

Safety Assessment on Cannabidiol (CBD) Used as a Novel Food for Use in Food supplements. (RP176)

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FSA Research and Evidence

An application was submitted to the Food Standards Agency (FSA) and Food Standards Scotland (FSS) in February 2021 from Curesupport Holding B.V. (“the applicant”) for the authorisation of cannabidiol (CBD) isolate as a novel food.

The novel food is a CBD isolate which is intended to be used as a food ingredient in food supplements for adults (excluding pregnant and lactating women and other specifically identified vulnerable groups such as those on medication and the immunosuppressed).

The novel food was assessed based on the data provided. This review indicated it was appropriate for the provisional ADI for 98% or greater CBD to form part of the evidence for this assessment. For CBD a provisional acceptable daily intake (ADI) of 10 mg/day for a healthy 70 kg adult has been published by the FSA and was considered in assessing this novel food. The provisional ADI (section 2.7) was recommended, subject to the existing advice to consumers that pregnant and breastfeeding women and people taking any prescription medication should avoid the consumption of CBD. Consumers on regular medications should seek advice from a medical professional before using any type of CBD food product. In addition, children and prospective parents trying for a baby are advised against consumption of CBD, as are those who are immunosuppressed. This is due to remaining data gaps and residual uncertainties concerning the safety of CBD for these groups of consumers.

To support the FSA and FSS in their evaluation of the application, the Advisory Committee on Novel Foods and Processes (ACNFP) were asked to review the safety dossier and supplementary information provided by the applicant. The Committee did not consider any potential health benefits or claims arising from consuming the food, as the focus of the novel food assessment is to ensure the food is safe and does not put consumers at a nutritional disadvantage.

The Committee concluded that the applicant had provided sufficient information to assure the novel food, which is an isolated CBD as detailed in application RP176, was safe under the proposed conditions of use. The

anticipated intake levels and the proposed use in foods and food supplements were not considered to be nutritionally disadvantageous. This safety assessment represents the opinion of the FSA and FSS.

This is a joint FSA and FSS publication.



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1. Introduction

The Advisory Committee on Novel Foods and Processes (ACNFP) assessed the food safety risks of CBD isolated from hemp (*Cannabis sativa*) and its production under the proposed uses in line with Article 7 of assimilated Commission Implementing Regulation (EU) 2017/2469. The regulatory framework and the retained technical guidance put in place by the European Food Safety Authority (EFSA) for full novel food applications is applicable and formed the basis and structure for the assessment (EFSA NDA Panel, 2016).

An application was submitted to the Food Standards Agency (FSA) and Food Standards Scotland (FSS) in February 2021 from Curesupport Holding B.V. ("the applicant") for the authorisation of isolated cannabidiol (CBD) as described in RP176, as a novel food. The novel food is a $\geq 98\%$ pure, hemp-derived (*Cannabis sativa*) CBD isolate, which is intended to be used as an ingredient in food supplements for adults (excluding pregnant and lactating women and other specifically identified vulnerable groups such as those on medication and the immunosuppressed).

Advice was sought from the Joint Subgroup of the ACNFP and the Committee on Toxicity (COT) on CBD and hemp-derived products on the quality of the toxicological evidence submitted to support the application. The ACNFP and COT have issued a joint statement on the safe upper intake of ingredients containing 98% or more CBD (ACNFP and COT, 2023). This, and wider evidence available in the public domain, was considered in reviewing the toxicological evidence for this application.

Following the review by the ACNFP at the 170th meeting, final recommendations were presented, allowing the Committee Advice to be concluded.

This document outlines the conclusions of the ACNFP on the safety of isolated cannabidiol (CBD) as detailed in application RP176, as a novel food.

2. Assessment

2.1. Identity of the Novel Food

The novel food is a cannabidiol (CBD) isolate in the form of a white to off white crystalline powder of purity equal to or greater than 98%. Information to support this characterisation was provided for five batches of the novel food.

CBD is characterised by the chemical formula: $C_{21}H_{30}O_2$; molecular mass: 314.46 g/mol; CAS number: 13956-29-1; IUPAC name: 2-[(1*R*,6*R*)-3-methyl-6-prop-1-en-2-ylcyclohex-2-en-1-yl]-5-pentylbenzene-1,3-diol.

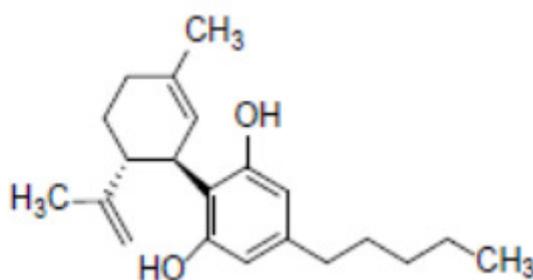


Diagram 1. The molecular structure of CBD

Confirmation of its identity and purity was provided by gas chromatography – flame ionisation detection (GC-FID), high performance liquid chromatography – ultraviolet (HPLC-UV), ultraviolet-visible spectroscopy (UV-Vis), gas chromatography – mass spectrometry (GC-MS) (electron impact ionisation) and Fourier-transform infrared spectroscopy (FTIR).

2.2. Production Process

The CBD isolate is manufactured using a multi-step process under controlled conditions.

Certificates of analysis for raw starting materials used in the extraction process were provided to demonstrate the effectiveness of the controls at this point in the process. The details of the commercially sensitive extraction process were shared and reviewed by the ACNFP.

The industrial hemp is first tested to ensure it meets all internal quality specifications before it is accepted. Manufacturing begins with botanical raw material in the form of either shredded flowers and leaves or compacted pelletised material. It is then processed further using an

n-pentane processing aid and filtered three times to produce filtrates that are combined and homogenised. The filtrates then go through several purifying, filtering, evaporation and crystallisation steps to produce the highly purified cannabidiol (CBD) isolate.

The ACNFP considered whether the use of solvents as processing aids resulted in residues that require highlighting to risk managers. To assess the safety of the solvent residues that remain in the novel food, comparison was made to residue limits for other consumed products as detailed in [Table 1](#).

Table 1. Comparison of information on permitted residue levels for solvents used in the novel foods production compared to the proposed specification.

Solvent used	Available data on safe maximum level of consumption	Level in specification for the novel food
<i>n</i> -Pentane	Guidance on residues in Pharmaceutical products states it to be a class 3 solvent which should be limited by GMP or other quality-based requirements. 15 mg per day or less (1,500 ppm) would be acceptable without justification ¹	≤ 300 ppm

[ICH Q3C \(R9\) Guideline on impurities: guideline for residual solvents_Step 5](#)

¹ [Q3C \(R8\) Step 5 - impurities: guideline for residual solvents \(europa.eu\)](#)

The evidence presented (see [Table 2](#) below) on composition indicates compliance with the specification for residues of solvents. When considered at the level of consumption, the evidence suggests the levels of solvent residues in the novel food are below those which would represent a safety concern.

A Hazards Analysis and Critical Control Points (HACCP) statement was provided along with further details of the process and how it operates. The production process has characterised the potential hazards and detailed the corresponding control measures sufficiently.

2.3. Compositional Information

Results from analysis of five independent batches of the novel food demonstrated that the CBD content is produced consistently. The data is presented within [Tables 2 to 8](#).

[Table 2](#) presents data on the physiochemical properties of five independent batches of isolated CBD. The data presented in [Table 3](#) indicates CBD content is consistently above 98% purity with negligible amounts of starting materials detected across the five representative batches.

It is recognised that the detection and characterisation of cannabinoids in a range of food matrices is an evolving area and there are yet to be internationally recognised methods. The limitations of analytical methodology available have been subject to discussion in the Joint ACNFP and COT CBD Subgroup, and remain a source of uncertainty in the assessment.

Table 2. Physicochemical analysis of five independent representative batches of cannabidiol (CBD) isolate

Parameter	Specification	LOD/LOQ	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
Colour and Appearance	White, crystalline powder free of particulates	NA	Conforms	Conforms	Conforms	Conforms	Conforms
CBD Identification	Retention time of the primary peak in sample chromatogram matches that in the analytical reference standard	NA	Conforms	Conforms	Conforms	Conforms	Conforms
CBD Identification	UV spectrum of the primary peak in sample chromatogram matches that in the analytical reference standard	NA	Conforms	Conforms	Conforms	Conforms	Conforms

Table 3. Cannabinoid analysis as % weight for weight of five independent representative batches of cannabidiol (CBD) isolate

Parameter	Specification	LOD/LOQ	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
CBD Content (% w/w)	≥98	0.05	100 ± 0.6	98 ± 0.3	99.3 ± 0.4	99.8 ± 0.2	99 ± 0.3
THC	≤0.05	0.05	ND	ND	<LOQ	ND	ND
THCA	<LOQ	0.05	ND	ND	ND	ND	ND
Total THC	≤0.05	0.05	0.008	0.02	0.0003	0.002	0.0017
CBN	<LOQ	0.05	0.023	0.017	ND	ND	ND
Δ9-THC	<LOQ	0.01	0.008	0.02	0.0003	0.002	0.0017
Δ8-THC	<LOQ	0.015/0.05	ND	ND	ND	ND	ND
CBDA	Report	0.05	0.11 ± 0.001	0.02 ± 0.001	ND	0.004 ± 0.0002	0.003 ± 0.0001
CBDVA	Report	0.005/0.05	ND	ND	ND	ND	ND

Parameter	Specification	LOD/ LOQ	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
CBDV	Report	0.05	0.24 ± 0.003	0.27 ± 0.005	0.09 ± 0.002	0.30 ± 0.005	0.28 ± 0.004
CBG	Report	0.05	0.014	0.025	ND	ND	ND
CBN	Report	0.005/ 0.05	0.023	0.017	ND	ND	ND
Total Unknowns	Report	0.05	ND	ND	ND	ND	ND
Total (Sum of all observed Related Cannabinoids known and unknown)	Report	0.05	0.504	0.532	0.479	0.512	0.590
Total Cannabinoids (CBD plus total Related Cannabinoids, %w/w)	Report	0.05	99.110	98.952	99.219	100.262	99.690

CBD = Cannabidiol; CBD-A = Cannabidiolic acid; CBDV = Cannabidivarin; CBDV-A = Cannabidivarinic acid; CBG = Cannabigerol; CBG-A = Cannabigerolic acid; CBN = Cannabinol; Δ8-THC = Delta-8-Tetrahydrocannabinol; Δ9-THC = Delta-9-Tetrahydrocannabinol; THC-A = Tetrahydrocannabinolic acid; THC = Tetrahydrocannabivarin; THCV-A = Tetrahydrocannabivarinic acid; LOQ = limit of quantification

Analytical data concerning the microbiological content from five batches of the novel food was reported (Table 4). The process in manufacturing this novel food uses extreme high and low temperatures and alcohol solvents. Full microbial analysis as per United States Pharmacopeia (USP) 2022 and 2021 confirm that the novel food shows absence of microbial growth.

Table 4. The microbiological analysis of the novel food

Parameter	Specification	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
<i>Escherichia coli</i> (<i>E. coli</i>)	Absent (N.D.)	N.D.	N.D.	N.D.	N.D.	N.D.
<i>Salmonella</i>	Absent (N.D.)	N.D.	N.D.	N.D.	N.D.	N.D.
Aerobic Plate Count	< 2000 CFU/g	N.D.	N.D.	N.D.	N.D.	N.D.
Yeast Count	< 200 CFU/g	N.D.	N.D.	N.D.	N.D.	N.D.
Mould Count	< 200 CFU/g	N.D.	N.D.	N.D.	N.D.	N.D.

CFU = colony forming unit

Additionally, water content as measured in five batches of CBD isolate was presented. The isolated CBD has a water content of <0.05% for all five batches, which suggests it is unable to support microbial growth.

The microbiological data presented confirm that the novel food does not raise a safety concern and consistently meets the proposed microbial specification levels.

Results from the mycotoxin analysis for five independent representative batches of isolated CBD are presented in [Table 5](#). The data show that the isolated CBD consistently complies with the specifications set for mycotoxins within the final product.

Table 5. Mycotoxin analysis of five independent representative batches of cannabidiol (CBD) isolate

Mycotoxins (ppb)	Specification	LOD/ LOQ	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
B1 (AFB1)	≤5	0.04/ 0.1	ND	ND	ND	ND	ND
B2 (AFB2)	≤0.5	0.04/ 0.1	ND	ND	ND	ND	ND
G1 (AFG1)	≤0.5	0.02/ 0.1	ND	ND	ND	ND	ND
G2 (AFG2)	≤0.5	0.1/ 0.4	ND	ND	ND	ND	ND
Total	≤4	0.04/ 0.5	ND	ND	ND	ND	ND
Ochratoxin A (µg/kg)	≤ 15.0		ND	ND	ND	ND	ND

PPB = Parts Per Billion; LOQ = Limit of quantification; ND = not detected; AF = Aflatoxin

Novel food products must comply with the legal requirements for heavy metal contaminants in food. Analytical data, presented for five independent batches of the novel food, demonstrated that heavy metals were present in low quantities and below established EU limits where applicable (applicable for arsenic, cadmium, mercury and lead) ([Table 6](#)).

Table 6. Heavy metal analysis of five independent representative batches of cannabidiol (CBD) isolate

Heavy metals (ppm)	Specification	LOD/ LOQ	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
Arsenic	<3.0	LOQ: 0.01	ND	ND	ND	ND	ND
Cadmium	<1.0	LOQ: 0.005	0.54	0.44	0.34	0.56	0.25
Lead	<3.0	LOQ: 0.005	2.6	1.1	1.3	0.039	0.16
Mercury	<0.1	LOQ: 0.005	ND	ND	ND	ND	ND

Results from the residual solvent analysis for five independent representative batches of isolated CBD are presented in [Table 7](#). The data show that the isolated CBD is able to consistently comply with the specifications set for residual solvents within the final product.

Table 7. Residual solvent analysis of five independent representative batches of cannabidiol (CBD) isolate

Residual Solvents (ppm) ²						
Parameter	Specification ¹	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5
<i>n</i> -pentane	≤1500	≤300	≤300	≤300	≤300	≤300

¹= [ICH Q3C \(R9\) Guideline on impurities: guideline for residual solvents_Step 5](#); LOQ = Limit of quantitation; ND = not detected

THC as a potential contaminant in the novel food

The extraction process may result in other cannabinoids remaining as contaminants. In particular, delta-9-tetrahydrocannabinol (Δ 9-THC), and its precursor acid, delta-9-tetrahydrocannabinolic acid (Δ 9-THCA), were analysed due to the potential for toxic effects resulting from their consumption, and the status of Δ 9-THC as a controlled drug within the UK ([Table 2](#)). Along with Δ 9-THC, other minor cannabinoids which occur at contaminant levels have the potential to play a role in the toxicity of CBD novel food products; as such, they require due consideration and monitoring to ensure the novel foods remain safe. As a result, the robustness, accuracy, and precision of the methods have been considered in interpreting the data on Δ 9-THC and were considered appropriate in this case.

A literature review was undertaken as part of the assessment of CBD as a novel food, to understand the impact on the safety of foods with trace levels of contamination with Δ 9-THC. The Joint ACNFP and COT Subgroup reviewed the information from literature and identified a point of departure from the European Food Safety Authority (EFSA) opinion on Δ 9-THC as a contaminant in milk and meat (EFSA, 2015).

Evidence from an EFSA review by the CONTAM Panel suggested a point of departure from a LOAEL (lowest observed adverse effect level) of 0.036 mg/kg bw/day in humans, which is drawn from the most sensitive individuals and at the lowest dose tested in the clinical studies that were reviewed (EFSA, 2015). Uncertainty factors were then applied to identify a safe upper intake level. These included a factor of 3 to extrapolate from a LOAEL to a NOAEL (no observed adverse effect level), which was considered appropriate as the effects are mild to moderate in severity. A further factor of 10 was applied for person-to-person variation, resulting

in total to an applied uncertainty factor of 30. This resulted in a safe upper intake level (SUL) of 1 µg /kg bw/day for Δ9-THC consumed as a contaminant in food.

The Subgroup agreed the SUL to be sufficiently protective to apply to the UK population also for chronic intake. It was noted that in applying the SUL, EFSA has assumed that the effects seen would be the same if humans were exposed to multiple doses of THC at very low levels (EFSA, 2015). The Subgroup commented that there was no data to verify this assumption, but if setting limits the dataset is the best available.

The analysis for delta-9-tetrahydrocannabinidiol (Δ9-THC) as a potential contaminant in the novel food was declared as not detected in any of the five batches tested ([Table 2](#)), with a limit of quantification of 0.05% (w/w).

The levels of Δ9-THC, where detected in the novel food, and once adjusted to reflect the proposed use of 10 mg of CBD being consumed a day, were below the SUL identified by EFSA of 1 µg /kg bw/day or 70 µg/day for a healthy adult. This level does not present a concern in terms of consumer safety for the novel food under the proposed conditions of use.

To ensure Δ9-THC levels remain consistently low in the production of CBD, THC and its precursor acid combined should be a standard substance included in the specification as relevant to all batches produced.

The data presented did not indicate any additional hazards for inclusion in the specification.

2.4. Stability

The stability of the novel food was assessed under ambient conditions (25°C and 60% relative humidity) in four batches for 12 months. Results showed that the novel food meets the specification criteria for CBD and other cannabinoid content, and microbiological stability over these time periods.

The stability of the CBD isolate was also assessed under accelerated conditions (40°C and 75% relative humidity) in four batches for 12 months. Results confirmed that the novel food meets the specification criteria for CBD content and no changes in appearance, water content and impurity levels are seen over these time periods. The Δ9-THC content was also tested and no significant changes in the levels of Δ9-THC were observed. The data provided supports the stability of CBD isolate for a period of at least 24 months.

2.5. Specification

The applicant's specification parameters (reported in [Table 8](#)) were assessed using internationally recognised methods or determined using internally developed and validated methods. The results of the analysis are detailed in [Tables 2 to 7](#) and indicate the novel food can be produced consistently to the specifications.

Table 8. Specifications of the novel food

Description		
Cannabidiol is a white crystalline powder free of particulates produced by a multistep extraction process		
Parameter	Specification	Method
Appearance	White to off-white crystalline powder free of particulates	Visual
Identity	Retention time of the primary peak in sample chromatogram matches that in the analytical reference standard; UV spectrum of the primary peak in sample chromatogram matches that in the analytical reference standard: Retention time of 9 minutes	FTIR: Ph. Eur. 2.2.24 HPLC: Ph. Eur. 2.2.29
CBD (% w/w)	≥ 98%	HPLC/DAD; Ph.Eur.2.2.29
THC (Δ^9 -Tetrahydrocannabinol) (% w/w)	≤ 0.05	HPLC/DAD; Ph.Eur.2.2.29
THCA (Δ^9 -Tetrahydrocannabinolic Acid) (% w/w)	≤ 0.05	HPLC/DAD; Ph.Eur.2.2.29
Total Related Cannabinoid Content (% w/w)	Report ¹	HPLC/DAD; Ph.Eur.2.2.29
Residual solvents (ppm)		
<i>n</i> -pentane (ppm)	≤1,500 ppm	GC-MS, E.P. 2.4.24
Elemental Impurities (mg/kg)		
Arsenic	≤ 1.0	ICP-MS
Cadmium	≤ 1.0	ICP-MS
Lead	≤ 3.0	ICP-MS
Mercury	≤ 0.1	ICP-MS

CBD = cannabidiol; GC = gas chromatography; HPLC = high-performance liquid chromatography; IR = infrared spectroscopy; USP = United States Pharmacopeia; DAD = diode-array detection; HS-GC-MS = headspace gas chromatography-mass spectrometry; LC-MS = liquid chromatography-mass spectrometry, ICP-MS = inductively coupled plasma mass spectrometry, ¹= LOQ and LOD values for cannabinoids found in CoA in application, ²= Individual pesticides and associated limits found in CoA in application,

The ACNFP concluded the information provided is sufficient for the specification of CBD and appropriately characterises the novel food seeking authorisation.

2.6. History of Use

Hemp has been widely consumed in the UK and EU as a seed oil, in tea and as an alternative to hops in beer. Extracts of hemp including CBD and synthetic CBD have not been widely consumed and are considered novel foods. While CBD products are widely available on the UK high street, indicating some consumption of CBD as a food, at the time of publication no previous applications for CBD have yet received authorisation as a novel food.

As detailed in the COT review of the literature there has been use of both hemp derived and synthetic forms of CBD for medicinal purposes. These provide an indication of the toxicological effects that should be explored in the testing regime – primarily effects on liver, thyroid and potential impacts on reproductive organs. Also reported are behavioural effects such as somnolence (COT, 2023).

As reported in the COT review of the publicly available data on CBD and summary data on a medicinal product, signs of adverse effects on the liver were observed at doses of CBD as low as 5 mg/kg bw/day in patients and healthy human volunteers; this dose is equivalent to 350 mg in a 70 kg adult. The data in the literature also suggested that humans might be more sensitive to the adverse effects of CBD on the liver than laboratory animals.

Somnolence effects were noted at doses ≤ 10 mg/kg bw/day in human studies. Inhibitory drug-drug interactions have also been observed with some medications when CBD is co-administered at doses of 1 mg/kg bw/day (equivalent to 70 mg in a 70 kg adult); the likelihood of effects at lower doses has not been determined (COT, 2023). Based on the COT assessment, therefore, the FSA concluded in February 2020 that 1 mg/kg bw/day, or 70 mg in a 70 kg adult, was a pragmatic upper level of intake above which there would be clear concerns about safety.

It is noted that the doses used for medicinal purposes are higher than those proposed for food use. The purpose of an assessment for medicines authorisation is different to that for food and this is reflected in the data requirements. Unlike medicines, there is no risk-benefit context in foods with the requirement instead being that the products are safe. This means that outcomes that are considered an adverse event for food might not be considered as such in a medicinal study.

Within the literature, further human studies utilising chemically derived CBD provides further evidence of a history of synthetic CBD use (Izgelov et al., 2020; Klotz et al., 2019; Stero Biotechs Ltd., 2024; Wheless et al., 2019). A review by Huestis et al., 2019 of cannabidiol adverse effects and toxicity

notes that, while CBD is not risk-free, severe adverse events occur at doses higher than those recommended for human pharmacotherapies which are prescribed to treat forms of epilepsy.

The data on previous consumption of CBD suggest areas for careful consideration in the toxicological review to understand potential effects at the lower doses used in foods.

2.7. Proposed Use and Anticipated Intake

The intended use is food supplements as defined by The Food Supplements (England, Scotland and Wales) Regulations 2003 in a range of forms.

The applicant initially proposed a use level of 35 mg/day CBD for the novel food in adults, excluding pregnant or lactating women. As a result of consultation with the applicant the proposed uses have been updated to reflect the provisional acceptable daily intake (ADI) for the use of $\geq 98\%$ pure form CBD established at 10 mg per day (ACNFP and COT, 2023). The proposed maximum use levels for the novel food are outlined in [Table 9](#).

Table 9. Amended proposed uses and maximum use levels for the novel food

Food category	Maximum use level per day (mg CBD/day)
Food Supplements (for adults) as defined in the Food Supplements (England) Regulations 2003 and equivalent legislation in the other countries of the GB as capsules and tablets and similar forms with the exception of chewable forms, intended for those 18 years of age or over excluding pregnant and lactating women and other specifically identified vulnerable groups.	10
Food supplements (for adults) as defined in the Food Supplements (England) Regulations 2003 and equivalent legislation in the other countries of the GB, supplied in a liquid form intended for those 18 years of age or older excluding pregnant and lactating women and other specifically identified vulnerable groups.	10
Food supplements (for adults) as defined in the Food Supplements (England) Regulations 2003 and equivalent legislation in the other countries of the GB, supplied in syrup or chewable form intended for those 18 years of age or older excluding pregnant and lactating women and other specifically identified vulnerable groups.	10

It is noted that consumers may be exposed to CBD from a range of food categories. The standard methodology for calculating exposure for a novel food would explore intake from a range of sources and ensure that exposure via the proposed uses would not exceed any safety level identified when consumption of the food category was analysed. It is noted that for CBD that there are already many products available. The assessment has been made on the basis of identification of a maximum level of CBD that can be consumed per day. As such proposed uses will

only be considered safe within the assessment when at a maximum consumption of 10 mg of CBD per day from all sources (as concluded in section 2.10 of this assessment).

Concerns were raised by the Committee regarding the potential for foreseeable misuse of CBD if consumed in multiple formats per day. However, the scope of the assessment is restricted to the uses proposed and any further uses or additional food categories would be subject to the change in conditions of use process.

Risk managers must consider whether consumers would benefit from information on the CBD content of foods in order to ensure their consumption does not exceed the maximum intake of 10 mg per day for a healthy adult.

As recommended in the ACNFP and COT statement on CBD of 98% purity, "The provisional ADI is recommended, subject to the existing advice to consumers that pregnant and breastfeeding women and people taking any prescription medication should avoid the consumption of CBD if possible. Consumers on regular medications should seek advice from a medical professional before using any type of CBD food product. In addition, children and prospective parents trying for a baby are advised against consumption of CBD, as are those who are immunosuppressed, due to remaining data gaps and residual uncertainties concerning the safety of CBD for these groups of consumers." (ACNFP and COT, 2023).

The ACNFP explored the potential for foreseeable misuse of the novel food. It was noted that the availability of multiple formats of the novel food could create conditions where exposure estimates are exceeded. It is highlighted to risk managers that they may wish to consider whether risk management measures are needed beyond those in the food supplements regulation to ensure consumers are aware of the provisional ADI of 10 mg CBD/day for the product, a dose at which it is considered that no adverse effects would be expected.

It is also recommended that risk managers consider how consumers can be supported to manage their intake appropriately within the safe limits identified and appreciate the nature of the potential risks at higher doses, for uses that are not in dosed forms.

The food supplement products are to be labelled in accordance with the labelling requirements of Food Supplements (England) Regulations 2003 and the equivalent legislation in the nations of GB. The ACNFP recommended that the applicants proposed warning labelling be updated to include information on not exceeding the safe limit of 10 mg/day for a 70 kg healthy adult and that the product is not suitable for use under the age

of 18 or for use during pregnancy or breastfeeding, as well as information on its suitability if the consumer is taking medication or has existing health conditions.

2.8. Absorption, Distribution, Metabolism and Excretion (ADME)

The Absorption, Distribution, Metabolism and Excretion (ADME) of CBD are known to be complicated by the food matrix and are currently still being defined by professional bodies.

The oral bioavailability of CBD is low, indicating that it is not absorbed to any notable extent following ingestion (Mechoulam et al., 2002). Published works report the bioavailability of CBD to be between 13 and 19% (Grotenhermen (2003)) or 6% (Hawksworth and McArdle (2004)). The low systemic availability was demonstrated by Martin-Santos et al., 2012 and further supported by a literature search which identified the pharmacokinetics of CBD in humans (Millar et al., 2018). The COT statement on CBD of 2020 noted that although CBD has low fasting bioavailability (<10%), consumption with food could increase CBD uptake, by for example, 5-fold if eaten with a high fat meal. As such, the potential for matrix effects that impact bioavailability cannot be ruled out.

Following oral absorption, CBD is extensively metabolised in the liver. This rapid first pass metabolism contributes to the low oral bioavailability reported in the literature (Taylor et al., 2018; WHO, 2018). In vitro studies indicate that CYP3A4 and CYP2C19 are the primary hepatic enzymes responsible for first-pass metabolism of cannabidiol; however, several other hepatic cytochrome P450 isoforms (CYP1A1, CYP1A2, CYP2C9, CYP2D6, and CYP3A5) have also demonstrated a capability of metabolising cannabidiol (Jiang et al., 2011; Zendulka et al., 2016).

The metabolism of CBD is thought to follow two separate pathways. One is P450-mediated, in which cannabidiol is metabolised into its major metabolite 7-COOH-CBD. This is followed by further metabolic reactions which yield the minor metabolites of CBD including 6-OH-CBD (Devinsky et al., 2018; Taylor et al., 2018). The other involves decarboxylation (Kraemer et al., 2019). The resultant metabolites are predominantly excreted in faeces and urine (Hawksworth & McArdle, 2004; WHO, 2018).

Multiple dosing with CBD is associated with a steady state concentration up to 2-fold accumulation of CBD in plasma when compared with a single dose (Taylor et al., 2018). Minimal evidence of plasma accumulation has been reported in dosing studies over 5–9 days (Millar et al., 2018; Sellers et al., 2013; Stott et al., 2013).

The pharmacokinetics of CBD have also been systematically reviewed by Millar et al., 2018 in 24 studies, most of which assessed the administration of CBD at doses of 5–20 mg/day. This correlates to a low dose application similar to this CBD novel food application. With oral administration, single doses of 5.4 and 10 mg CBD achieved peak serum concentrations (C_{max}) of 0.9 and 2.5 ng/mL. The time to maximum concentration (T_{max}) was approximately 1 hour, with a half-life between 1 to 3 hours. Given the intended use of this CBD, with an approximate half-life of one to three hours, with a total clearance of 6 hours, there are no significant concerns of accumulation. (Millar et al., 2018).

The ADME data provides context for interpreting the toxicological data. It is noted that the bioavailability of CBD is typically low but can be affected by the matrix. It is noted that the potential for CBD to accumulate in the body has not been examined based on the data supplied. This also suggests the food context for CBD could impact whether the CBD present in the ingredient is more, or less, bioavailable. This has been taken into account when considering the additional uncertainty factors used for setting the provisional ADI.

2.9. Nutritional Information

The ACNFP sought clarification of the potential for the presence of antinutritional factors from the preparation. It was noted that hemp can contain a range of substances that could impact the digestion and absorption of nutrients from the diet. These include phytic acid (which can negatively affect the bioavailability of dietary and endogenous some minerals), tannins (which can inhibit interrupt the absorption of iron), trypsin inhibitors (which can affect protein digestion), and saponins (which can cause gastric irritation and increase the permeability of the intestine).

The product is highly purified as indicated in the information on the composition. There is no presence of other components that would impact the digestion or absorption of nutrients from the diet.

The data on nutritional composition confirms that CBD has no caloric or nutritional value. The application is not intending that CBD replace another food in the diet. Consumption of the novel food at the proposed use levels is not expected to be nutritionally disadvantageous for consumers.

2.10. Toxicological Information

Toxicological studies on CBD were performed by the applicant to support the safety assessment of the novel food. The respective study reports are unpublished and claimed as confidential and proprietary data. They were considered essential in the assessment of the safety of the novel food and

were reviewed by the ACNFP. How data on systemic toxicity was managed and interpreted in the context of the provisional ADI is explained in the subchronic toxicology section (Section 2.10.2) below.

2.11.1. Genotoxicity

In vitro genotoxicity testing of CBD was conducted under Good Laboratory Practice (GLP) conditions and utilised the following OECD guidelines: *in vitro* bacterial reverse mutation test (OECD TG 471) and *in vitro* mammalian cell micronucleus test (OECD TG 487). This approach is recommended by the UK Committee on Mutagenicity and is also the basis of guidance on the preparation and submission of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283.

The *in vitro* bacterial reverse mutation test (Study B-03261) demonstrated that this CBD ingredient was non-mutagenic, in the absence or presence of metabolic activation. In addition, the *in vitro* mammalian cell micronucleus test demonstrated that CBD was non-clastogenic and non-aneugenic in the absence and presence of metabolic activation (MIC PH-21-0522).

The results from these *in vitro* studies (Study No.: B-03261 and MIC-PH-21/0522) support the conclusion that the novel food ($\geq 98\%$ pure CBD) is not genotoxic. This is consistent with the view of the Committee on Mutagenicity in reviewing CBD generically as a substance from evidence available in the public domain (Committee on Mutagenicity; MUT/MIN/2020/1, 2020).

2.11.2. Subchronic Toxicology Study

A Joint Subgroup of the ACNFP and COT was formed to address a series of questions in relation to the safety of CBD, cannabinoids and hemp-derived ingredients; this included examination of data submitted to support individual novel food applications.

This applicant provided a repeated dose 90-day oral toxicity study in rodents (Study no. 22448 (unpublished)), which was conducted under GLP conditions and to OECD Technical Guideline 408. In this 90-day study, each group comprised female and male rats which were dosed with 0 (control – corn oil), 25, 75, or 150 mg/kg bw/day CBD once per day by oral gavage at a dose volume of 10 mL/kg bw/day. The applicant concluded a NOAEL of 150 mg/kg bw/day based on the absence of any reported adverse effects.

The Subgroup reviewed the data and concluded the effects seen at 25 mg/kg bw/day for the clinical chemistry observations were minimal but not adverse; however, the effects in clinical chemistry parameters relating to the thyroid seen at 75 mg/kg bw/day are potentially adverse. As such the

Subgroup considered that the NOAEL for the study be 25 mg/kg bw/day. A review of the study by the Subgroup supported the conclusion that it was of sufficient quality to support the safety of the novel food.

In addition to the data submitted by the applicant there is a body of evidence on the effect of 98% or greater CBD. In order to take account of all pertinent data and to put the individual assessment in the context of the totality of relevant evidence for the active substance. The data from this application was compared to the wider body of evidence.

A weight of evidence approach allowed the Subgroup to identify a provisional ADI for CBD ingredients of >98% purity of 0.15 mg/kg bw/day or 10 mg per day for a 70 kg healthy adult (Joint position paper from the ACNFP and COT; FSA consumer advice published in October 2023). This value was identified to be protective of the most sensitive known effects in the liver and thyroid parameters, and included consideration of data gaps and uncertainties. The dataset includes several studies where highly purified CBD has been tested. Given the low level of contaminants, it is reasonable to consider that these represent the effect of CBD as a substance and are therefore relevant to other novel foods with similar compositions of >98% CBD.

It was considered whether the wider data and therefore the provisional ADI for CBD of 98% or greater purity was relevant to the review of this novel food. It was considered appropriate, on the basis that the test substance used in the study to support the novel food was 98% pure and the compositional data was consistent with a highly purified CBD. The contaminants present were not suggestive of a significant impact on the toxicology. The point of departure in the form of a NOAEL from the study submitted to support safety of this novel food, once corrected for CBD content, is consistent with the range of the points of departure used to develop the provisional ADI (ACNFP and COT, 2023). The NOAEL was also based on the same effect – impacts on the thyroid. The uncertainty factors identified in the provisional ADI would also apply to the applicant's submitted study (22448 unpublished) for the same reasons as identified in the provisional ADI statement. It was, therefore, considered scientifically appropriate to apply the provisional ADI of 0.15 mg/kg bw/day or 10 mg/day as identified in the joint statement of the ACNFP and COT on $\geq 98\%$ pure forms of CBD to the novel food in this application.

2.11. Allergenicity

This CBD isolate comprises >98% CBD and the production process for CBD does not introduce any risk of allergenic potential. As a chemical entity the potential for IgE-mediated food allergy is unlikely.

Given that CBD as a substance is not considered allergenic, the allergenicity assessment considered whether the other 2% of the novel food's composition was likely to be allergenic or elicit food allergic reactions. It was noted that none of the raw materials or processing aids used in the production process are derived from or contain any of the allergenic food ingredients specified under assimilated Regulation (EU) No 1169/2011 on the provision of food information to consumers. This suggests the potential to elicit reactions in those sensitive to those foods is unlikely.

The novel food is unlikely to trigger allergic reactions in the target population under the proposed conditions of use.

3. Discussion

The novel food is a CBD isolate ingredient from industrial hemp containing >98% CBD produced using a multi-step manufacturing process.

This CBD isolate is intended to be used as a food ingredient in food supplements for adults excluding pregnant and lactating women and other specifically identified vulnerable groups, at a defined intake for each product type of up to 10 mg CBD per day; it is not intended to replace any food.

In October 2023, the Joint ACNFP and COT Subgroup identified a provisional acceptable daily intake (ADI) of 10 mg per day (0.15 mg/kg bw/day) for CBD products containing 98% CBD or above, such as the novel food discussed in this assessment. A weight of evidence approach was used to arrive at a provisional ADI of 10 mg/day (0.15 mg/kg bw/day). The most sensitive human health effects, which this provisional ADI protects against, are seen consistently in the liver and thyroid in a number of studies using $\geq 98\%$ pure CBD. This value also takes account of the lack of human-based long-term evidence or evidence regarding potentially vulnerable groups.

Based on the dossier of evidence provided by the applicant, the safety of the novel food was reviewed and evidence to reach a conclusion on safety provided. The novel food discussed in this assessment is of high purity, containing 98% or above CBD, and demonstrates a similar toxicological profile as novel foods containing >98% CBD content. The evidence presented by the applicant was then compared to the wider data set on CBD and is consistent with evidence presented to support the development of a provisional ADI of 10 mg/day for CBD of 98% purity or above. As such it is appropriate to apply the provisional ADI to this novel food.

This is subject to the existing advice to consumers that pregnant and breastfeeding women and people taking any prescription medication should avoid the consumption of CBD. Consumers on regular medications

should seek advice from a medical professional before using any type of CBD food product. In addition, children and prospective parents trying for a baby are advised against consumption of CBD, as are those who are immunosuppressed, due to remaining data gaps and residual uncertainties concerning the safety of CBD for these groups of consumers. These contraindications would also apply to this novel food.

The maximum safe exposure for healthy adults of 70 kg as identified in the provisional ADI is 10 mg per day from all food sources. If the inclusion level of this CBD isolate leads to an intake per individual serving of each product type of 10 mg/day, multiple intakes of food products containing CBD on the same day should be avoided to support minimising exposure to below the provisional ADI.

4. Conclusions

The ACNFP has undertaken a review of this CBD isolate and concluded that the novel food is safe under the proposed conditions of use and does not pose a safety risk to human health. The proposed uses are not considered nutritionally disadvantageous.

These conclusions were supported by the information in the novel food dossier submitted by the applicant, plus the supplementary information, and could not have been reached without the following data claimed as proprietary by the applicant:

- annexes to the dossier which relate to the identity of the novel food, the production process, stability, methods of analysis, particle size analysis and toxicology;
- *in vitro* bacterial reverse mutation test [study n. B-03261];
- *in vitro* mammalian cell micronucleus test [study n. MIC-PH-21/052];
- 90-day repeat dose oral gavage study [study n.22448].

Abbreviations

Abbreviation	Definition
ACNFP	Advisory Committee on Novel Foods and Processes
ADI	Acceptable daily intake
ADME	Absorption, Distribution, Metabolism and Excretion
AOAC	Association of Official Analytical Chemists
ARfD	Acute reference dose
a_w	Water activity
bw	Body weight

Abbreviation	Definition
CAS	Chemical Abstracts Service
CBD	Cannabidiol
Cmax	Peak serum concentration
CONTAM	Panel on Contaminants in the Food Chain
COT	Committee on Toxicity
CFU	Colony Forming Unit
DSC	Differential scanning calorimetry
EC	European Commission
EDA	Energy dispersive X-ray
EFSA	European Food Safety Authority
EMA	Environmental Medicines Agency
EU	European Union
FDA	Food and Drug Administration (USA)
FSA	Food Standards Agency
FSS	Food Standards Scotland
FTIR	Fourier-transform infrared spectroscopy
GC	Gas chromatography
GLP	Good Laboratory Practice
HACCP	Hazards Analysis and Critical Control Points
HPLC	High performance liquid chromatography
HS	Headspace
ICP-MS	Inductively coupled plasma mass spectrometry
LC-MS	Liquid chromatography-mass spectrometry
LOAEL	Lowest observable adverse effect level
LOD	Limit of detection
LOQ	Limit of quantification
MS	Mass spectrometry
ND	Not determined
NOAEL	No observed adverse effect level
NM	Not measured
OECD	Organisation for Economic Co-operation and Development
Ph.Eur	European Pharmacopeia
TGA	Thermogravimetric analysis
Tmax	Time to maximum concentration
USP	United States Pharmacopeia
UV	Ultra-violet
XRD	X-ray diffraction

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To note, interests were received from members of the ACNFP; Dr Alldrick declared a potential interest relating to his previous employment, this was considered a potential conflict and as a result he was not present for discussions of CBD by the Committee. Emeritus Prof Harry McArdle declared an interest from his work with EFSA's novel food Committee in considering data requirements for CBD. While not seen as a conflict, to avoid Prof McArdle being subject to information that would influence his EFSA work, it was agreed that he would not be present in discussions for CBD by the ACNFP but could supply comments for consideration by the Committee upon review of the minutes.

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References

- Advisory Committee on Novel Foods and Processes (ACNFP) & Committee on Toxicity (COT). (2023). *Joint position paper from the Advisory Committee on Novel Foods and Processes (ACNFP) & Committee on Toxicity (COT) on establishing a provisional acceptable daily intake (ADI) for pure form (≥98%) cannabidiol (CBD) in foods, based on new evidence.* <https://doi.org/10.46756/sci.fsa.zcg392>
- Committee On Mutagenicity Of Chemicals In Food, Consumer Products And The Environment (No. MUT/MIN/2020/1). (2020). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/967784/Final_COM_mins_February_2020.pdf#:~:text=The%20Committee%20on%20the%20Toxicity%20of%20Chemicals%20in,requested%20a%20COM%20view%20of%20the%20genotoxicity%20data
- Devinsky, O., Patel, A. D., Thiele, E. A., Wong, M. H., Appleton, R., Harden, C. L., Greenwood, S., Morrison, G., & Sommerville, K. (2018). Randomized, dose-ranging safety trial of cannabidiol in Dravet syndrome [GWPCARE1 Part A Study Group]. *Neurology*, *90*, e1204–e1211. <https://doi.org/10.1212/WNL.0000000000005254>
- EC. (2017). Commission Implementing Regulation (EU) 2017/2469 of 20 December 2017 laying down administrative and scientific requirements for applications referred to in Article 10 of Regulation (EU) 2015/2283 of the European Parliament and of the Council on novel foods. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R2469>
- EFSA CONTAM Panel (Panel on Contaminants in the Food Chain). (2015). *Scientific opinion on the risks for human health related to the presence of Tetrahydrocannabinol (THC) in milk and other food from animal origin.* <https://doi.org/10.2903/j.efsa.2015.4141>
- EFSA NDA Panel (EFSA Panel on Nutrition and Novel Foods). (2016). Guidance on the Preparation and Presentation of an Application for Authorisation of a Novel Food in the Context of Regulation (EU) 2015/2283. *EFSA Journal*, *14*(11), 4594. <https://doi.org/10.2903/j.efsa.2016.4594>
- EU (2015) Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on Novel Foods, Amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and Repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001 (2015). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R2283>
- Grotenhermen, F. (2003). Pharmacokinetics and pharmacodynamics of cannabinoids. *Clinical Pharmacokinetics*, *42*(4), 327–360. <https://doi.org/10.2165/00003088-200342040-00003>

- Hawksworth, G., & McArdle, K. (2004). Metabolism and pharmacokinetics of cannabinoids. In G. Guy, B. Whittle, & P. Robson (Eds.), *The Medicinal Uses of Cannabis and Cannabinoids* (pp. 205–228). London Pharmaceutical Press.
- Huestis, M. A., Solimini, R., Pichini, S., Pacifici, R., Carlier, J., & Busardò, F. P. (2019). Cannabidiol Adverse Effects and Toxicity. *Curr Neuropharmacol*, *17*(10), 974–989. <https://doi.org/10.2174/1570159X17666190603171901>
- Izgelov, D., Davidson, E., Barasch, D., Regev, A., Domb, A. J., & Hoffman, A. (2020). Pharmacokinetic investigation of synthetic cannabidiol oral formulations in healthy volunteers. *Eur J Pharm Biopharm*, *154*, 108–115. <https://doi.org/10.1016/j.ejpb.2020.06.021>
- Jiang, R., Yamaori, S., Takeda, S., Yamamoto, I., & Watanabe, K. (2011). Identification of cytochrome P450 enzymes responsible for metabolism of cannabidiol by human liver microsomes. *Life Sciences*, *89*(5–6), 165–170. <https://doi.org/10.1016/j.lfs.2011.05.018>
- Joint position paper from the Advisory Committee on Novel Foods and Processes (ANCFP) & Committee on Toxicity (COT) on establishing a provisional acceptable daily intake (ADI) for pure form (≥98%) cannabidiol (CBD) in foods, based on new evidence. (2023). <https://doi.org/10.46756/sci.fsa.zcg392>
- Klotz, K. A., Grob, D., Hirsch, M., Metternich, B., Schulze-Bonhage, A., & Jacobs, J. (2019). Efficacy and Tolerance of Synthetic Cannabidiol for Treatment of Drug Resistant Epilepsy. *Front Neurol*, *10*, 1313. <https://doi.org/10.3389/fneur.2019.01313>
- Kraemer, M., Broecker, S., Madea, B., & Hess, C. (2019). Decarboxylation: A metabolic pathway of cannabidiol in humans. *Drug Test Anal*, *11*(7), 957–967. <https://doi.org/10.1002/dta.2572>
- Martin-Santos, R., Crippa, J. A., Batalla, A., Bhattacharyya, S., Atakan, Z., Borgwardt, S., Allen, P., Seal, M., Langohr, K., Farré, M., Zuardi, A. W., & McGuire, P. K. (2012). Acute effects of a single, oral dose of Δ^9 -tetrahydrocannabinol (THC) and cannabidiol (CBD) administration in healthy volunteers. *Current Pharmaceutical Design*, *18*(32), 4966–4979. <https://doi.org/10.2174/138161212802884780>
- Mechoulam, R., Parker, L. A., & Gallily, R. (2002). Cannabidiol: an overview of some pharmacological aspects. *Journal of Clinical Pharmacology*, *42*, 115–195. <https://doi.org/10.1002/j.1552-4604.2002.tb05998.x>
- Millar, S. A., Stone, N. L., Yates, A. S., & O'Sullivan, S. E. (2018). A Systematic Review on the Pharmacokinetics of Cannabidiol in Humans. *Frontiers in Pharmacology*, *9*, 1365. <https://doi.org/10.3389/fphar.2018.01365>

Sellers, E. M., Schoedel, K., Bartlett, C., Romach, M., Russo, E. B., Stott, C. G., Wright, S., White, L., Duncombe, P., & Chen, C. F. (2013). A Multiple-Dose, Randomized, Double-Blind, Placebo-Controlled, Parallel-Group QT/QTc Study to Evaluate the Electrophysiologic Effects of THC/CBD Spray. *Clin Pharmacol Drug Dev*, 2(3), 285–294. <https://doi.org/10.1002/cpdd.36>

Stero Biotechs Ltd. (2024). *Phase 2a Study to Evaluate the Safety, Tolerability and Efficacy of Cannabidiol as a Steroid-sparing Therapy in Steroid-dependent Crohn's Disease Patients*. ClinicalTrials.gov Identifier: NCT04056442. <https://classic.clinicaltrials.gov/ct2/show/NCT04056442?term=Phase+2a+Study+to+Evaluate+the+Safety%2C+Tolerability+and+Efficacy+of+Cannabidiol+as+a+Steroid-sparing+Therapy+in+Steroid-dependent+Crohn%27s+Disease+Patients&draw=2&rank=1>

Stott, C. G., White, L., Wright, S., Wilbraham, D., & Guy, G. W. (2013). A phase I study to assess the single and multiple dose pharmacokinetics of THC/CBD oromucosal spray. *Eur J Clin Pharmacol*, 69(5), 1135–1147. <https://doi.org/10.1007/s00228-012-1441-0>

Taylor, L., Gidal, B., Blakey, G., Tayo, B., & Morrison, G. (2018). A Phase I, Randomized, Double-Blind, Placebo Controlled, Single Ascending Dose, Multiple Dose, and Food Effect Trial of the Safety, Tolerability and Pharmacokinetics of Highly Purified Cannabidiol in Healthy Subjects. *CNS Drugs*, 32(11), 1053–1067. <https://doi.org/10.1007/s40263-018-0578-5>

Wheless, J. W., Dlugos, D., Miller, I., Oh, D. A., Parikh, N., Phillips, S., Renfroe, J. B., Roberts, C. M., Saeed, I., Sparagana, S. P., Yu, J., Cilio, M. R., & INS011-14-029 Study Investigators. (2019). Pharmacokinetics and Tolerability of Multiple Doses of Pharmaceutical-Grade Synthetic Cannabidiol in Pediatric Patients with Treatment-Resistant Epilepsy. *CNS Drugs*, 33(6), 593–604. <https://doi.org/10.1007/s40263-019-00624-4>

WHO (World Health Organization). (2018). Cannabidiol (CBD) critical review report. In *40th Meeting - Expert Committee on Drug Dependence*. <https://www.who.int/medicines/access/controlled-substances/CannabidiolCriticalReview.pdf>

Zendulka, O., Dovrtělová, G., Nosková, K., Turjap, M., Šulcová, A., Hanuš, L., & Juřica, J. (2016). Cannabinoids and Cytochrome P450 Interactions. *Current Drug Metabolism*, 17(3), 206–226. <https://doi.org/10.2174/1389200217666151210142051>