additives, taking especially into account the priorities, procedure and deadlines that are enshrined in the Regulation (EU) No 257/2010 of 25 March 2010 setting up a programme for the re-evaluation of approved food additives in accordance with the Regulation (EC) No 1333/2008 of the European Parliament and of the Council on food additives.

[5] Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives, OJ L 354, 31.12.2008, p. 16.

[6] Commission Regulation (EU) No 257/2010 of 25 March 2010 setting up the program for the re-evaluation of approved food additives in accordance with Regulation (EC) No 1333/2008 of the European Parliament and of the Council on food additives, OJ L 80, 26.03.2010, p.19.

[7] Report from the Commission on Dietary Food Additive Intake in the European Union, Brussels, 01.10.2001, COM (2001) 542 final.

[8] Food Additives in Europe 2000, Status of safety assessments of food additives presently permitted in the EU, Nordic Council of Ministers. TemaNord 2002:560.

## ASSESSMENT

### 1. Introduction

The present opinion deals with the re-evaluation of the safety of paprika extract, capsanthin, capsorubin (E 160c) when used as a food additive.

Paprika extract (E 160c) is a natural food colouring substance that contains capsanthin and capsorubin as its two major colouring principles. Paprika extract has not been evaluated by the Scientific Committee on Food (SCF). Paprika extract has been evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) for use as a flavouring agent in 1970, 1989 and 2000, and for use as a colour in 2008, 2013 and 2014 (JECFA, 1970; 1990; 2001; 2008; 2013; 2014).

According to Commission Regulation (EU) No 231/2012[9], the official name of the colouring is paprika extract, capsanthin, capsorubin (E 160c), but in the text only the name paprika extract (E 160c) is used. The term paprika oleoresin has been used as a synonym of paprika extract. According to the European Commission (EC) specifications, concentrations of up to 250 mg of residual capsaicin/kg i.e. 0.025% are allowed in the food additive. The paprika extract generally contains less than 0.01% capsaicin (JECFA, 2008).

As the source material and the manufacturing process differ for paprika preparations used as a spice and as a food colour, the name paprika extract was adopted for use as a food colour (this identification has preferentially been used in the text of this Opinion), leaving the term paprika oleoresin for use as a spice, of which capsaicin is an important component. JECFA (2008) was aware that food colouring substances that are currently available in the marketplace may be referred to as paprika oleoresin. The extract contains mainly oil and neutral lipids.

The Panel on Food Additives and Nutrient Sources added to Food (ANS Panel) was not provided with a newly submitted dossier and based its evaluation on previous evaluations, additional literature that became available since then and the data available following public calls for data.[10,11,12] The Panel noted that not all original studies on which previous evaluations were based were available for re-evaluation by the Panel. To assist in identifying any emerging issue or any information relevant for the risk assessment, the European Food Safety Authority (EFSA) outsourced a contract to deliver an updated literature review on toxicological endpoints, dietary exposure and occurrence levels of paprika extract, (E 160c), which covered the period from the beginning of 2013 up to the end of 2014. Further update has been performed by the Panel.

### 2. Technical data

#### 2.1. Identity of the substance

Paprika extract (E 160c) is obtained by solvent extraction of the strains of paprika, which consists of the ground fruit pods, with or without seeds, of *Capsicum annuum* L., and contains as its major colouring principles, the carotenoids capsanthin and capsorubin (Commission Regulation (EU) No 231/2012). A variety of other coloured compounds, such as other carotenoids, is known to be present, and capsaicin at low concentrations (JECFA, 2009).

[9] Commission Regulation (EU) No 231/2012 on food additives specifications of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council. OJ L 83, 22.3.2012, p. 1.

[10] Call for scientific data on food colours to support re-evaluation of all food colours authorised under the EU legislation. Published: 8 December 2006. Available online: http://www.efsa.europa.eu/en/dataclosed/call/afc061208.htm

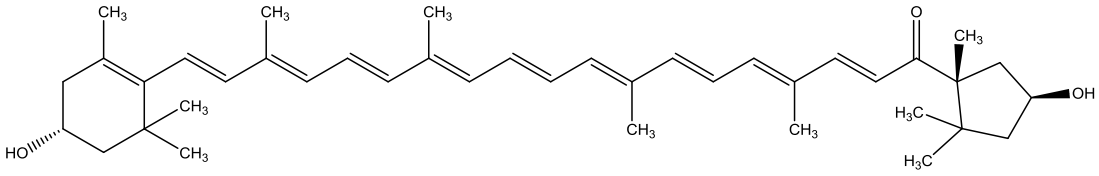
[11] Call for scientific data on paprika extract, capsanthin, capsorubin (E 160c). Published 30 March 2011. Available online: http://www.efsa.europa.eu/en/dataclosed/call/ans110331.htm

[12] Call for scientific data on selected food additives permitted in the EU. Published 23 March 2014. Available online: http://www.efsa.europa.eu/en/dataclosed/call/140324.htm

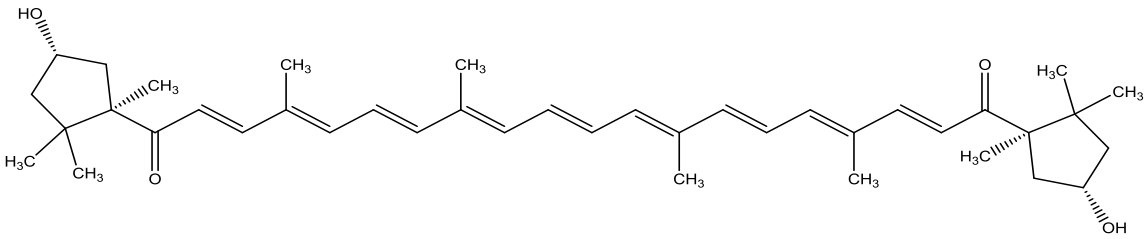
The chemical name of capsanthin is (3R, 3'S, 5'R)-3,3'-dihydroxy-β,k-carotene-6-one. It has the molecular formula $C_{40}H_{56}O_3$, a molecular weight of 584.85 g/mol, the CAS Registry Number is 465-42-9 and the EINECS (EC) number is 207-364-1 (Commission Regulation (EU) No 231/2012; SciFinder software, 2015).

Capsorubin has the chemical name (3S, 3'S, 5R, 5'R)-3,3'-dihydroxy-k,k-carotene-6,6'-dione. It has the molecular formula $C_{40}H_{56}O_4$, a molecular weight of 600.85 g/mol, the CAS Registry Number is 470-38-2 and the EINECS (EC) number is 207-425-2 (Commission Regulation (EU) No 231/2012; SciFinder software, 2015).

The structural formulae of capsanthin and capsorubin are given in Figure 1.



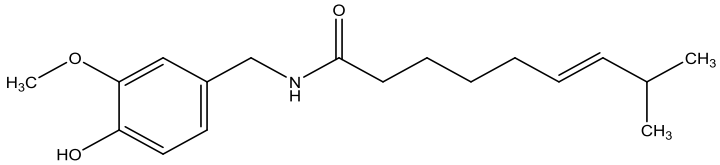

Capsanthin




Capsorubin

**Figure 1:** Structural formulae of capsanthin and capsorubin

Capsaicin is a non-colouring compound and the major pungent and pharmacological active component of various *Capsicum* fruits. It has the chemical name (E)-8-methyl-*N*-vanillyl-6-nonenamide. The molecular formula is $C_{18}H_{27}NO_3$ and its molecular weight is 305.40 g/mol. Its CAS Registry Number is 404-86-4 and the EINECS (EC) number is 206-969-8 (SciFinder software, 2015). Capsaicin is a minor component (less than 0.025%) of the food additive paprika extract (E 160c).




Capsaicin

**Figure 2:** Structural formula of capsaicin. The structure of capsaicin is shown for completeness, but this non-colouring compound can be present in E 160c only at levels much lower than capsanthin and capsorubin together.

Paprika extract (E 160c) is a dark-red viscous liquid practically insoluble in water, but soluble in acetone and other organic solvents (Commission Regulation (EU) No 231/2012; JECFA, 2014); capsanthin, capsorubin and capsaicin are soluble in oil (Emerton, 2008).

## 2.2. Specifications

Specifications have been defined in Commission Regulation (EU) No 231/2012, laying down specifications for food additives and by JECFA (2014) (Table 1).

**Table 1:** Specifications for paprika extract (E 160c) according to Commission Regulation (EU) No 231/2012 and JECFA (JECFA, 2014)

| Purity | Commission Regulation (EU) No 231/2012 | JECFA (2014) |
|---|---|---|
| *Solvent residues*: | | |
| Ethyl acetate<br>Methanol<br>Ethanol<br>Acetone<br>Hexane<br>Propan-2-ol | ≤ 50 mg/kg, singly or in combination | ≤ 50 mg/kg, singly or in combination |
| Dichloromethane | ≤ 10 mg/kg | — [a] |
| Carbon dioxide, supercritical | — [b] | — [b] |
| Capsaicin | ≤ 250 mg/kg | — [c] |
| Capsaicinoids | — [b] | ≤ 200 mg/kg |
| Assay | Paprika extract: content not less than 7.0% carotenoids<br>Capsanthin/capsorubin: not less than 30% of total carotenoids<br>$E^{1\%}_{1cm}$ 2 100 at ca. 462 nm in acetone | Total carotenoids: not less than 7%<br>Capsanthin: not less than 30% of total carotenoids<br>Maximum absorption in acetone at about 462 nm and in hexane at about 470 nm |
| Arsenic | ≤ 3 mg/kg | ≤ 1 mg/kg |
| Lead | ≤ 2 mg/kg | ≤ 1 mg/kg |
| Mercury | ≤ 1 mg/kg | — [b] |
| Cadmium | ≤ 1 mg/kg | — [b] |

(a) The use of dichloromethane for extraction is not foreseen.
(b) No maximum level is provided.
(c) Capsaicin is included in the maximum level for capsaicinoids.

Paprika extract (E 160c) contains the colouring principles capsanthin and capsorubin in varying proportions; several other colouring principles and a variety of chemicals have been reported (see Section 2.4) to be present in the extract (Cantrill, 2013; Natural Food Colours Association (NATCOL), 2014). According to Commission Regulation (EU) No 231/2012, the amount of total carotenoids in the extract should not be less than 7.0%, while the sum of capsanthin/capsorubin should not be less than 30% of total carotenoids. Therefore, it may be inferred that the level of capsanthin and capsorubin together in the extract should be at least 2.1%.

It can be noticed that in the EC specifications 'paprika oleoresin' is a synonym of 'paprika extract, capsanthin, capsorubin'. However, as the source material and the manufacturing process differ for paprika preparations used as a spice or as a food colour, in 2008 JECFA adopted the name 'paprika extract' for the food colour and 'paprika oleoresin' for the spice (JECFA, 2009) (the identification paprika extract has preferentially been used in the text of this opinion), despite the fact that marketed paprika preparations used for food colouring may commonly be referred to as paprika oleoresin.

Additionally, JECFA considered the major colouring principles and decided to remove capsorubin from the specifications because it appeared to be a minor component of the article in commerce: in the JECFA 2014 specifications, the synonyms for paprika extract are INS No 160c (ii) and capsanthin. As in Regulation (EU) No 231/2012, also for JECFA, the amount of total carotenoids in the paprika extract should not be less than 7.0%; however, relative to total carotenoid content, the minimum value of 30% applies to capsanthin only.

The Panel noted that the specifications for paprika extract (E 160c) according to Commission Regulation (EU) No 231/2012 and JECFA (2014) differ slightly with regard to the solvents allowed for extraction and purification of paprika extract and to the maximum allowed concentrations of heavy metals (Table 1). The Panel noted that according to the EC specifications for paprika extract (E 160c), impurities of the toxic elements arsenic, lead, mercury and cadmium are accepted up to a concentration of 3, 2, 1 and 1 mg/kg, respectively. Contamination at these levels could have a significant impact on the exposure to these metals, for which the intake are already close to the health-based guidance values established by EFSA (EFSA CONTAM Panel, 2009a, 2009b, 2010, 2012). The Panel considered that the maximum limits for certain of toxic elements (arsenic, lead, mercury and cadmium) present as impurities in the EC specifications for paprika extract (E 160c), should be revised in order to ensure that E 160c used as food additive will not be a significant source of exposure to these toxic elements in food.

The Panel noted that capsaicinoids, including capsaicin, being responsible for the pungency of the spice, are undesired substances in the food colour, for which processing steps are applied to reduce its content. Therefore, limits for this substance have been set in the EC specifications, limiting capsaicin to 250 mg/kg and by JECFA for total capsaicinoids, to 200 mg/kg.

Paprika extracts are obtained from ground fruit pods, with or without seeds, and may contain mycotoxins and pesticide residues. The Panel noted that limits on pesticides, mycotoxins and other components with biological activity (e.g. phytoestrogens, phytotoxins and allergens), possibly present in the food additive as used, could be considered in the specifications to avoid any potential adverse effects.

### 2.3. Manufacturing process

Paprika extract (E 160c) contains as the major colouring principles capsanthin and capsorubin. A wide variety of other coloured compounds are also known to be present. Oil-soluble extract of varying concentrations is produced by diluting or solubilising paprika extract in refined food-grade vegetable oil with the purpose of standardization of the extract (Emerton, 2008).

The solvents that may be used for extraction are reported in the preceding section.

Fruits of crops of *Capsicum annuum* L. strains, with or without seeds, are harvested and then dried out by sun-drying, in hot air-dryers or in drying chambers. The dried *Capsicum* pods are ground and pelleted before solvent extraction of the colour, leading to a paprika extract which, in addition to pigments, may contain a relatively high level of capsaicin. Typically, 1 kg of dried *Capsicum* pods yields 90 to 120 g of paprika extract. The pigment concentration in the extract depends mainly on two parameters, the composition of the fruit and the extraction technique employed. With respect to the fruit, the organic solvent will extract all of the lipophilic compounds, which are the pigments and the oil from the pepper. The oil is present in much higher quantity than the pigments. In addition, the pigments are located in cellular structures that are more difficult to access for the solvent. The oil is preferentially extracted at the early stage of the process and subsequently becomes richer in pigments. At the end of this process the solvent is evaporated (Jarén-Galán et al., 1999). This material is termed the primary extract.

The primary extract can undergo a second extraction process to remove some or all of the capsaicinoids which yields:

(i) purified capsaicin for which a commercial demand exists and which can also be used to standardise the capsaicin content of other *Capsicum* extracts and,

(ii) a resin containing less capsaicin than the primary extract and which, depending on the analytical results and its flavour characteristics, may be sold as a colouring extract or as a spice oleoresin.

The primary extract, if low in capsaicin, or the capsaicin-reduced extract, can be subjected to a further processing step to reduce flavour and aroma, and so yield the colour extract. These final extracts are standardised by either adding food-grade oils or turned into water-dispersible formulations by adding food emulsifiers.

Although new extraction methods, such as extraction with supercritical carbon dioxide have been investigated, according to NATCOL (2014), there was no information on the extent these new extraction methods are being utilised commercially. Jarén-Galán et al. (1999) noted that using these methods, higher pigment yields could be obtained with higher extraction volumes, increasing extraction pressures, and similarly, the use of co-solvents such as 1% ethanol or acetone. The supercritical methods also allowed differential pigment concentration, with *β*-carotene almost exclusively isolated at lower pressures, and a greater proportion of red carotenoids (capsorubin, capsanthin, zeaxanthin, *β*-cryptoxanthin), with small amounts of *β*-carotene obtained at higher pressures.

### 2.4. Composition of paprika extracts

A study containing indications of the relative amounts of capsanthin and capsorubin in the extracted carotenoid mixture was provided by Deli et al. (2001). These authors investigated the changes in carotenoid pigments of *Capsicum annuum* var. *lycopersiciforme rubrum* during ripening using a high-performance liquid chromatography (HPLC) technique: 40 peaks were detected and 34 carotenoids identified. The total carotenoid content of the ripe fruits was about 1.3 g/100 g dry weight and exhibited the following composition: capsanthin, 37%; zeaxanthin, 8%; cucurbitaxanthin A, 7%; capsorubin, 3.2%; *β*-carotene, 9%. The remainder comprised capsanthin-5,6-epoxide, capsanthin-3,6-epoxide, 5,6-diepikarpoxanthin, violaxanthin, antheraxanthin, *β*-cryptoxanthin, and several isomers and furanoid oxides.

NATCOL submitted analytical data on the composition of six commercial paprika extracts used as food colours (Cantrill, 2013; NATCOL, 2014). These data included the levels of capsaicin and capsaicinoids, heavy metals, minerals, mycotoxins and residual solvents in the different extracts. The data were part of the original NATCOL data submission and follow-up for paprika extract (E 160c) in reply to the call for data for the 77$^{th}$ JECFA Meeting in 2013. These data were the basis for revision of JECFA specifications for paprika extract, and for removal of the provisional 'tentative status' (JECFA, 2008) from the specifications defined at the 79th JECFA Meeting (JECFA, 2014).

The paprika extracts, marketed for the commercial colouring of food, were selected from different producers in Spain and India and identified with the following sample codes: N1, Japanese-sourced material, originated in Spain; N2, Indian-extracted material; N3, Spanish-extracted material; N5, Spanish-extracted material; N6, Spanish-extracted material; N7, Peruvian material extracted in Spain. NATCOL considered that the comparison of extract N1 with the other paprika extracts allowed the conclusion that extract N1 is representative of commercially produced paprika extracts used as food colours. The results obtained (Cantrill, 2013; NATCOL, 2014) can be summarised as follows:

- carotenoids (including capsanthin and capsorubin): 4 243–8 438 mg/100 g (4.2–8.4% of the extract);
- total amount of capsanthin and capsorubin together: 1 859–4 432 mg/100 g (37.5–58.1% of total carotenoids);
- capsaicin: < 0.15–82 mg/kg (compliant with regulatory limit);
- capsaicinoids (including capsaicin): < 0.45–< 190 mg/kg;
- proteins: 0.2–0.4 g/100 g;

- carbohydrates: < 0.1–0.9 g/100 g;
- total fats (following acid digestion): 98.7–99.6 g/100 g;
- water: ≤ 0.1 g/100 g;
- ash: < 0.1–0.2 g/100 g;
- sum of regulated heavy metals: < 0.2 mg/kg (individually compliant with regulatory limits);
- sum of aflatoxins tested: < 0.4–< 0.8 µg/kg;
- solvents: in general, compliant with regulatory limits.

The carotenoid composition in paprika extract samples was analysed via HPLC and diode array detection (DAD) (Seybold et al., 2004). The content of total carotenoids in the different paprika extracts varied between 4.2% and 8.4%. However, according to NATCOL (2014), these data cannot be directly compared with the minimum content requirement for total carotenoids as defined in the specifications for paprika extracts, as for the latter, a spectrophotometric assay is foreseen. In total, the samples were analysed for 17 different carotenoids, of which capsanthin accounted for the largest proportion with values between 36.7% and 56.1% of total carotenoids. Other major pigments were (13Z)-*β*-carotene (mean, 8.7%), (15Z)-*β*-carotene (7.8%) and zeaxanthin (7.4%). The content of capsorubin varied between 0.6% and 2.3% of total carotenoids, whereas capsaicinoids (including capsaicin) were less than 190 mg/kg. In subsequent submissions, NATCOL reduced the list of the carotenoids of interest for the analytical laboratory to those expected to occur naturally in *Capsicum* plants, as some compounds had never been detected in any of the six commercial batches of paprika extract analysed. In particular, the following carotenoids were removed from the list: citranaxanthin, lycopene and *β*-apo-8'-carotenoic acid ethyl ester. In addition, a peak originally identified as canthaxanthin was later reported as 'not identified carotenoid' on the basis that this peak was only detected in the saponified fraction of the samples but not in the unsaponified fraction. On the whole, 10 carotenoids were identified and quantified.

The Panel considered that pigment concentrations in an extract are known to be quite variable and mainly dependent on the composition of the fruit and the extraction technique employed. The organic solvent used extracts from the fruit all the lipophilic compounds, i.e. the pigments and the oil from the pepper pericarp, and at the end of the process it is evaporated; therefore, paprika extracts primarily consist of carotenoid pigments, and extracted and/or added vegetable oil. Commercially available products are standardised to give a minimum total carotenoid content of 7%.

The six paprika extract samples were analysed for 26 different fatty acids according to the method published by the German Society of Fat Science (DGF, 1998). Major components of the fatty acid composition were palmitic acid (7.1–17.6%), oleic acid (8.3–43.5%), linoleic acid (35.2–56.4%) and linolenic acid (6.4–12.0%). In total, *trans* fatty acids were present below 0.3%, although in extract N1 they reached up to approximately 0.9%.

Heavy metals and minerals in paprika extracts were determined by inductively coupled plasma optical emission spectroscopy (ICP-OES) and mass spectrometry (ICP-MS). Samples were prepared according to the official method of LFGB (Guideline BVL L 00.00-19/1).[13] Concentrations of heavy metals were below their limit of detection (in mg/kg): arsenic, < 0.1; cadmium, < 0.01; lead, < 0.05; mercury, < 0.005. The content of iron varied between 0.6 and 18 mg/kg, whereas copper concentrations fell in the range < 0.1–0.5 mg/kg. The following elements were also measured: sodium

[13] Amtliche Sammlung §64 LFGB, L 00.00-19/1: Untersuchung von Lebensmitteln – Bestimmungen von Elementspuren in Lebensmitteln – Teil 1: Druckaufschluss (Übernahme der gleichnamigen Deutschen Norm DIN EN 13805, Ausgabe Juni 2002), Beuth Verlag GmbH, Berlin.

(< 3–320 mg/kg), calcium (4–50 mg/kg), magnesium (4.5–78 mg/kg), and phosphorus (140–390 mg/kg). According to NATCOL (2014), the inorganic phosphorus found in the samples was probably present as phospholipids before samples were digested with acid for the determination of total fat. On average, phospholipids were estimated to be 7.5% of total fat, as discussed in Carelli et al. (2002).

Aflatoxins B1, B2, G1 and G2 were quantified via HPLC-immunoaffinity chromatography (HPLC-IAC) (DIN EN 14123).[14] The highest concentration found in a sample was 0.5 µg/kg (aflatoxin B1), with a measurement uncertainty of 0.2 µg/kg. Concentrations for the other aflatoxins (B2, G1 and G2) were below the limit of detection (< 0.1 µg/kg) for all six paprika extracts.

Paprika extract samples were tested for the presence of 30 different solvents by gas chromatography-mass spectrometry (GC-MS) according to a modified version of the US EPA method 5021A.[15] In one sample (N5), hexane was found at a level of 43 mg/kg, whereas in all the other samples it was not detected (< 0.5 mg/kg). No other solvents were found to be present at levels above their limit of detection (< 5 mg/kg or lower).

The Panel noted that the overall mass balance of the quantitative data submitted can exceed 100% by approximately 5–10%, a feature that characterises all the extracts. The deviation was assumed as possibly due to the different analytical methods used to quantify various groups of substances.

Based on the evaluation of the aforementioned data, the Panel expressed a general agreement with NATCOL conclusions, that: (1) the composition of the six paprika extracts tested was reasonably homogenous; (2) batch N1 could be taken to be representative of marketed commercial preparations; (3) capsaicinoid levels (as sum of capsaicin, dihydrocapsaicin and nordihydrocapsaicin) were below 190 mg/kg and thus complied with the EC specifications established for paprika extracts (E 160c). The Panel also noted that the assessed heavy metal levels were significantly lower than the current EC specifications.

### 2.5. Methods of analysis in foods

According to Commission Regulation (EU) 231/2012 and to JECFA (2014), the identification of carotenoids in paprika extract (E 160c) can be made by spectrophotometry, with a maximum in acetone at ca. 462 nm, or by colour reaction, through a deep blue colour that is produced by adding one drop of sulphuric acid to one drop of sample in 2-3 drops of chloroform. However, these methods are non-specific and thus not suitable to determine the capsanthin/capsorubin content of food. The method described in JECFA (2014) for capsanthin is a reversed-phase HPLC assay with diode array detector and a C-18 column. The sample is saponified prior to analysis to release the parent hydroxy-carotenoids, using known standards to allow quantification of individual carotenoids. Some minor carotenoids, capsorubin and capsanthin elute first, being the $\beta$-carotene the last one. Total capsanthin (% of total carotenoids) is calculated as the ratio between the area of capsanthin peak and the total area of the peaks in the chromatogram. The majority of the carotenoid separations in the literature involve the use of reversed phase HPLC. Among the published methods for the determination and quantification of carotenoids, a simultaneous reversed-phase HPLC determination of different carotenoids in food colourings including capsanthin, has been developed, with an accelerated solvent extraction using various food matrices and mass spectrometry for identification (Breithaupt, 2004). Other techniques have been proposed for the analysis of carotenoids in paprika extract, as ultra high-performance supercritical fluid chromatography (UHPSFC) with an optimum separation of the pigments (Berger and Berger, 2013). A method using the HPLC-DAD-TOF-MS system, with a reversed-phase column coupled with a time-of-flight mass spectrophotometer has also been reported (Cervantes-Paz et al., 2012).

[14] Foodstuffs – Determination of aflatoxin B1 and the sum of aflatoxin B1, B2, G1 and G2 in hazelnuts, peanuts, pistachios, figs and paprika powder – High performance liquid chromatographic method with post-column derivatisation and immunoaffinity column clean up; German version EN 14123:2008.

[15] United States Environmental Protection Agency. Method 5021A – Volatile organic compounds in various sample matrices using equilibrium headspace analysis. Revision 1, June 2003.

## 2.6. Reaction and fate in foods

The carotenoids in paprika extract (E 160c) present a polyene chain with alternated double and single bonds, that is responsible for their colouring properties, but also makes them very sensitive to heat, light and prooxidant conditions, reacting very easily with free radicals generated in oxidative processes, as lipid oxidation (Boon et al., 2010). Carotenoids in the paprika extract are solved in a lipid substrate where endogenous oxidation occurs very easily. The influence of the lipid composition on the stability of paprika extracts has been studied, concluding that a high unsaturation level of the lipid fraction can enhance the degradative reactions in the extracts promoted by the oxygen, and found that the loss of colour quality takes place as a consequence of the temperature (Pérez-Gálvez and Minguez-Mosquera, 2004). To avoid oxygen-mediated autoxidation reactions and a consequent loss of colour in paprika extracts, the contact with oxygen may be minimised through different strategies.

The temperatures and times of drying of the fruit used for extraction are variable and can affect the thermolabile compounds as the carotenoids (Jarén-Galán and Mínguez-Mosquera et al., 1999). When extracts are stored at different temperatures (40, 60, 80 and 100ºC) covering all the industrial processes in which paprika extract can be used as food colourant, the increase in temperature leads to higher pigment loss and a decrease in colouring capacity. It has been reported that for total pigments in extracts and each temperature, the change in concentration was related to treatment time, although the same qualitative pigment profile was maintained throughout the heat treatments. The loss of pigmentation in paprika extracts is marked at temperatures above 60ºC, although any heat treatment would result in a decrease of the total pigment concentration (Jarén-Galán and Mínguez-Mosquera, 1999).

## 2.7. Case of need and proposed uses

Maximum levels of paprika extract (E 160c) have been defined in Annex II to Regulation (EC) No 1333/2008[16] on food additives. These levels are referred by the Panel as maximum permitted levels (MPLs) in this document.

Currently, paprika extract (E 160c) is a food additive authorised in the EU to be added at *quantum satis* (QS) in foods, apart from meat preparations and processed meat (authorised at 10 mg/kg). Paprika extract (E 160c) is included in Group II (food colours authorised at QS).

Table 2 summarises foods that are permitted to contain paprika extract, capsanthin, capsorubin (E 160c), as set by Annex II to Regulation (EC) No 1333/2008.

**Table 2:** MPLs of paprika extract (E 160c) in foods according to the Annex II to Regulation (EC) No 1333/2008

| FCS category no.[(a)] | FCS food category | E-number/ Group | Restrictions/exceptions | MPL (mg/L or mg/kg as appropriate) |
|---|---|---|---|---|
| **01.4** | Flavoured fermented milk products including heat-treated products | Group II | | *Quantum satis* |
| **01.5** | Dehydrated milk as defined by Directive 2001/114/EC | Group II | Except unflavoured products | *Quantum satis* |
| **01.6.3** | Other creams | Group II | Only flavoured creams | *Quantum satis* |
| **01.7.1** | Unripened cheese excluding products falling in category 16 | Group II | Only flavoured unripened cheese | *Quantum satis* |
| **01.7.2** | Ripened cheese | E 160c | Only ripened orange, yellow and broken-white cheese and red pesto | *Quantum satis* |

[16] Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives. OJ L 354, 31.12.2008.

| FCS category no.[(a)] | FCS food category | E-number/ Group | Restrictions/exceptions | MPL (mg/L or mg/kg as appropriate) |
|---|---|---|---|---|
| | | | cheese | |
| **01.7.3** | Edible cheese rind | Group II | | *Quantum satis* |
| **01.7.4** | Whey cheese | Group II | | *Quantum satis* |
| **01.7.5** | Processed cheese | Group II | Only flavoured processed cheese | *Quantum satis* |
| **01.7.5** | Processed cheese | E 160c | | *Quantum satis* |
| **01.7.6** | Cheese products (excluding products falling in category 16) | Group II | Only flavoured unripened products | *Quantum satis* |
| **01.7.6** | Cheese products (excluding products falling in category 16) | E 160c | Only ripened orange, yellow and broken-white cheese | *Quantum satis* |
| **01.8** | Dairy analogues, including beverage whiteners | Group II | | *Quantum satis* |
| **03** | Edible ices | Group II | | *Quantum satis* |
| **04.2.1** | Dried fruits and vegetables | E 160c | Only preserves of red fruit | *Quantum satis* |
| **04.2.2** | Fruits and vegetables in vinegar, oil or brine | E 160c | Only preserves of red fruit | *Quantum satis* |
| **04.2.3** | Canned or bottled fruit and vegetables | E 160c | Only preserves of red fruit | *Quantum satis* |
| **04.2.4.1** | Fruit and vegetable preparations excluding compote | Group II | Only *mostarda di frutta* | *Quantum satis* |
| **04.2.4.1** | Fruit and vegetable preparations excluding compote | E 160c | Only preserves of red fruit | *Quantum satis* |
| **04.2.4.1** | Fruit and vegetable preparations excluding compote | E 160c | Only seaweed based fish roe analogues | *Quantum satis* |
| **04.2.5.2** | Jam, jellies and marmalades and sweetened chestnut purée as defined by Directive 2001/113/EC | E 160c | Except chestnut purée | *Quantum satis* |
| **04.2.5.3** | Other similar fruit or vegetable spreads | Group II | Except *crème de pruneaux* | *Quantum satis* |
| **05.2** | Other confectionery including breath freshening microsweets | Group II | | *Quantum satis* |
| **05.3** | Chewing gum | Group II | | *Quantum satis* |
| **05.4** | Decorations, coatings and fillings, except fruit-based fillings covered by category 4.2.4 | Group II | | *Quantum satis* |
| **06.3** | Breakfast cereals | Group II | Only breakfast cereals other than extruded, puffed and/or fruit-flavoured breakfast cereals | *Quantum satis* |
| **06.3** | Breakfast cereals | E 160c | Only extruded puffed and or fruit flavoured breakfast cereals | *Quantum satis* |
| **06.5** | Noodles | Group II | | *Quantum satis* |
| **06.6** | Batters | Group II | | *Quantum satis* |
| **06.7** | Precooked or processed cereals | Group II | | *Quantum satis* |
| **07.2** | Fine bakery wares | Group II | | *Quantum satis* |
| **08.2** | Meat preparations as defined by Regulation (EC) No 853/2004 | E 160c | Only merguez type products, *salsicha fresca, butifarra fresca, longaniza fresca, chorizo fresco, bifteki, soutzoukaki* and *kebap* | 10 |
| **08.3.1** | Non-heat-treated processed meat | E 160c | Only sausages | 10 |

| FCS category no.[(a)] | FCS food category | E-number/ Group | Restrictions/exceptions | MPL (mg/L or mg/kg as appropriate) |
|---|---|---|---|---|
| **08.3.2** | Heat-treated processed meat | E 160c | Only sausages, patés and terrines | 10 |
| **08.3.3** | Casings and coatings and decorations for meat | Group II | Except edible external coating of *pasturmas* | *Quantum satis* |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | Group II | Only surimi and similar products and salmon substitutes | *Quantum satis* |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | E 160c | Only fish paste and crustacean paste | *Quantum satis* |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | E 160c | Only precooked crustacean | *Quantum satis* |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | E 160c | Only smoked fish | *Quantum satis* |
| **09.3** | Fish roe | Group II | Except Sturgeons' eggs (Caviar) | *Quantum satis* |
| **12.2.2** | Seasonings and condiments | Group II | Only seasonings, for example curry powder, tandoori | *Quantum satis* |
| **12.4** | Mustard | Group II | | *Quantum satis* |
| **12.5** | Soups and broths | Group II | | *Quantum satis* |
| **12.6** | Sauces | Group II | Excluding tomato-based sauces | *Quantum satis* |
| **12.7** | Salads and savoury-based sandwich spreads | Group II | | *Quantum satis* |
| **12.9** | Protein products, excluding products covered in category 1.8 | Group II | | *Quantum satis* |
| **13.2** | Dietary foods for special medical purposes defined in Directive 1999/21/EC (excluding products from food category 13.1.5) | Group II | | *Quantum satis* |
| **13.3** | Dietary foods for weight-control diets intended to replace total daily food intake or an individual meal (the whole or part of the total daily diet) | Group II | | *Quantum satis* |
| **13.4** | Foods suitable for people intolerant to gluten as defined by Regulation (EC) No 41/2009 | Group II | | *Quantum satis* |
| **14.1.4** | Flavoured drinks | Group II | Excluding chocolate milk and malt products | *Quantum satis* |
| **14.2.3** | Cider and perry | Group II | Excluding *cidre bouché* | *Quantum satis* |
| **14.2.4** | Fruit wine and made wine | Group II | Excluding *wino owocowe markowe* | *Quantum satis* |
| **14.2.5** | Mead | Group II | | *Quantum satis* |
| **14.2.6** | Spirit drinks as defined in Regulation (EC) No 110/2008 | Group II | Except: spirit drinks as defined in Article 5(1) and sales denominations listed in Annex II, paragraphs 1-14 of Regulation (EC) No 110/2008 and spirits (preceded by the name of the fruit) obtained by | *Quantum satis* |

| FCS category no.[(a)] | FCS food category | E-number/ Group | Restrictions/exceptions | MPL (mg/L or mg/kg as appropriate) |
|---|---|---|---|---|
| | | | maceration and distillation, Geist (with the name of the fruit or the raw material used), London Gin, Sambuca, Maraschino, Marrasquino or Maraskino and Mistrà | |
| **14.2.7.3** | Aromatised wine-product cocktails | Group II | | *Quantum satis* |
| **14.2.8** | Other alcoholic drinks including mixtures of alcoholic drinks with non-alcoholic drinks and spirits with less than 15% of alcohol | Group II | | *Quantum satis* |
| **15.1** | Potato-, cereal-, flour- or starch-based snacks | Group II | | *Quantum satis* |
| **15.2** | Processed nuts | Group II | | *Quantum satis* |
| **16** | Desserts excluding products covered in categories 01, 03 and 04 | Group II | | *Quantum satis* |
| **17.1** | Food supplements supplied in a solid form including capsules and tablets and similar forms, excluding chewable forms | Group II | | *Quantum satis* |
| **17.2** | Food supplements supplied in a liquid form | Group II | | *Quantum satis* |
| **17.3** | Food supplements supplied in a syrup-type or chewable form | Group II | | *Quantum satis* |

FCS: Food Categorisation System (food nomenclature) presented in the Annex II to Regulation (EC) No 1333/2008.

## 2.8. Reported use levels of paprika extract (E 160c)

Most food additives in the EU are authorised at a specific MPL. However, a food additive may be used at a lower level than the MPL. Therefore, information on actual use levels is required for performing a more realistic exposure assessment, especially for those food additives for which no MPL is set and which are authorised according to QS.

In the framework of Commission Regulation (EU) No 257/2010[17] setting up a programme for the re-evaluation of approved food additives in accordance with Regulation (EC) No 1333/2008 of the European Parliament and of the Council on food additives, EFSA launched a public call[18] for scientific data on food colours (including also paprika extract, E 160c) to support the re-evaluation of all food colours authorised under the EU legislation. Among other information, the former EFSA Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (AFC) was seeking data on present use and use patterns (i.e. which food categories and subcategories, proportion of food within categories/subcategories in which it is used, actual use levels (typical and maximum use levels), especially for those uses which are limited only by QS. In response to this public call, usage data on paprika extract (E 160c) were submitted to EFSA by industry.

[17] Commission Regulation (EU) No 257/2010 of 25 March 2010 setting up a programme for the re-evaluation of approved food additives in accordance with Regulation (EC) No 1333/2008 of the European Parliament and of the Council on food additives. OJ L 80, 26.3.2010.

[18] Call for scientific data on food colours to support re-evaluation of all food colours authorised under the EU legislation. Published: 8 December 2006. Available online: http://www.efsa.europa.eu/en/dataclosed/call/afc061208.htm

### 2.8.1. Summarised data on reported use levels in foods provided by industry

Industry provided EFSA with data on use levels of paprika extract (E 160c) in foods for 45 out of the 61 food categories in which E 160c is authorised. Information was provided by the following interested parties: Confederation of the Food and Drink Industries of the EU (CIAA – currently FoodDrinkEurope, FDE) and by NATCOL in 2009. In July 2015, NATCOL submitted updated use levels. These levels were expressed as total carotenoids, therefore used as such for the present exposure estimates.

The Panel noted that for almost all foods in which paprika extract (E 160c) is authorised, use levels were reported by industry especially for the most consumed ones (flavoured fermented milk products, breakfast cereals, fine bakery wares). No use levels were reported for paprika extract (E 160c) for some dairy products, fish roe, dietary foods and food supplements. The Panel noted that, according to the Mintel GNDP database,[19] very few foods belonging to some of the food categories mentioned above are reported to contain E 160c (i.e. one fish roe product), consistently with what was reported to EFSA. Considering that these foods are not important contributors, this would result in minor underestimation of the exposure.

On the contrary, according to the information available in this database, other foods in which the use of paprika extract (E 160c) is not authorised were found to contain E 160c: processed meat products (other than those permitted to contain E 160c), chocolates.

Appendix A provides data on the use levels of paprika extract (E 160c) in foods as reported by industry.

## 2.9. Information on existing authorisations and evaluations

Although paprika extract (E 160c) has not been previously evaluated by the Scientific Committee for Food (SCF) specifically as a food colour, it is permitted as a food additive in the EU under Regulation (EC) No 1333/2008. Capsaicin, a component of paprika extract (E 160c), was evaluated as a flavouring substance by the SCF in 2002. It was concluded that 'the available data did not allow the committee to establish a safe exposure level for capsaicinoids in food' (SCF, 2002).

Paprika oleoresins for use as a spice have been evaluated by JECFA in 1970 and 2000 (JECFA, 1970, 2001). In 1970, no ADI was established by JECFA as it was concluded that 'Use as a spice will be self-limiting and governed by good manufacturing practice'. The 2000 JECFA evaluation (JECFA, 2001) did not evaluate data on paprika oleoresin, but reviewed the 1970 JECFA evaluation following a request for clarification by the Codex Committee on Food Additives and Contaminants. Overall, the Committee concluded that the previous evaluation is to be interpreted as 'the use of paprika oleoresin as a spice is acceptable'. In 1989, the extraction solvents used for paprika oleoresin production were evaluated, and the specifications were revised (JECFA, 1990).

Paprika extract has been evaluated as a food colour by JECFA in 2008. As the source material and manufacturing process for paprika preparations used as a spice differ from those used for paprika preparations used as a food colour, it was decided to apply the term 'paprika oleoresin' for use as a spice and 'paprika extract' (E 160c) for use as a food colour (JECFA, 2008). JECFA did not allocate an ADI due to concerns regarding the composition of the test material used in the studies included in the evaluation. The Committee was concerned as to whether the test material in these studies was sufficiently representative of all commercial products of paprika extract (E 160c). JECFA requested information on the concentrations of capsaicin present in the extracts and additional information about the composition of batches of extract produced by a variety of manufacturers. JECFA also wanted assurance that the material tested in the 90-day and long-term studies in rats was representative of all commercial production of paprika extract.

[19] Mintel Global New Products Database (http://www.mintel.com/global-new-products-database). Accessed on 05/11/2015.

At the 77th meeting of JECFA (JECFA, 2013), following receipt of additional analytical data, the specifications were revised, and the tentative status was removed. The Chemical and Technical Assessment prepared at the 69th meeting was also revised to include the composition of commercial preparations.

At its 79th meeting, JECFA reconsidered the toxicological data and the dietary exposure in order to establish an ADI for paprika extract for use as a food colour (JECFA, 2014). The data are presented in detail in the toxicological monograph prepared at the 69th meeting and were summarised only briefly in the report of the 79th meeting. No new toxicity data or data on dietary exposure had been submitted to the Committee since its 69th meeting, therefore no monograph addendum was prepared at the 79th meeting. JECFA established an ADI for paprika extract used as a food colour of 0–1.51 mg/kg bw, expressed as total carotenoids, with the application of an uncertainty factor of 100 to the no-observed-adverse-effect level (NOAEL) of 153 mg/kg bw/day from a 2-year toxicity and carcinogenicity study in rats.

In 2006, in the opinion of the EFSA Scientific Panel on Additives and Products or Substances used in Animal Feed (FEEDAP Panel) Part II. Capsanthin (citranaxanthin and cryptoxanthin), the Panel concluded that there were insufficient data for quantitative risk assessment (EFSA, 2006). Consumption figures for *Capsicum spp.* as vegetable sources of capsanthin in human diets were not available for the EU Member states. A scenario calculated from the available data showed that daily intake of capsanthin/capsorubin via 100 g of egg could amount to 90 µg capsanthin/capsorubin (16 mg paprika carotenoids/kg diet) and to another 360 µg capsanthin (20 mg paprika xanthophylls/kg diet) by 90 g poultry skin, which is equivalent to a maximum of 21.4 (4.3 + 17.1) mg of paprika extracts (E 160c). On the basis of this scenario, the FEEDAP Panel considered it likely that capsanthin/capsorubin derived from poultry fed paprika extracts at concentrations adequate for egg and skin colour negligibly contribute to total human exposure.

## 2.10. Exposure assessment

### 2.10.1. Food consumption data used for exposure assessment

#### 2.10.1.1. EFSA Comprehensive European Food Consumption Database

Since 2010, the EFSA Comprehensive European Food Consumption Database (Comprehensive Database) has been populated with national data on food consumption at a detailed level. Competent authorities in the European countries provide EFSA with data on the level of food consumption by the individual consumer from the most recent national dietary survey in their country (cf. Guidance of EFSA 'Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment' (EFSA, 2011a)). New consumption surveys recently added in the Comprehensive Database were also taken into account in this assessment.[20,21]

The food consumption data gathered by EFSA were collected using different methodologies and thus direct country-to-country comparison should be made with caution. Depending on the food category and the level of detail used for exposure calculations, uncertainties could be introduced owing to possible underreporting by subjects and/or misreporting of the consumption amounts. Nevertheless, the EFSA Comprehensive Database represents the best available source of food consumption data across Europe at present.

Food consumption data for the following population groups: infants, toddlers, children, adolescents, adults and the elderly were used for the exposure assessment. For the present assessment, food consumption data were available from 33 different dietary surveys carried out in 19 European countries (Table 3).

[20] Available online: http://www.efsa.europa.eu/en/datexfoodcdb/datexfooddb.htm
[21] Available online: http://www.efsa.europa.eu/en/press/news/150428.htm

**Table 3:** Population groups considered for the exposure estimates of paprika extracts (E 160c)

| Population | Age range | Countries with food consumption surveys covering more than one day |
|---|---|---|
| Infants | From 4 months up to and including 11 months of age | Bulgaria, Denmark, Finland, Germany, Italy, UK |
| Toddlers | From 12 months up to and including 35 months of age | Belgium, Bulgaria, Denmark, Finland, Germany, Italy, Netherlands, Spain, UK |
| Children [(a)] | From 36 months up to and including 9 years of age | Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Latvia, Netherlands, Spain, Sweden, UK |
| Adolescents | From 10 years up to and including 17 years of age | Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Italy, Latvia, Spain, Sweden, UK |
| Adults | From 18 years up to and including 64 years of age | Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Romania, Spain, Sweden, UK |
| The elderly [(a)] | From 65 years of age and older | Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Romania, Sweden, UK |

(a) The terms 'children' and 'the elderly' correspond, respectively, to 'other children' and the merge of 'elderly' and 'very elderly' in the Guidance of EFSA on the 'Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment' (EFSA, 2011b).

Consumption records were codified according to the FoodEx classification system (EFSA, 2011b). Nomenclature from the FoodEx classification system has been linked to the Food Categorisation System (FCS) as presented in the Annex II to Regulation (EC) No 1333/2008, part D, to perform exposure estimates. In practice, FoodEx food codes were matched to the FCS food categories.

2.10.1.2. Food categories selected for the exposure assessment of paprika extract (E 160c)

The food categories in which the use of paprika extract (E 160c) is authorised were selected from the nomenclature of the EFSA Comprehensive Database (FoodEx classification system food codes), at a detailed level (up to FoodEx Level 4) (EFSA, 2011b).

Some food categories and/or their relative restrictions/exceptions are not referenced in the EFSA Comprehensive Database and therefore could not be taken into account in the present estimate. This might result in an underestimation of the exposure. The food categories which were not taken into account are described below (in ascending order of the FCS codes):

- 01.6.3. Other creams, only flavoured creams;
- 01.7.3. Edible cheese rind;
- 04.2.4.1. Fruit and vegetable preparations excluding compote, only *mostarda di frutta*;
- 04.2.4.1. Fruit and vegetable preparations excluding compote, only seaweed based fish roe analogues;
- 05.4. Decorations, coatings and fillings, except fruit-based fillings covered by category 04.2.4;
- 06.6. Batters;
- 06.7. Pre-cooked or processed cereals;
- 08.3.3. Casings and coatings and decorations for meat, except edible external coating of *pasturmas*;
- 14.2.4. Fruit wine and made wine, excluding *wino owocowe markowe*;
- 14.2.5. Mead.

For the following food categories, the restrictions which apply to the use of paprika extract (E 160c), could not be taken into account, and therefore the whole food category was considered for the exposure estimates. This results in an overestimation of the exposure:

- 01.7.1. Unripened cheese excluding products falling in category 16, only flavoured unripened cheese;
- 01.7.2. Ripened cheese, only ripened orange, yellow and broken-white cheese and red pesto cheese;
- 01.7.6. Cheese products, (excluding products falling in category 16), only flavoured unripened products/only ripened orange, yellow and broken-white cheese;
- 04.2.5.2. Jam, jellies and marmalades and sweetened chestnut purée as defined by Directive 2001/113/EC, except chestnut purée;
- 04.2.5.3. Other similar fruit or vegetable spreads, except *crème de pruneaux*;
- 9.3. Fish roe, except sturgeons' eggs (caviar);
- 14.2.3. Cider and perry, excluding *cidre bouché*;
- 17.1./17.2./17.3. Food supplements: it was not possible to differentiate solid, liquid or syrup-type, or chewable forms of food supplements within FoodEx codes.

Overall, 10 food categories were not taken into account in the exposure assessment because these are not referenced in the EFSA Comprehensive Database, and 10 food categories were included in the exposure assessment without considering the restrictions as set in Annex II to Regulation No 1333/2008. Added to that, no reported use levels were made available for 16 out of the 61 food categories in which paprika extract (E 160c) is authorised (Appendix A). In total, 19 food categories were not taken into account in the exposure assessment of paprika extract (E 160c) for one or both reasons described above (no FoodEx code, no reported use levels available).

### 2.10.2. Exposure to paprika extract (E 160c) from its use as a food additive

The Panel estimated chronic exposure to paprika extract (E 160c) for the following population groups: infants, toddlers, children, adolescents, adults and the elderly. Dietary exposure was calculated by multiplying paprika extract (E 160c) concentrations reported in Appendix B for each food category with their respective consumption amount per kilogram of body weight for each individual in the Comprehensive Database. The exposure per food category was subsequently added to derive an individual total exposure per day. These exposure estimates were averaged over the number of survey days, resulting in an individual average exposure per day for the survey period. Surveys with only one day per subject were excluded as considered not adequate to assess chronic dietary exposure.

This was carried out for all individuals per survey and per population group, resulting in distributions of individual exposure per survey and population group (Table 3). Based on these distributions, the mean and 95th percentile of exposure were calculated per survey for the total population and per population group. High percentile exposure was only calculated for those population groups where the sample size was sufficiently large to allow calculation of the 95th percentile of exposure (EFSA, 2011b). Therefore, in the present assessment, high levels of exposure for infants from Italy and for toddlers from Belgium, Italy and Spain were not included. Thus, for this assessment, food consumption data were available from 33 different dietary surveys carried out in 19 European countries (Table 3).

Exposure assessment for paprika extract (E 160c) was carried out by the ANS Panel based on (1) maximum use levels (defined as the maximum level exposure assessment scenario) and (2) reported use levels (defined as the refined exposure assessment scenario) as provided to EFSA by industry. These two scenarios are discussed in detail below.

2.10.2.1. Maximum level exposure assessment scenario

The regulatory maximum level exposure assessment scenario is based on the MPLs as set in Annex II to Regulation (EC) No 1333/2008. As paprika extract (E 160c) is authorised at QS in almost all food categories, a maximum level exposure assessment scenario was estimated based on the maximum reported use levels provided by industry (Appendix A), as described in the EFSA Conceptual framework (EFSA ANS Panel, 2014).

The exposure estimates derived following this scenario should be considered as the most conservative, as this scenario assumes that a consumer will be continuously (over a lifetime) exposed to paprika extract (E 160c) present in food at the maximum reported use levels.

Appendix B summarises the concentration levels of paprika extract (E 160c) used in the maximum level exposure assessment scenario (column maximum).

2.10.2.2. Refined exposure assessment scenario

The refined exposure assessment scenario is based on use levels reported by industry. This exposure scenario can consider only food categories where the above data were available.

Appendix B summarises the concentration levels of paprika extract (E 160c) used in the refined exposure assessment scenario. Based on the available dataset, the Panel calculated two refined exposure estimates based on different model populations:

1. The brand-loyal consumer scenario: it was assumed that a consumer is exposed long-term to the food additive present at the maximum reported use levels for one food category. The exposure estimate is calculated as follows:

    - Combining food consumption with the maximum reported use for the main contributing food category at the individual level.

    - Using the mean of the typical reported use for the remaining food categories.

2. The non-brand-loyal consumer scenario: it was assumed that a consumer is exposed long-term to the food additive at the mean reported use levels in food. This exposure estimate is calculated using the mean of the typical reported use levels for all food categories.

Food categories (n=10) for which FoodEx classification linkage was available, but no usage levels were reported, were not considered in the exposure assessment (Appendix B). The Panel noted that if paprika extract (E 160c) is nevertheless used in those food categories for which reported use/analytical levels were not available, the calculated refined exposure assessment might result in underestimation of exposure.

2.10.2.3. Anticipated exposure to paprika extract (E 160c)

Table 4 summarises the estimated exposure to E 160c from its use as food additive in all six population groups (Table 3) according to the different exposure scenario's (Sections 2.10.2.1 and 2.10.2.2). Detailed results by population group and survey are presented in Appendix C.

**Table 4:** Summary of anticipated exposure to paprika extract (E 160c) from its use as a food additive using the maximum level exposure assessment scenario and refined exposure scenarios, in six population groups (min–max across the dietary surveys in mg/kg bw/day) expressed as total carotenoids

| | Infants (4-11 months) | Toddlers (12–35 months) | Children (3–9 years) | Adolescents (10–17 years) | Adults (18–64 years) | The elderly (≥ 65 years) |
|---|---|---|---|---|---|---|
| **Maximum level exposure assessment scenario** | | | | | | |
| Mean | 0.1-0.5 | 0.5-1.8 | 0.4-1.4 | 0.2-0.8 | 0.1-0.5 | 0.1-0.4 |
| High level (95th percentile) | 0.4-1.6 | 1.1-2.4 | 1.0-2.7 | 0.4-1.5 | 0.3-1.0 | 0.3-0.8 |
| **Refined exposure assessment scenario** | | | | | | |
| **Brand-loyal scenario** | | | | | | |
| Mean | 0.1-0.3 | 0.4-1.1 | 0.3-0.9 | 0.1-0.5 | 0.1-0.3 | 0.1-0.3 |
| High level (95th percentile) | 0.4-1.2 | 0.7-1.7 | 0.7-1.7 | 0.3-0.9 | 0.2-0.7 | 0.2-0.6 |
| **Non-brand-loyal scenario** | | | | | | |
| Mean | 0.1-0.2 | 0.2-0.5 | 0.2-0.4 | 0.1-0.2 | <0.1-0.1 | <0.1-0.2 |
| High level (95th percentile) | 0.2-0.8 | 0.4-0.8 | 0.3-0.8 | 0.2-0.5 | 0.1-0.4 | 0.1-0.4 |

### 2.10.3. Main food categories contributing to exposure to paprika extract (E 160c) using the maximum level exposure assessment scenario

**Table 5:** Main food categories contributing to exposure to paprika extract (E 160c) using maximum usage levels (> 5% to the total mean exposure) and number of surveys in which each food category is contributing

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[(a)] | | | | | |
| **01.4** | Flavoured fermented milk products including heat-treated products | 9.6-20.7 (2) | - | 5.2-20.8 (12) | 5.3-13.9 (6) | 5.3-8.6 (4) | 5.0-6.3 (5) |
| **01.7.1** | Unripened cheese excluding products falling in category 16 | 15.2 (1) | 5.0-8.4 (2) | 7.1 (1) | 7.9 (1) | 10.8 (1) | 6.0-9.7 (2) |
| **01.7.1** | Ripened cheese | 16.8 (1) | 5.0-7.0 (2) | - | 9.4 (1) | 5.3-6.0 (3) | 7.2-8.1 (3) |
| **01.7.5** | Processed cheese | 5.1-21.3 (2) | 16.9-25.9 (2) | 5.2-6.0 (2) | – | 5.2 (1) | 9.1 (1) |
| **03** | Edible ices | - | – | 5.5-8.6 (6) | 5.0-7.6 (2) | 5.2 (1) | – |
| **04.2** | Processed fruit and vegetables | 7.3-23.6 (3) | 5.1-7.0 (2) | – | – | - | 5.6-8.6 (5) |
| **05.2** | Other confectionery including breath freshening microsweets | - | - | 6.6-23.3 (3) | 5.6-32.6 (4) | 6.3-9.6 (3) | - |
| **06.3** | Breakfast cereals | 20.3-71.2 (4) | 6.4-49.2 (6) | 6.4-13.3 (11) | 5.4-18.0 (8) | 5.1-29.4 (7) | 6.9-51.1 (7) |
| **07.2** | Fine bakery wares | 6.1-58.9 (3) | 5.2-55.4 (9) | 12.7-50.5 (16) | 14.3-37.2 (15) | 76.2-35.3 (17) | 8.1-33.3 (14) |
| **08.3** | Meat products | - | - | - | - | 5.8 (1) | 5.5 (1) |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | - | 5.0-6.7 (3) | 5.8-11.9 (2) | 5.1 (1) | - | - |

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[a] | | | | | |
| **12.2.2** | Seasonings and condiments | - | 9.4 (1) | - | 11.2 (1) | 18.1 (1) | 17.8 (1) |
| **12.5** | Soups and broths | 7.2-67.0 (2) | 5.8-23.2 (6) | 5.4-36.5 (8) | 5.3-34.7 (7) | 5.1-42.1 (9) | 14.6-44.8 (8) |
| **12.6** | Sauces | 9.6 (1) | 6.8-10.6 (6) | 5.2-15.8 (14) | 6.0-19.4 (12) | 5.2-21.9 (14) | 6.5-17.7 (11) |
| **12.7** | Salads and savoury-based sandwich spreads | - | - | 5.7-5.8 (2) | 7.2 (1) | 6.2-12.4 (3) | 8.6-10.2 (2) |
| **14.1.4** | Flavoured drinks | 5.2-19.5 (2) | 9.0-31.6 (7) | 6.7-38.6 (18) | 9.4-50.0 (17) | 5.1-44.8 (17) | 5.2-34.0 (8) |
| **15.1** | Potato-, cereal-, flour- or starch-based snacks | 5.1-5.4 (2) | 5.7-8.4 (2) | 6.8-7.2 (2) | 5.5-9.8 (5) | 10.1 (1) | - |
| **16** | Desserts | 5.9-7.6 (2) | 5.2-11.0 (4) | 5.8-8.7 (3) | 6.2 (1) | 5.3 (1) | 5.3-7.5 (3) |

(a): The total number of surveys may be greater than the total number of countries as listed in Table 3, as some countries submitted more than one survey for a specific population.

### 2.10.4. Main food categories contributing to exposure to paprika extract (E 160c) using the refined exposure assessment scenarios

**Table 6:** Main food categories contributing to exposure to paprika extract (E 160c) using the brand-loyal refined exposure scenario (> 5% to the total mean exposure) and number of surveys in which each food category is contributing

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[a] | | | | | |
| **01.4** | Flavoured fermented milk products including heat-treated products | 9.3-15.4 (2) | 5.5-23.8 (9) | 5.4-22.9 (11) | 5.8-14.5 (6) | 5.5-7.9 (4) | 5.2-6.1 (3) |
| **01.7.1** | Unripened cheese excluding products falling in category 16 | 18.2 (1) | 6.2-10.1 (2) | 5.0-7.9 (2) | 10.1 (1) | 5.2-13.7 (2) | 5.5-11.8 (4) |
| **01.7.2** | Ripened cheese | 9.7-27.2 (2) | 5.5-12.5 (3) | 5.8-9.0 (4) | 5.7-16.6 (6) | 6.0-14.1 (10) | 6.2-17.1 (7) |
| **01.7.5** | Processed cheese | 20.5 (1) | 16.2-24.1 (2) | 6.1 (1) | - | 5.1 (1) | 8.9 (1) |
| **03** | Edible ices | - | - | 5.6-5.8 (2) | 5.4 (1) | - | - |
| **04.2** | Processed fruit and vegetables | 7.3 (1) | - | - | - | - | - |
| **05.2** | Other confectionery including breath freshening microsweets | - | 5-5 (2) | 5.8-27.6 (7) | 5.4-41.9 (7) | 5.5-10 (4) | - |
| **06.3** | Breakfast cereals | 33.6-90.3 (4) | 6-63.8 (7) | 5-24.4 (15) | 6.0-25.9 (14) | 5.4-43.6 (11) | 5.2-63.3 (9) |
| **06.5** | Noodles | - | - | - | 6.9 (1) | - | - |
| **07.2** | Fine bakery wares | 7.5-57.9 | 5.8-60 | 6.4-59.1 | 5.6-46.8 | 8.8-43.9 | 8.7-42.6 |

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[a] | | | | | |
| | | (3) | (9) | (17) | (16) | (17) | (14) |
| **08.3** | Processed meat | 5.4 (1) | 8.2 (1) | 5.8-6.6 (3) | 5.2-5.9 (4) | 5.4-18.6 (4) | 5.9-16.6 (3) |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | - | 5.6-6.4 (2) | 5.7-10.8 (2) | 6.1 (1) | - | - |
| **12.5** | Soups and broths | 7.1-65.7 (2) | 7.6-27.9 (5) | 6.4-37.4 (8) | 5.2-36.8 (8) | 5.4-43.6 (9) | 13.9-47.4 (8) |
| **12.6** | Sauces | - | - | - | 5.2 (1) | 5.0-5.2 (3) | - |
| **12.7** | Salads and savoury-based sandwich spreads | - | - | 5.1-5.6 (2) | 7.2 (1) | 6.3-13.4 (3) | 8.2-10 (2) |
| **14.1.4** | Flavoured drinks | 8.3 (1) | 5.2-17.1 (6) | 5.3-21.3 (13) | 6.8-28.8 (16) | 6-23.9 (13) | 5.4-17 (4) |
| **15.1** | Potato-, cereal-, flour- or starch-based snacks | - | 6.7 (1) | 6.4-6.9 (2) | 5.2-7.7 (6) | 9.3 (1) | - |
| **15.2** | Processed nuts | - | - | - | - | 7.9 (1) | 6.5 (1) |
| **16** | Desserts excluding products covered in category 1, 3 and 4 | - | 6.0-7.6 (2) | 5.0-6.0 (2) | - | - | - |

(a): The total number of surveys may be greater than the total number of countries as listed in Table 3, as some countries submitted more than one survey for a specific population.

**Table 7:** Main food categories contributing to exposure to paprika extract (E 160c) following the non-brand-loyal refined exposure scenario (> 5% to the total mean exposure) and number of surveys in which each food category is contributing

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[a] | | | | | |
| **01.4** | Flavoured fermented milk products including heat-treated products | 10.5-22.3 (2) | 6.8-29.1 (7) | 9.7-27.5 (8) | 6.3-13.5 (5) | 7.0-7.1 (2) | 5.1-7.8 (2) |
| **01.7.1** | Unripened cheese excluding products falling in category 16 | 15.5 (1) | 7.7 (1) | 5.2 (1) | 5.6 (1) | 8.7 (1) | 8.0 (1) |
| **01.7.2** | Ripened cheese | 16.3 (1) | 5.4-6.8 (2) | - | 10.0 (1) | 5.5-6.7 (3) | 7.6-9.2 (3) |
| **01.7.5** | Processed cheese | 17.3 (1) | 14.6-32.8 (2) | 9.1 (1) | - | - | 8.6 (1) |
| **03** | Edible ices | - | - | 5.4-5.7 (3) | 5.7 (1) | - | - |
| **04.2** | Processed fruit and vegetables | 6.5-20.3 (3) | - | - | - | - | - |
| **05.2** | Other confectionery including breath freshening microsweets | - | - | 5.6-30.8 (3) | 11.5-45.1 (2) | 5.0-11.1 (3) | - |
| **06.3** | Breakfast cereals | 24.8-76.9 (4) | 7-57.3 (6) | 6.9-16.4 (11) | 5.6-20 (8) | 5.2-39.7 (7) | 8.6-64.7 (7) |

| FCS category no. | FCS food category | Infants | Toddlers | Children | Adolescents | Adults | The elderly |
|---|---|---|---|---|---|---|---|
| | | Range of % contribution to the total exposure (Number of surveys)[a] | | | | | |
| **07.2** | Fine bakery wares | 5.3-64.2 (3) | 8.8-65.2 (8) | 11.5-60.8 (16) | 13.6-53.5 (15) | 5.3-47.9 (17) | 7.1-46.4 (14) |
| **08.3** | Processed meat | - | 5.2 (1) | - | - | 7.7 (1) | 7.3 (1) |
| **09.2** | Processed fish and fishery products including molluscs and crustaceans | - | 5.9-6.6 (3) | 13.9 (1) | 5.1 (1) | - | - |
| **12.2.2** | Herbs, spices, seasonings | - | 11.8 (1) | - | 14.2 (1) | 22.6 (1) | 20.7 (1) |
| **12.5** | Soups and broths | 7.9-72.6 (2) | 5.3-31.9 (6) | 5.2-49.5 (8) | 5.4-47.6 (7) | 5.8-54.8 (9) | 16.6-59.7 (8) |
| **12.6** | Sauces | 8.9 (1) | 5.1-8.9 (3) | 7-13.1 (4) | 6.3-18.3 (7) | 7.0-19.7 (10) | 5.4-16.5 (9) |
| **12.7** | Salads and savoury-based sandwich spreads | - | - | - | - | 8.1-12.0 (2) | 6.6-8.9 (2) |
| **14.1.4** | Flavoured drinks | 5-17.8 (2) | 8.2-42.8 (7) | 7.3-55.5 (15) | 6.1-67.1 (17) | 6.2-55.4 (16) | 5.2-39.4 (6) |
| **15.1** | Potato-, cereal-, flour- or starch-based snacks | - | 5.8-6.5 (2) | 6.5 (1) | 5.7-8.6 (3) | 11.8 (1) | |
| **16** | Desserts excluding products covered in categories 1, 3 and 4 | 6.8 (1) | 9.2 (1) | 6.6 (1) | - | - | 5.2 (1) |

(a): The total number of surveys may be greater than the total number of countries as listed in Table 3, as some countries submitted more than one survey for a specific population.

### 2.10.5. Uncertainty analysis

Uncertainties in the exposure assessment of paprika extract (E 160c) have been discussed above. According to the guidance provided in the EFSA opinion related to uncertainties in dietary exposure assessment (EFSA, 2006), the following sources of uncertainties have been considered and summarised in Table 8.

**Table 8:** Qualitative evaluation of influence of uncertainties on the dietary exposure estimate

| Sources of uncertainties | Direction[a] |
|---|---|
| Consumption data: different methodologies/representativeness/under reporting/misreporting/no portion size standard | +/- |
| Use of data from food consumption survey of few days to estimate long-term (chronic) exposure for high percentiles (95th percentile) | + |
| Correspondence of reported use levels to the food items in the EFSA Comprehensive Food Consumption Database: uncertainties on which precise types of food the levels refer to | +/- |
| Food categories selected for the exposure assessment: exclusion of food categories due to missing FoodEx linkage (n=10) | - |
| Food categories selected for the exposure assessment: inclusion of food categories without considering the restriction/exception (n=10) | + |
| Food categories included in the exposure assessment: concentration data not available for certain food categories which could not be included in the exposure estimates (n=16) | - |
| Reported use levels:<br>- uncertainty in possible national differences in use levels of food categories, usage data not fully representative of foods on the EU market<br>- levels considered applicable for the whole food category | + |

| Sources of uncertainties | Direction[(a)] |
|---|---|
| Maximum exposure assessment scenario: food categories authorised at the maximum reported use levels | + |
| Refined exposure assessment scenarios: exposure calculations based on the maximum or mean levels (reported use from industries) | +/- |

(a): Uncertainties with potential to cause overestimation of exposure are indicated by '+'; uncertainties with potential to cause underestimation of exposure are indicated by '–'.

Overall, the Panel considered that the uncertainties identified would result in an overestimation of the real exposure to paprika extract (E 160c) used as food additive considering the maximum exposure scenario, but not for the non-brand-loyal scenario, in European countries.

### 2.10.6. Exposure via the regular diet

The above exposure estimates (Table 4) do not take into account the intake of paprika used in the regular diet as a spice or of paprika peppers. Therefore, the intake of carotenoids from paprika used as a spice or paprika pepper was assessed using the EFSA Comprehensive database (Table 9).

Concentration levels of carotenoids in paprika (pepper and powder) were retrieved from the literature. According to Daood et al., 2014, carotenoid content of spice red pepper ranged between 3.6 and 7.6 mg/g dry weight basis. For paprika pepper (*Capsicum* varieties), a great variation is observed (both quantitative and qualitative) in carotenoid composition (Hart and Scott, 1995), ranging from 5.3 to 11.5 mg/g dry weight basis (from 22 varieties cultivated in indoor conditions). It was assumed that the average moisture of pepper is around 80%.

The mean intake coming from natural diet is negligible (below 0.1 mg/kg bw/day, expressed as total carotenoids) compared to the food additive.

Assessing exposure due to spice consumption based on food survey data would lead to underestimation.

**Table 9:** Consumption of paprika (pepper and powder) (all population) and resulting consumption of carotenoids in the six population groups

| | Infants (4-11 months) | Toddlers (12–35 months) | Children (3–9 years) | Adolescents (10–17 years) | Adults (18–64 years) | The elderly (≥ 65 years) |
|---|---|---|---|---|---|---|
| **Consumption of paprika (pepper and powder) (g/person/day)** | | | | | | |
| Mean | 0.0-0.9 | 0.0-4.5 | 0.0-6.9 | 0.0-9.4 | 0.0-15.5 | 0.0-15.9 |
| 95$^{th}$ percentile | 0.0-5.6 | 0.0-22.5 | 0.0-38-8 | 0.0-56.0 | 0.0-97.5 | 0.0-56.8 |
| **Consumption of carotenoids from natural diet (mg/kg bw/day)** | | | | | | |
| Mean | <0.001-0.005 | <0.001-0.021 | <0.001-0.019 | <0.001-0.011 | <0.001-0.012 | <0.001-0.011 |
| 95$^{th}$ percentile | <0.001-0.027 | 0.011-0.103 | <0.001-0.099 | <0.001-0.061 | <0.001-0.059 | <0.001-0.040 |

Dietary exposure to paprika carotenoids from the food additive and the regular diet would lead to a mean intake for toddlers of 0.2 to 0.5 mg/kg bw/day (non-brand-loyal scenario). On average, dietary exposure from the natural diet would represent around 1% of the dietary exposure.

## 3. Biological and toxicological data

The present opinion briefly reports the major studies evaluated in the JECFA evaluation (2008) and describes the additional new literature data in some more detail. As a limit of 250 mg/kg has been set for the content of capsaicin in paprika (E 160c) (Commission Regulation (EU) No 231/2012), studies dealing with capsaicin toxicity are not further discussed in this opinion.

It is unclear whether studies described in the previous evaluations and studies in the new literature comply with the (OECD) GLP guidelines. It may be noted that the design of the various studies may not be in full compliance with current regulatory requirements. However, the main concern is whether the test compounds in the various studies were in compliance with EC specifications for paprika extract (E 160c). None of the studies described in evaluations prior to 2014, nor those in the more recent literature give details about the purity and colour content of the test compound used (especially the concentration of total carotenoids, capsanthin and capsorubin). In several studies, the test compound is referred to as 'paprika extract', 'chilli', 'chilli extract', 'capsicum extract' etc. In these cases it is not clear whether indeed paprika (*Capsicum annuum*) extract (used as a food colour) has been tested and if so, whether the extract complies with the existing EC specifications. The relevance to paprika extract (E 160c) of studies performed with extracts other than *Capsicum annuum* extract (i.e. *Capsicum frutescens)*, with unspecified capsanthin, capsorubin or capsaicin content is unclear.

Data on these extracts and capsaicin were available to the Panel, but in the Panel's opinion these were of limited relevance to paprika extracts used as a food colour (E 160c), and are therefore not described in this opinion.

### 3.1. Absorption, distribution, metabolism and excretion

#### 3.1.1. Human studies

The bioavailability of carotenoids from paprika extract (provided by EVESA; not further specified) found in dietary products was assessed in humans (Pérez -Gálvez et al., 2003). After overnight fasting, nine volunteers ingested a single dose of a paprika extract containing 6.4 mg zeaxanthin, 4.2 mg *β*-cryptoxanthin, 6.2 mg *β*-carotene, 35.0 mg capsanthin and 2.0 mg capsorubin. At different time points, the carotenoid pattern in the chylomicron fraction of whole blood was analysed to evaluate carotenoid absorption. Only zeaxanthin, *β*-cryptoxanthin and *β*-carotene were detectable in measurable amounts in the chylomicrons (not further specified), however these three components only represent 18.6% of the paprika extract. Although the xanthophylls in paprika extract were mainly present as mono or diesters, only free zeaxanthin and *β*-cryptoxanthin were found. The bioavailability of the pepper-specific carotenoids capsanthin and capsorubin from paprika extract was found to be very low (percentage not specified). The rationale for solely measuring blood chylomicrons is unclear and it is not possible to conclude whether the failure to detect the other components is due to limited absorption, rapid metabolism or failure to measure the appropriate sample.

Four male volunteers (aged 26-30 years) with plasma essentially free of capsanthin received a 'capsanthin-rich paprika juice' 3 times daily for 1 week, providing three doses of 5.4 µM (about 3.2 mg) capsanthin/day, equivalent to a total of 16.2 µM (about 9 mg)/day (Oshima et al., 1997). The level of capsanthin in plasma reached a plateau (0.10-0.12 µM) between day 2 and day 7, and capsanthin was not detectable in plasma by day 16 (i.e. 9 days after the last intake). After 1 week, capsanthin was distributed in the plasma lipoproteins as follows: 13 ± 3% very low density lipoprotein, 44 ± 3% low-density lipoprotein and 43 ± 3% high-density lipoprotein. In another experiment involving a single ingestion of paprika juice (equivalent to 34.2 µM capsanthin) by the same men, the plasma concentration of capsanthin ranged from 0.10 to 0.29 µM 8 hours after ingestion (Oshima et al., 1997). In contrast, the elevation of the plasma concentration of an acyclic hydrocarbon carotenoid, lycopene, following a single ingestion of tomato soup (equivalent to 186.3 µM lycopene) in the same subjects was minimal (0.02-0.06 µM). The areas under the plasma concentration-time curves for capsanthin between 0 and 74 hours and for lycopene between 0 and 72 hours were 4.68 ± 1.22 and 0.81 ± 0.17 µmol·hour/L respectively. The half-lives were calculated to be 20.1 ± 1.3 hours for capsanthin and 222 ± 15 hours for lycopene. The authors concluded that the clearance of capsanthin was much faster than that of lycopene, although capsanthin was transported into plasma lipoproteins in larger amounts.

JECFA (2008) concluded that there are no indications that carotenoids from paprika extract (E 160c) would behave differently from other oxygenated carotenoids with respect to their bioavailability.

*Etoh et al. (2000) undertook a study to identify the carotenoids not identified in the study of Oshima et al. (1997). A male human subject ingested 200 g of paprika juice (containing 2 mg capsanthin/100 g juice) 3 times daily for 3 days (diet 1). The same subject also ingested 300 g of concentrated paprika juice (equivalent to 10 mg of capsanthin) in a single dose (diet 2) (no specifications for the diet of the subject are available). Blood samples were taken before the start of the study and at specific intervals for a 7-day period starting after the first ingestion of paprika extract (diet 1) and 3, 7 and 10 hours after ingestion of the concentrated paprika juice (diet 2). Plasma carotenoids were quantified using HPLC with diode array detection. Capsanthin was oxidised to capsanthone and isomerised to its geometrical isomer 11-cis-capsanthin. After consumption of diet 1, capsanthin, its oxidation product capsanthone and its geometrical isomer 11-cis-capsanthin, as well as cucurbitaxanthin A were identified in the human plasma 7 days after starting paprika juice ingestion. Also lutein, zeaxanthin and an unknown compound were present in the plasma, but these compounds were also present in the plasma samples taken before the start of the study. After consumption of diet 2, plasma capsanthin started decreasing 7 hours after ingestion, whereas capsanthone started increasing; capsanthin concentration fell below the detection limit after 10 hours. Cucurbitaxanthin and lutein + zeaxanthin concentrations also increased during the first 10 hours.*

## 3.2. Toxicological data

### 3.2.1. Acute toxicity

The acute oral toxicity of natural paprika colour in rats was reported to be low, with an $LD_{50}$ exceeding 11.25 g/kg bw (Noda et al., 1984; Hallagan et al., 1995). At the dose of 11.25 g/kg bw, body weight gain was slightly suppressed, which was not observed at a dose of 5.0 or 7.5 g/kg bw (Noda et al., 1984).

### 3.2.2. Short-term and subchronic toxicity

The JECFA reviews (1970, 2008) referred to several subchronic toxicity studies on paprika extract (E 160c), capsaicin and red chilli peppers.

#### 3.2.2.1. Paprika extract, capsanthin and capsorubin

A 13-week toxicity study with paprika extract (E 160c) was performed in F344/DuCrj rats (Kanki et al., 2003) and cited by JECFA 2008. The material tested was described as a paprika colour preparation extracted from Spanish paprika fruit with hexane (DN-933, Lot number 001110, not further characterised; comparable to N1, NATCOL 2014), with a total carotenoid content of approximately 7.5%. Groups of 10 rats of each sex were fed powdered diet containing the test material at dose levels of 0 (basal diet), 0.62, 1.25, 2.5 or 5% (approximately 380, 750, 1 500 and 2 950 mg/kg bw/day in males and 420, 800, 1 640 and 3 200 mg/kg bw/day in females) from 5 weeks of age for 13 weeks. There were no remarkable changes in general appearance, no deaths occurred in any experimental group, no differences in organ weights and no histopathological changes observed. Although total serum cholesterol was dose-dependently increased in both sexes, no related histopathological changes were observed in the liver. Other observed differences in serum chemistry or haematology were neither consistent nor dose-dependent. According to the authors, the NOAEL was concluded to be 5% in the diet, equivalent to 2948 mg/kg bw/day for males and 3197 mg/kg bw/day for females.

### 3.2.3. Genotoxicity

Mixed results are reported in the literature from limited *in vitro* genotoxicity studies with paprika extracts of different purity and composition.

According to JECFA (2009) extracts of chilli peppers of different levels of purity have been tested, with mixed, inconsistent and often contradictory results. For example, both negative (Buchanan et al., 1981) and positive (Damhoeri et al., 1985; Nagabhushan and Bhide, 1985) results have been reported in bacterial assays. Similarly, both positive (Lawson and Gannett, 1989) and negative (Nagabhushan and Bhide, 1986) results have been reported in assays using Chinese hamster V79 cells.

Negative results were reported in other published studies on paprika dye with undefined composition not considered in previous JECFA evaluations, i.e. a limited Ames test (Yasui et al., 1982), an Ames test and a limited cytogenetic assay (Ishidate et al., 1984) and a rec assay in bacteria (Ueno et al., 1983).

Overall, the Panel concluded that the limited information available from the open literature does not allow a reliable assessment of the genotoxicity of paprika extracts. Therefore, upon request of EFSA, two new GLP compliant genotoxicity studies using Paprika extract DN-933 (see Section 2.4) were submitted by NATCOL in 2014. Purity was stated as total carotenoid amount as capsanthin and capsorubin: 7.1%, relative purity of capsanthin and capsorubin: 35.8%. The information and certificate of analysis provided were considered by the test laboratory an adequate description of the characterisation, purity and stability of the test article.

An OECD test guideline (TG) 471 mutation assay in five *Salmonella typhimurium* (TA98, TA100, TA1535, TA1537 and TA102) of both in the absence and in the presence of metabolic activation by an Aroclor 1254-induced rat liver post-mitochondrial fraction (S9), was performed (Mc Garry et al., 2014, unpublished report). Paprika extract (DN-933, comparable to N1 NATCOL 2014) dissolved in dimethylformamide was tested at concentrations of 5, 16, 50, 160, 500, 1 600 and 5 000 µg/plate, plus vehicle and positive controls in the first experiment, and 160, 500, 1 600 and 5 000 µg/plate in the second experiment, which also included a pre-incubation step in the presence of S9. Evidence of toxicity was only observed at 5 000 µg/plate in strain TA102 in the absence of S9 in both experiments and in strain TA1537 in the presence of S9 in experiment one. No increases in revertant numbers were observed in the absence and presence of S9. The authors concluded that paprika extract DN-933 did not induce mutation. The Panel agreed with this conclusion.

An OECD TG 487 *in vitro* micronucleus assay was performed using duplicate human lymphocyte cultures prepared from the pooled blood of two female donors in a single experiment (Watters, 2014, unpublished report). Treatments with paprika extract (DN-933, comparable to N1 NATCOL 2014) dissolved in dimethylformamide covering a broad range of concentrations (50, 100, 200, 300, 400, 500, 600, 750, 1 000, 1 500 µg/mL), were performed both in the absence and presence of metabolic activation (S9) from Aroclor 1254-induced rats. The highest concentration tested in the micronucleus experiment, 1500 µg/ml (in excess of the solubility limit in the test system) was selected following a range finding study. Treatments were conducted (3+21 hour -S9; 3+21 hour +S9; 24+24 hour -S9) 48 hours following mitogen stimulation by phytohaemagglutinin. Appropriate negative (vehicle and untreated) and positive control cultures were included in the test system under each treatment condition. Treatment of cells with paprika extract DN-933 in the absence and presence of S9 resulted in no reduction in replication index and in frequencies of micronucleated binucleate (MNBN) cells that were similar to those observed in concurrent vehicle controls for all concentrations analysed under all three treatment conditions. The MNBN cell frequency of all treated cultures fell within normal ranges. The authors concluded that paprika extract DN-933 did not induce micronuclei in cultured human peripheral blood lymphocytes following treatment in the absence and presence of a rat liver metabolic activation system (S9) at concentrations up to the limit of solubility of the test system. The Panel agreed with this conclusion.

Based on the newly provided GLP compliant studies on a specified paprika extract, DN-933, which fulfil the requirements for genotoxicity assessment according to the EFSA guidelines on food additives (EFSA ANS Panel, 2012), the Panel concluded that paprika extracts used as a food colour do not raise a genotoxic concern.

### 3.2.4. Chronic toxicity and carcinogenicity

Groups of ten F344 rats of each sex were given diets containing paprika colour, DN-933 (paprika extract (E 160c, comparable to N1 NATCOL 2014) at concentrations of 0%, 0.62%, 1.25%, 2.5% and 5% from approximately 6 weeks of age for 52 weeks. A carcinogenicity study used groups of 50 rats of each sex given diets containing the test material at concentrations of 0%, 2.5% and 5% for 104

weeks (Inoue et al., 2008). Haematological parameters and serum biochemical parameters were assessed. All animals were subjected to complete pathological evaluation. There were no effects in either study on survival rates, clinical signs of toxicity, or food consumption and body weight. In the 52-week study there were no effects on haematological parameters, serum biochemical measurements or organ weights. There was no evidence of pathological changes, with the exception of an increased incidence of hepatocellular vacuolation in the 5% male group; a finding which the authors concluded was not adverse. In the carcinogenicity study, there was no effect of treatment on the pattern or incidence of tumours, but significant decreases in absolute and relative weights of the spleen were observed in 5% males and 2.5% females. The hepatocyte alterations observed in the highest dose males were consistent with an 8- and 13-week feeding study, and the authors suggested these might be a characteristic effect of capsicum extracts. Nevertheless, the authors concluded that this was not of major significance, given that the lesion was observed to the same extent in all groups, including controls, in the previous 13-week subchronic study, and that severity in this study was very slight. Additionally, as paprika colour extracts contained soluble fat at high levels, this lesion could have resulted from the intake of fat soluble paprika constituents. Based on all these considerations, the authors concluded that the lesion was a treatment-related change, but not of toxicological significance. Likewise, the decrease in relative spleen weight in 5% males in the chronic toxicity study was not associated with histopathological alterations, and was considered of little toxicological significance. Based on the slight histopathological changes in liver observed in 5% males, the NOEL was estimated by the authors to be 2.5% in the diet (equivalent to 1253 mg/kg bw/day) and the NOAEL was determined to be 5% in the diet (equivalent to 2 388 mg/kg bw/day) for male rats. For females, the NOAEL was concluded to be 5% in the diet (equivalent to 2 826 mg/kg bw/day).

Therefore, the Panel concluded that the NOAEL in rats from this combined chronic toxicity and carcinogenicity study is approximately equivalent to 2 400 mg paprika extract (E 160c)/kg bw/day.

### 3.2.5. Reproductive and developmental toxicity

No reproductive and/or developmental toxicity data were available in the previous evaluations of paprika extract (E 160c).

JECFA (2014) noted that the results of reproductive and developmental toxicity tests were not included in the toxicological database for paprika extracts and assumed that such studies were not performed. However, JECFA was aware of the results of a dietary, GLP compliant developmental toxicity study that had been performed with lutein, a carotenoid of similar chemical structure to capsanthin (Edwards et al, 2002). No developmental abnormalities were observed in this study with lutein at any dose level and a NOAEL of 1000 mg/kg bw per day was identified (the highest dose tested). Thus, JECFA concluded, based on a read-across, that paprika extracts meeting the specifications for use as a food colour are unlikely to pose a reproductive/developmental hazard. The Panel agreed that this read-across was appropriate and agreed with this conclusion.

### 3.2.6. Hypersensitivity, allergenicity and intolerance

One case has been reported on the development of IgE antibodies specific to paprika (no details provided) in a butcher who previously has been diagnosed as having food allergies to coconut, banana and kiwi, and allergic rhinitis to horse, cat, dog and cow, one year after starting to prepare a certain kind of sausage, but no cases have been reported after intake of food containing paprika extract (E 160c) (Sastre et al., 1996).

Using immunoblot analysis, Leitner et al. (1998) reported that a 23 kD paprika protein was recognised by IgE from sera of patients with hypersensitivity to mugwort, birch pollen or celery.

In a review by Johnson (2007), several additional studies regarding hypersensitivity are described. Two cases are described in which a patient tested positive in a skin prick test for, respectively, fresh *Capsicum annuum* and paprika powder (Gallo et al., 1997; Foti et al., 1997). Kanerva et al. (1996)

evaluated 1 000 patients with occupational skin disease. Five patients had spice-induced allergic contact dermatitis, and in two of them, paprika (spice from *Capsicum annuum*) induced a weak allergic patch test reaction. One case report of anaphylaxis after the intake of paprika was reported (Vega de la Osada et al., 1998). As these are the only cases reported in literature, the incidence of allergic reactions to paprika extract (E 160c) seems to be very low.

***Immunotoxicity studies***

An *ex vivo* study indicated that ethanolic extracts of *Capsicum annuum* may induce the production of T-helper cytokines (IL-2 and IFN-γ) in murine Peyer's patch (PP) cells (Takano et al., 2007). Capsicum extract did not induce gross toxicity and enhanced the production of the T-helper 1 cytokines IL-2 and IFN-γ in PP cells in a small, but statistically significant and dose-dependent way, especially in response to Concanavalin A (Con A) stimulation. The T-helper 2 cytokine IL-4 was not affected by capsicum extract, whereas the cytokine IL-5 production was moderately enhanced, irrespective of Con A. In a further study (Yamaguchi et al., 2010), the authors reported that carotenoids and capsaicin, which are common components of foods such as *Capsicum*, mutually modulate T-cell immune responses to exogenous or endogenous inducers such as antigens in PPs, without changing the lymphoid population. The biological relevance and clinical significance of these findings are however not established. The Panel noted that the effects observed when extracts of *Capsicum annuum* were used, were fully reproduced if capsaicin was used. Therefore, the immunotoxic effects reported were most probably due to capsaicin.

Considering the widespread consumption of paprika extract (E 160c) and the absence of reports on allergic and intolerance reactions, the Panel concluded that the food additive paprika extract (E 160c) is unlikely to represent a safety concern as regards allergenicity and immunotoxicity.

### 3.2.7. Studies in humans

No human data were available on paprika extract (E 160c).

## 4. Discussion

The Panel was not provided with a newly submitted dossier and based its evaluation on the previous evaluations of paprika extract (E 160c) used as a food colour but included additional literature that had become available since the evaluation by JECFA (2008) and additional data made available, following public calls.

Paprika extract (E 160c) is a natural dye, authorised as a food additive in the EU under Regulation (EC) No 1333/2008. Specifications have been defined in the Commission Regulation (EU) No 231/2012; concentrations up to 250 mg of residual capsaicin/kg paprika extract are allowed in the food additive.

Paprika extract (E 160c) was evaluated by JECFA in 2008 and the Committee did not allocate an ADI. Concern was expressed as to whether the material tested in the 90-day study and long-term studies was representative of all commercial products of paprika extract (E 160c) used as a food colour. The fact that the material tested contained less than 0.01% capsaicin and the fact that the Committee did not receive adequate data to establish a limit for capsaicin in the specifications for paprika extract (E 160c) added to this concern. New tentative specifications were prepared, pending receipt of additional information on paprika extract (E 160c) used as a food colour, including concentrations of capsaicin (to differentiate from materials used as flavours), and additional information about the composition of batches of extract produced by a variety of manufacturers.

In 2014, following receipt of analytical data on paprika extracts, JECFA established an ADI for paprika extract used as a food colour of 0–1.53 mg/kg bw, expressed as total carotenoids, with the application of an uncertainty factor of 100 to the NOAEL of 153 mg/kg bw per day from a 2-year toxicity and carcinogenicity study in rats, and removed the tentative status from the revised

specifications. Detailed information on the composition of commercially available paprika extracts was provided by NATCOL. Based on these data, the Panel concluded that the material tested in the Inoue et al. (2008) and Kanki et al. (2003) studies on a specified paprika extract DN-933 was representative of commercially available paprika extracts, and that the conclusions were applicable to all commercially available paprika extracts (E 160c) for which data were provided.

The bioavailability of capsanthin and capsorubin from paprika extract is very low. The Panel agreed with the conclusion of JECFA (2008) that there are no indications that carotenoids from paprika extract (E 160c) would behave differently from other oxygenated carotenoids with respect to their low bioavailability. When capsanthin is absorbed, it is transported by plasma lipoproteins. The half-life for capsanthin in plasma is approximately 20 hours in man. In man, capsanthin can be oxidised to capsanthone and its geometrical isomer 11-*cis*-capsanthin.

Toxicological data on paprika extract (E 160c) were limited to one 13-week oral toxicity and one long-term toxicity and carcinogenicity study on a specified paprika extract (DN-933). The NOAEL from the 13-week oral toxicity study was 5% paprika extract/kg bw/day, equivalent to 2948 and 3197 mg paprika extract/kg bw/day for males and females respectively.

Paprika extract (E 160c) was not carcinogenic to male and female F344 rats according to a 2-year combined toxicity and carcinogenicity study (Inoue et al., 2008). Slight hepatocellular vacuolation was observed in males at the highest dose tested (5% paprika extract, E 160c). However, it was questioned whether this effect is adverse, thus the authors concluded that 5% paprika extract in the diet was the NOAEL from the study. For males, this was equivalent to 2388 mg paprika extract/kg bw/day and for females, to 2826 mg paprika extract/kg bw/day.

Mixed results are reported in the literature from limited *in vitro* genotoxicity studies with paprika extracts of different purity and composition. On the other hand, clearly negative results were obtained in recent adequately performed and controlled *in vitro* studies (gene mutations in bacteria and micronucleus in mammalian cells) assays on a specified paprika extract DN-933. Based on these findings, and according to EFSA guidelines on food additives, paprika extracts used as food colours do not raise a genotoxic concern.

No data on reproductive and developmental toxicity of paprika extract (E 160c) are available. JECFA (2014) noted that the results of reproductive and developmental toxicity tests were not included in the toxicological database for paprika extracts and assumed that such studies were not performed. However, JECFA was aware of the results of a dietary, GLP compliant developmental toxicity study that had been performed with lutein, a carotenoid of similar structure to capsanthin (Edwards et al, 2002). No developmental abnormalities were observed in this study with lutein at any dose level, and a NOAEL of 1 000 mg/kg bw per day was identified (the highest dose tested). Thus, JECFA concluded based upon a read-across, that paprika extracts meeting the specifications for use as a food colour are unlikely to pose a reproductive/developmental hazard. The Panel agreed that this read-across was appropriate and agreed with this conclusion.

Based on the lack of genotoxic potential, the Panel considered that the NOAEL for histopathological changes from the combined chronic toxicity and carcinogenicity study by Inoue et al. (2008) could be used for establishing an ADI. For males this was equivalent to 2388 mg paprika extract/kg bw/day, and for females, to 2826 mg paprika extract/kg bw/day. On this basis, and using the default uncertainty factor of 100, the Panel established an ADI of 24 mg paprika extract/kg bw/day for paprika extract (E 160c).

Based on the analytical data on paprika extract N1, which is reported by NATCOL to be comparable to the specified paprika extract DN-933 used in these studies, the total carotenoid content was 7.1%. Using this value, the NOAELs expressed on a carotenoid basis would be equivalent to 170 mg carotenoids/kg bw/day and 200 mg carotenoids/kg bw/day for males and females, respectively. On this

basis and using the default uncertainty factor of 100, the Panel established an ADI of 1.7 mg carotenoids/kg bw/day for paprika extract (E 160c).

No human data were available on paprika extract (E 160c).

Considering the widespread consumption of paprika extract (E 160c) and the absence of reports on allergic and intolerance reactions, the Panel concluded that the food additive paprika extract (E 160c) is unlikely to represent a safety concern as regards allergenicity and immunotoxicity.

Exposure assessments of food additives under re-evaluation are carried out by the ANS Panel based on (1) MPLs set down in the EU legislation (defined as the *regulatory maximum level exposure assessment scenario*) and (2) usage or analytical data (defined as the *refined exposure assessment scenario*). The regulatory maximum level exposure assessment scenario is based on the MPLs as set in Annex II to Regulation (EC) No 1333/2008. As paprika extract (E 160c) is authorised according to QS in almost all food categories, a maximum level exposure assessment scenario was estimated based on the maximum reported use levels provided by industry (Appendix A), as described in the EFSA Conceptual framework (EFSA ANS Panel, 2014).

The refined exposure assessment scenario is considered a more realistic approach than the maximum level exposure assessment scenario. Exposure estimates derived following this last scenario should be considered most conservative as this scenario assumes that the consumer will be continuously (over a lifetime) exposed to a food additive present in food at the maximum level. The Panel noted that the refined exposure estimates will not cover future changes in the level of use of paprika extract (E 160c).

For the maximum level exposure assessment scenario, mean estimates ranged from 0.1 to 1.8 mg carotenoids/kg bw/day across all population groups. Estimates based on the high percentile (95th percentile) ranged from 0.3 to 2.7 mg carotenoids/kg bw/day across all population groups.

For the refined estimated exposure scenario in the brand-loyal scenario, mean exposure to paprika extract (E 160c) from its use as a food additive ranged from 0.1 mg carotenoids/kg bw/day to 1.1 mg carotenoids/kg bw/day. The high exposure to paprika extract (E 160c) ranged from 0.2 mg carotenoids/kg bw/day to 1.7 mg carotenoids/kg bw/day. In the non-brand-loyal scenario, mean exposure to paprika extract (E 160c) ranged from <0.1 mg carotenoids/kg bw/day to 0.5 mg carotenoids/kg bw/day in children. The high exposure ranged from 0.1 mg carotenoids/kg bw/day to 0.8 mg carotenoids/kg bw/day. A dietary exposure from the food additive and the regular diet would lead to a mean intake for children of 0.2 to 0.5 µg/kg bw/day (non-brand-loyal scenario). On average, dietary exposure from the natural diet would represent around 1% of the dietary exposure.

## CONCLUSIONS

The Panel established an ADI of 1.7 mg carotenoids/kg bw/day for paprika extract (E 160c).

Exposures to paprika extract (E 160c) in refined exposure scenarios were below the ADI established by the Panel.

Therefore, the Panel concluded that the use of paprika extract (E 160c) as a food additive at the reported use levels in food would not be of safety concern.

## RECOMMENDATIONS

The Panel recommended that:

- In the EC specifications, the term ‘paprika oleoresin’ as a synonym of ‘paprika extract’ should not be used.

- Limits for pesticides and mycotoxins could be considered in the specifications to avoid any potential adverse effects.

- The maximum limits for toxic elements (arsenic, lead, mercury and cadmium) present as impurities in the EC specification for paprika extract (E 160c) should be revised to ensure that paprika extract (E 160c) as food additive will not be a significant source of exposure to these toxic elements in food.

- The EC specifications could be based on total capsaicinoids rather than capsaicin only.

## DOCUMENTATION PROVIDED TO EFSA

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# APPENDICES

## Appendix A. Summary of reported use levels (mg/L or mg/kg as appropriate) of paprika extract (E 160c) provided by industry, expressed as carotenoids

| FCS category no. | FCS food category | MPL | Restrictions/exceptions | Reported use levels* | | Information provided by |
|---|---|---|---|---|---|---|
| | | | | Typical mean | Highest maximum level | |
| 01.4 | Flavoured fermented milk products including heat-treated products | QS | | 12.3 | 35.0 | NATCOL |
| 01.6.3 | Other creams | QS | Only flavoured creams | 14.0 | 36.0 | NATCOL |
| 01.7.1 | Unripened cheese excluding products falling in category 16 | QS | | 13.0 | 30.0 | NATCOL |
| 01.7.1 | Unripened cheese excluding products falling in category 16 | QS | Only flavoured-unripened cheese | 10.0 | 15.0 | NATCOL |
| 01.7.2 | Ripened cheese | QS | Only ripened orange, yellow and broken-white cheese and red and green pesto cheese | 22.0 | 30.0 | NATCOL |
| 01.7.5 | Processed cheese | QS | Only flavoured-processed cheese | 35.0 | 100.0 | NATCOL |
| 01.7.6 | Cheese products (excluding products falling in category 16) | QS | Only flavoured-unripened products | 35.0 | 100.0 | NATCOL |
| 01.7.6 | Cheese products (excluding products falling in category 16) | QS | Only ripened orange, yellow and broken-white products | 35.0 | 100.0 | NATCOL |
| 01.8 | Dairy analogues, including beverage whiteners | QS | | 14.0 | 35.0 | NATCOL |
| 03 | Edible ices | QS | | 11.9 | 50.0 | NATCOL |
| 04.2.1 | Dried fruit and vegetables | QS | Only preserves of red fruit | 7.0 | 45.0 | NATCOL |
| 04.2.2 | Fruit and vegetables in vinegar, oil, or brine | QS | Only preserves of red fruit | 7.0 | 45.0 | NATCOL |
| 04.2.3 | Canned or bottled fruit and vegetables | QS | Only preserves of red fruit | 7.0 | 45.0 | NATCOL |
| 04.2.4.1 | Fruit and vegetable preparations excluding compote | QS | Only energy-reduced or with no added sugar, with the exception of those intended for the manufacture of fruit-juice based drinks | 10.0 | 50.0 | NATCOL |
| 04.2.4.1 | Fruit and vegetable preparations excluding compote | QS | Only preserves of red fruit | 10.0 | 50.0 | NATCOL |

| FCS category no. | FCS food category | MPL | Restrictions/exceptions | Reported use levels* | | Information provided by |
|---|---|---|---|---|---|---|
| | | | | Typical mean | Highest maximum level | |
| 04.2.5.2 | Jam, jellies and marmalades and sweetened chestnut purée as defined by Directive 2001/113/EC | QS | Except chestnut purée | 7.2 | 50.0 | NATCOL |
| 04.2.5.3 | Other similar fruit or vegetable spreads | QS | Except crème de pruneaux | 7.0 | 50.0 | NATCOL |
| 05.2 | Other confectionery including breath refreshening microsweets | QS | | 40.0 | 92.0 | NATCOL |
| 05.3 | Chewing gum | QS | | 18.0 | 60.0 | NATCOL |
| 05.4 | Decorations, coatings and fillings, except fruit based fillings covered by category 4.2.4 | QS | | 48.0 | 265.0 | NATCOL |
| 06.3 | Breakfast cereals | QS | Only extruded puffed and or fruit-flavoured breakfast cereals | 60.0 | 100.0 | NATCOL |
| 06.5 | Noodles | QS | | | 100.0 | NATCOL |
| 06.6 | Batters | QS | | 40.0 | 100.0 | NATCOL |
| 07.2 | Fine bakery wares | QS | | 38.7 | 90.0 | NATCOL |
| 08.3.1 | Non-heat-treated meat products | 10 | Only sausages | 9.9 | 10.0 | NATCOL |
| 08.3.2 | Heat-treated meat products | 10 | Only sausages, patés and terrines | 10.0 | 10.0 | NATCOL |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | QS | Only surimi and similar products and salmon substitutes. | 50.0 | 150.0 | NATCOL |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | QS | Only precooked crustacean | 20.0 | 30.0 | NATCOL |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | QS | Only fish paste and crustacean paste | 20.0 | 30.0 | NATCOL |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | QS | Only smoked fish | 20.0 | 30.0 | NATCOL |
| 12.2.2 | Seasonings and condiments | QS | Only seasonings, for example curry powder, tandoori | 30.0 | 350.0 | NATCOL |
| 12.4 | Mustard | QS | | 15.0 | 40.0 | NATCOL |
| 12.5 | Soups and broths | QS | | 29.5 | 84.0 | NATCOL |
| 12.6 | Sauces | QS | Excluding tomato-based sauces | 12.0 | 150.0 | NATCOL |
| 12.7 | Salads and savoury based sandwich spreads | QS | | 17.0 | 50.0 | NATCOL |

| FCS category no. | FCS food category | MPL | Restrictions/exceptions | Reported use levels* | | Information provided by |
|---|---|---|---|---|---|---|
| | | | | Typical mean | Highest maximum level | |
| 12.9 | Protein products, excluding products covered in category 1.8 | QS | | 4.0 | 4.0 | NATCOL |
| 14.1.4 | Flavoured drinks | QS | Excluding chocolate milk and malt products | 4.9 | 30.0 | NATCOL |
| 14.2.3 | Cider and perry | QS | Excluding *cidre bouché* | 1.9 | 2.6 | NATCOL |
| 14.2.4 | Fruit wine and made wine | QS | Excluding *wino owocowe markowe* | 5.0 | 10.0 | NATCOL |
| 14.2.7.3 | Aromatised wine-product cocktails | QS | | 5.0 | 10.0 | NATCOL |
| 14.2.8 | Other alcoholic drinks including mixtures of alcoholic drinks with non-alcoholic drinks and spirits with less than 15% of alcohol | QS | | 5.0 | 15.0 | NATCOL |
| 15.1 | Potato-, cereal-, flour- or starch-based snacks | QS | | 32.9 | 100.0 | NATCOL |
| 15.2 | Processed nuts | QS | | 50.0 | 100.0 | NATCOL |
| 16 | Desserts excluding products covered in category 1, 3 and 4 | QS | | 11.3 | 50.0 | NATCOL |

*Use levels are reported as ranges, no information on the number of data were provided to EFSA

## Appendix B. Concentration levels of paprika extract (E 160c) used in the refined exposure scenarios (mg/L or mg/kg as appropriate), expressed as carotenoids

| FCS category no. | FCS food category | Restrictions/exceptions | MPL | Concentration levels used in the exposure assessment | | Comments |
|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | |
| 01.4 | Flavoured fermented milk products including heat-treated products | | QS | 12.3 | 35 | |
| 01.5 | Dehydrated milk as defined by Directive 2001/114/EC | Except unflavoured products | QS | - | - | Not taken into account (no usage data available) |
| 01.6.3 | Other creams | Only flavoured creams | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 01.7.1 | Unripened cheese excluding products falling in category 16 | Only flavoured unripened cheese | QS | 13 | 30 | |
| 01.7.2 | Ripened cheese | Only ripened orange, yellow and broken-white cheese and red pesto cheese | QS | 22 | 30 | |
| 01.7.3 | Edible cheese rind | | QS | - | - | Not taken into account (no corresponding FoodEx code/no usage data available) |
| 01.7.4 | Whey cheese | | QS | - | - | Not taken into account (no usage data available) |
| 01.7.5 | Processed cheese | Only flavoured processed cheese | QS | 35 | 100 | |
| 01.7.5 | Processed cheese | | QS | 35 | 100 | |
| 01.7.6 | Cheese products (excluding products falling in category 16) | Only flavoured-unripened products | QS | 35 | 100 | |
| 01.7.6 | Cheese products (excluding products falling in category 16) | Only ripened orange, yellow and broken-white products | QS | 35 | 100 | |
| 01.8 | Dairy analogues, including beverage whiteners | | QS | 14 | 35 | |
| 03 | Edible ices | | QS | 12 | 50 | |
| 04.2.1 | Dried fruit and vegetables | Only preserves of red fruit | QS | 7 | 45 | |
| 04.2.2 | Fruit and vegetables in vinegar, oil, or brine | Only preserves of red fruit | QS | 7 | 45 | |
| 04.2.3 | Canned or bottled fruit and | Only preserves of red fruit | QS | 7 | 45 | |

| FCS category no. | FCS food category | Restrictions/exceptions | MPL | Concentration levels used in the exposure assessment | | Comments |
|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | |
| | vegetables | | | | | |
| 04.2.4.1 | Fruit and vegetable preparations excluding compote | Only *mostarda di frutta* | QS | - | - | Not taken into account (no corresponding FoodEx code/no usage data available) |
| 04.2.4.1 | Fruit and vegetable preparations excluding compote | Only preserves of red fruit | QS | 10 | 50 | |
| 04.2.4.1 | Fruit and vegetable preparations excluding compote | Only seaweed based fish roe analogues | QS | - | - | Not taken into account (no corresponding FoodEx code/no usage data available) |
| 04.2.5.2 | Jam, jellies and marmalades and sweetened chestnut purée as defined by Directive 2001/113/EC | Except chestnut purée | QS | 7 | 50 | |
| 04.2.5.3 | Other similar fruit or vegetable spreads | Except crème de pruneaux | QS | 7 | 50 | |
| 05.2 | Other confectionery including breath-refreshening microsweets | | QS | 40 | 92 | |
| 05.3 | Chewing gum | | QS | 18 | 60 | |
| 05.4 | Decorations, coatings and fillings, except fruit-based fillings covered by category 4.2.4 | | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 06.3 | Breakfast cereals | Only breakfast cereals other than extruded, puffed and/or fruit-flavoured breakfast cereals | QS | 60 | 100 | |
| 06.3 | Breakfast cereals | Only extruded puffed and or fruit-flavoured breakfast cereals | QS | | | |
| 06.5 | Noodles | | QS | 50 | 100 | |
| 06.6 | Batters | | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 06.7 | Precooked or processed cereals | | QS | - | - | Not taken into account (no corresponding FoodEx code/no data available) |
| 07.2 | Fine bakery wares | | QS | 39 | 90 | |

| FCS category no. | FCS food category | Restrictions/exceptions | MPL | Concentration levels used in the exposure assessment | | Comments |
|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | |
| 08.2 | Meat preparations as defined by Regulation (EC) No 853/2004 (M42) | Only merguez type products, *salsicha fresca, butifarra fresca, longaniza fresca, chorizo fresco, bifteki, soutzoukaki* and *kebap* | 10 | 10 | 10 | |
| 08.3.1 | Non-heat-treated meat products | Only sausages | 10 | 10 | 10 | |
| 08.3.2 | Heat–treated meat products | Only sausages, patés and terrines | 10 | 10 | 10 | |
| 08.3.3 | Casings and coatings and decorations for meat | Except edible external coating of pasturmas | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | Only surimi and similar products and salmon substitutes. | QS | 50 | 150 | |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | Only smoked fish | QS | 20 | 30 | |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | Only fish paste and crustacean paste | QS | 20 | 30 | |
| 09.2 | Processed fish and fishery products including molluscs and crustaceans | Only precooked crustacean | QS | 20 | 30 | |
| 09.3 | Fish roe | Except Sturgeons' eggs (Caviar) | QS | - | - | Not taken into account (no usage data available) |
| 12.2.2 | Seasonings and condiments | Only seasonings, for example curry powder, tandoori | QS | 30 | 350 | |
| 12.4 | Mustard | | QS | 15 | 40 | |
| 12.5 | Soups and broths | | QS | 30 | 84 | |
| 12.6 | Sauces | Excluding tomato-based sauces | QS | 12 | 150 | |
| 12.7 | Salads and savoury based sandwich spreads | | QS | 17 | 50 | |
| 12.9 | Protein products, excluding products covered in category 1.8 | | QS | 4 | 4 | |
| 13.2 | Dietary foods for special medical purposes defined in Directive 1999/21/EC (excluding products from food category 13.1.5) | | QS | - | - | Not taken into account (no usage data available) |

| FCS category no. | FCS food category | Restrictions/exceptions | MPL | Concentration levels used in the exposure assessment | | Comments |
|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | |
| 13.3 | Dietary foods for weight control diets intended to replace total daily food intake or an individual meal (the whole or part of the total daily diet) | | QS | - | - | Not taken into account (no usage data available) |
| 13.4 | Foods suitable for people intolerant to gluten as defined by Regulation (EC) No 41/2009 | | QS | - | - | Not taken into account (no usage data available) |
| 14.1.4 | Flavoured drinks | Excluding chocolate milk and malt products | QS | 5 | 30 | |
| 14.2.3 | Cider and perry | Excluding *cidre bouché* | QS | 1.9 | 2.6 | |
| 14.2.4 | Fruit wine and made wine | Excluding *wino owocowe markowe* | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 14.2.5 | Mead | | QS | - | - | Not taken into account (no corresponding FoodEx code) |
| 14.2.6 | Spirit drinks as defined in Regulation (EC) No 110/2008 | Except: spirit drinks as defined in Article 5(1) and sales denominations listed in Annex II, paragraphs 1-14 of Regulation 110/2008 and spirits (preceded by the name of the fruit) obtained by maceration and distillation, Geist (with the name of the fruit or the raw material used), London Gin, Sambuca, Maraschino, Marrasquino or Maraskino and Mistrà | QS | 5 | 15 | No data received, reported levels from other alcoholic beverages were used |
| 14.2.7.3 | Aromatised wine-product cocktails | | QS | 5 | 10 | |
| 14.2.8 | Other alcoholic drinks including mixtures of alcoholic drinks with non-alcoholic drinks and spirits with less than 15% of alcohol | | QS | 5 | 15 | |
| 15.1 | Potato-, cereal-, flour- or starch-based snacks | | QS | 33 | 100 | |
| 15.2 | Processed nuts | | QS | 50 | 100 | |

| FCS category no. | FCS food category | Restrictions/exceptions | MPL | Concentration levels used in the exposure assessment | | Comments |
|---|---|---|---|---|---|---|
| | | | | Mean | Maximum | |
| 16 | Desserts excluding products covered in category 1, 3 and 4 | | QS | 11 | 50 | |
| 17.1 | Food supplements supplied in a solid form including capsules and tablets and similar forms, excluding chewable forms | | QS | - | - | Not taken into account (no usage data available) |
| 17.2 | Food supplements supplied in a liquid form | | QS | - | - | Not taken into account (no usage data available) |
| 17.3 | Food supplements supplied in a syrup-type or chewable form | | QS | - | - | Not taken into account (no usage data available) |

## Appendix C. Summary of total estimated exposure to paprika extract (E 160c) from its use as a food additive for the maximum level exposure scenario and the refined exposure assessment scenarios per population group and survey: mean and high level (mg/kg bw/day) expressed as total carotenoids

| | Number of subjects | Maximum level scenario | | Brand-loyal scenario | | Non-brand-loyal scenario | |
|---|---|---|---|---|---|---|---|
| | | Mean | High level | Mean | High level | Mean | High level |
| **Infants** | | | | | | | |
| Bulgaria (NUTRICHILD) | 859 | 0.129 | 0.539 | 0.114 | 0.487 | 0.058 | 0.241 |
| Germany (VELS) | 159 | 0.417 | 1.603 | 0.321 | 1.173 | 0.164 | 0.755 |
| Denmark (IAT 2006_07) | 826 | 0.319 | 0.810 | 0.246 | 0.644 | 0.151 | 0.371 |
| Finland (DIPP_2001_2009) | 500 | 0.138 | 0.389 | 0.123 | 0.356 | 0.065 | 0.193 |
| United Kingdom (DNSIYC_2011) | 1366 | 0.482 | 1.285 | 0.335 | 0.838 | 0.175 | 0.476 |
| Italy (INRAN_SCAI_2005_06) | 16 | 0.253 | | 0.234 | | 0.092 | |
| **Toddlers** | | | | | | | |
| Belgium (Regional_Flanders) | 36 | 1.817 | | 1.136 | | 0.541 | |
| Bulgaria (NUTRICHILD) | 428 | 0.502 | 1.142 | 0.399 | 0.920 | 0.206 | 0.466 |
| Germany (VELS) | 348 | 1.152 | 2.432 | 0.746 | 1.720 | 0.355 | 0.732 |
| Denmark (IAT 2006_07) | 917 | 0.616 | 1.128 | 0.382 | 0.714 | 0.243 | 0.440 |
| Spain (enKid) | 17 | 0.709 | | 0.559 | | 0.266 | |
| Finland (DIPP_2001_2009) | 500 | 0.479 | 1.074 | 0.378 | 0.871 | 0.221 | 0.485 |
| United Kingdom (NDNS-RollingProgrammeYears1-3) | 185 | 1.027 | 2.037 | 0.601 | 1.310 | 0.359 | 0.718 |
| United Kingdom (DNSIYC_2011) | 1314 | 0.893 | 1.897 | 0.552 | 1.178 | 0.322 | 0.671 |
| Italy (INRAN_SCAI_2005_06) | 36 | 0.530 | | 0.403 | | 0.194 | |
| Netherlands (VCP_kids) | 322 | 1.222 | 2.439 | 0.785 | 1.503 | 0.392 | 0.803 |
| **Children** | | | | | | | |
| Austria (ASNS_Children) | 128 | 0.743 | 1.438 | 0.466 | 0.937 | 0.260 | 0.544 |
| Belgium (Regional_Flanders) | 625 | 1.446 | 2.670 | 0.904 | 1.700 | 0.447 | 0.848 |
| Bulgaria (NUTRICHILD) | 433 | 0.618 | 1.342 | 0.466 | 1.032 | 0.235 | 0.502 |
| Czech Republic (SISP04) | 389 | 0.744 | 1.723 | 0.485 | 1.178 | 0.250 | 0.559 |
| Germany (EsKiMo) | 835 | 0.604 | 1.261 | 0.395 | 0.862 | 0.208 | 0.394 |
| Germany (VELS) | 293 | 1.130 | 2.088 | 0.694 | 1.452 | 0.344 | 0.613 |
| Denmark (DANSDA 2005-08) | 298 | 0.570 | 1.087 | 0.367 | 0.709 | 0.177 | 0.321 |
| Spain (enKid) | 156 | 0.623 | 1.413 | 0.415 | 0.921 | 0.215 | 0.465 |
| Spain (NUT_INK05) | 399 | 0.650 | 1.357 | 0.412 | 0.822 | 0.221 | 0.441 |
| Finland (DIPP_2001_2009) | 750 | 0.558 | 1.148 | 0.368 | 0.819 | 0.205 | 0.425 |
| France (INCA2) | 482 | 0.794 | 1.451 | 0.480 | 0.910 | 0.285 | 0.496 |
| United Kingdom (NDNS-RollingProgrammeYears1-3) | 651 | 0.884 | 1.635 | 0.513 | 1.011 | 0.288 | 0.526 |
| Greece (Regional_Crete) | 838 | 0.572 | 1.188 | 0.408 | 0.917 | 0.219 | 0.460 |
| Italy (INRAN_SCAI_2005_06) | 193 | 0.424 | 0.970 | 0.300 | 0.668 | 0.164 | 0.368 |
| Latvia (EFSA_TEST) | 187 | 0.958 | 1.958 | 0.631 | 1.278 | 0.334 | 0.712 |
| Netherlands (VCP_kids) | 957 | 1.123 | 2.100 | 0.690 | 1.349 | 0.358 | 0.690 |
| Netherlands (VCPBasis_AVL2007_2010) | 447 | 1.154 | 1.989 | 0.716 | 1.305 | 0.321 | 0.599 |
| Sweden (NFA) | 1473 | 1.174 | 2.112 | 0.672 | 1.236 | 0.355 | 0.665 |
| **Adolescents** | | | | | | | |
| Austria (ASNS_Children) | 237 | 0.438 | 0.968 | 0.292 | 0.626 | 0.144 | 0.311 |
| Belgium (Diet_National_2004) | 576 | 0.616 | 1.261 | 0.407 | 0.842 | 0.171 | 0.351 |
| Cyprus (Childhealth) | 303 | 0.181 | 0.413 | 0.132 | 0.295 | 0.075 | 0.164 |
| Czech Republic (SISP04) | 298 | 0.534 | 1.196 | 0.359 | 0.855 | 0.174 | 0.361 |
| Germany (National_Nutrition_Survey_II) | 1011 | 0.439 | 1.083 | 0.302 | 0.725 | 0.130 | 0.343 |
| Germany (EsKiMo) | 393 | 0.471 | 1.045 | 0.323 | 0.774 | 0.156 | 0.311 |

| | Number of subjects | Maximum level scenario | | Brand-loyal scenario | | Non-brand-loyal scenario | |
|---|---|---|---|---|---|---|---|
| | | Mean | High level | Mean | High level | Mean | High level |
| Denmark (DANSDA 2005-08) | 377 | 0.337 | 0.740 | 0.239 | 0.537 | 0.098 | 0.202 |
| Spain (AESAN_FIAB) | 86 | 0.252 | 0.560 | 0.184 | 0.419 | 0.095 | 0.222 |
| Spain (enKid) | 209 | 0.372 | 0.865 | 0.246 | 0.535 | 0.121 | 0.302 |
| Spain (NUT_INK05) | 651 | 0.395 | 0.785 | 0.250 | 0.484 | 0.125 | 0.261 |
| Finland (NWSSP07_08) | 306 | 0.302 | 0.803 | 0.205 | 0.573 | 0.102 | 0.273 |
| France (INCA2) | 973 | 0.401 | 0.825 | 0.251 | 0.542 | 0.142 | 0.297 |
| United Kingdom (NDNS-RollingProgrammeYears1-3) | 666 | 0.507 | 1.052 | 0.319 | 0.655 | 0.147 | 0.301 |
| Italy (INRAN_SCAI_2005_06) | 247 | 0.268 | 0.723 | 0.185 | 0.504 | 0.091 | 0.217 |
| Latvia (EFSA_TEST) | 453 | 0.626 | 1.323 | 0.414 | 0.851 | 0.211 | 0.457 |
| Netherlands (VCPBasis_AVL2007_2010) | 1142 | 0.767 | 1.479 | 0.482 | 0.942 | 0.207 | 0.411 |
| Sweden (NFA) | 1018 | 0.670 | 1.241 | 0.409 | 0.758 | 0.197 | 0.373 |
| **Adults** | | | | | | | |
| Austria (ASNS_Adults) | 308 | 0.382 | 0.882 | 0.253 | 0.566 | 0.127 | 0.306 |
| Belgium (Diet_National_2004) | 1292 | 0.458 | 0.998 | 0.312 | 0.709 | 0.132 | 0.283 |
| Czech Republic (SISP04) | 1666 | 0.228 | 0.562 | 0.161 | 0.398 | 0.082 | 0.192 |
| Germany (National_Nutrition_Survey_II) | 10419 | 0.336 | 0.801 | 0.232 | 0.563 | 0.106 | 0.251 |
| Denmark (DANSDA 2005-08) | 1739 | 0.190 | 0.440 | 0.131 | 0.343 | 0.060 | 0.120 |
| Spain (AESAN) | 410 | 0.203 | 0.562 | 0.151 | 0.427 | 0.069 | 0.166 |
| Spain (AESAN_FIAB) | 981 | 0.179 | 0.417 | 0.130 | 0.302 | 0.065 | 0.153 |
| Finland (FINDIET2012) | 1295 | 0.338 | 0.804 | 0.240 | 0.578 | 0.141 | 0.370 |
| France (INCA2) | 2276 | 0.236 | 0.496 | 0.149 | 0.313 | 0.081 | 0.166 |
| United Kingdom (NDNS-RollingProgrammeYears1-3) | 1266 | 0.285 | 0.591 | 0.184 | 0.393 | 0.085 | 0.185 |
| Hungary (National_Repr_Surv) | 1074 | 0.129 | 0.355 | 0.098 | 0.271 | 0.040 | 0.101 |
| Ireland (NANS_2012) | 1274 | 0.304 | 0.612 | 0.201 | 0.428 | 0.105 | 0.239 |
| Italy (INRAN_SCAI_2005_06) | 2313 | 0.143 | 0.366 | 0.105 | 0.274 | 0.049 | 0.111 |
| Latvia (EFSA_TEST) | 1271 | 0.382 | 0.785 | 0.273 | 0.549 | 0.132 | 0.273 |
| Netherlands (VCPBasis_AVL2007_2010) | 2057 | 0.442 | 0.925 | 0.282 | 0.625 | 0.126 | 0.265 |
| Romania (Dieta_Pilot_Adults) | 1254 | 0.151 | 0.347 | 0.102 | 0.242 | 0.054 | 0.127 |
| Sweden (Riksmaten 2010) | 1430 | 0.360 | 0.693 | 0.222 | 0.437 | 0.113 | 0.222 |
| **The elderly** | | | | | | | |
| Austria (ASNS_Adults) | 92 | 0.333 | 0.650 | 0.228 | 0.454 | 0.118 | 0.241 |
| Belgium (Diet_National_2004) | 1215 | 0.382 | 0.825 | 0.272 | 0.594 | 0.129 | 0.283 |
| Germany (National_Nutrition_Survey_II) | 2496 | 0.271 | 0.634 | 0.193 | 0.477 | 0.095 | 0.231 |
| Denmark (DANSDA 2005-08) | 286 | 0.123 | 0.280 | 0.079 | 0.204 | 0.045 | 0.096 |
| Finland (FINDIET2012) | 413 | 0.333 | 0.741 | 0.259 | 0.591 | 0.161 | 0.392 |
| France (INCA2) | 348 | 0.172 | 0.363 | 0.113 | 0.246 | 0.060 | 0.137 |
| United Kingdom (NDNS-RollingProgrammeYears1-3) | 305 | 0.281 | 0.547 | 0.180 | 0.363 | 0.100 | 0.207 |
| Hungary (National_Repr_Surv) | 286 | 0.101 | 0.265 | 0.077 | 0.205 | 0.034 | 0.088 |
| Ireland (NANS_2012) | 226 | 0.285 | 0.641 | 0.202 | 0.464 | 0.124 | 0.301 |
| Italy (INRAN_SCAI_2005_06) | 518 | 0.107 | 0.297 | 0.082 | 0.222 | 0.038 | 0.089 |
| Netherlands (VCPBasis_AVL2007_2010) | 173 | 0.337 | 0.662 | 0.224 | 0.425 | 0.112 | 0.230 |
| Netherlands (VCP-Elderly) | 739 | 0.331 | 0.702 | 0.215 | 0.479 | 0.112 | 0.250 |
| Romania (Dieta_Pilot_Adults) | 128 | 0.138 | 0.311 | 0.094 | 0.218 | 0.057 | 0.147 |
| Sweden (Riksmaten 2010) | 367 | 0.333 | 0.665 | 0.210 | 0.409 | 0.115 | 0.232 |

## GLOSSARY AND ABBREVIATIONS

| | |
|---|---|
| ADI | acceptable daily intake |
| AFC | Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food |
| ANS | Panel on Food Additives and Nutrient Sources added to Food |
| CAS | Chemical Abstracts Service |
| CIAA | Confederation of the Food and Drink Industries of the EU |
| Con A | Concanavalin A |
| CONTAM | EFSA Panel on Contaminants in the Food Chain |
| DAD | diode array detection |
| EC | European Commission |
| EFSA | European Food Safety Authority |
| EINECS | European Inventory of Existing Commercial Chemical Substances |
| EPA | US Environmental Protection Agency |
| EU | European Union |
| FAO/WHO | Food and Agriculture Organization/World Health Organization |
| FCS | Food Categorisation System |
| FDE | FoodDrinkEurope |
| FEEDAP | Panel on Additives and Products or Substances used in Animal Feed |
| GC-MS | gas chromatography-mass spectrometry |
| GLP | good laboratory practice |
| HPLC | high-performance liquid chromatography |
| HPLC-IAC | HPLC immunoaffinity chromatography |
| JECFA | Joint FAO/WHO Expert Committee on Food Additives |
| ICP-OES | inductively coupled plasma optical emission spectroscopy |
| ICP-MS | inductively coupled plasma mass spectrometry |
| IgE | immunoglobulin E |
| IL | interleukin |
| IFN | interferon |
| $LD_{50}$ | lethal dose, 50 %, i.e. dose that causes death among 50 % of treated animals |
| LFGB | Lebensmittel und Futtermittelgesetzbuches (German Food and Feed Code) |
| MNBN | micronucleated binucleated cells |
| MPL | maximum permitted level |
| NATCOL | Natural Food Colours Association |
| NOAEL | no-observed-adverse-effect level |
| NOEL | no-observed-effect level |
| OECD | Organisation for Economic Co-operation and Development |

| | |
|---|---|
| PP | Peyer's patch |
| QS | quantum satis |
| SCF | Scientific Committee on Food |
| TG | test guideline |
| TOF | time-of-flight |
| UHPSFC | ultra high-performance supercritical fluid chromatography |