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INTEGRAL CAPITALISATION OF HEMP OILS IN ACCORDANCE WITH CIRCULAR BIO-ECONOMY PRINCIPLES

ABSTRACT

The present paper makes a review of the current industrial hemp uses, given the biological, ecological, technological, sociological and economic properties of its cultivation and capitalisation. The whole plant can be processed with zero waste. The oils from the organic hemp plant, with a complex composition, being non-toxic and processed by modern technologies, can be used as raw materials for the manufacture of phyto-medicines and food supplements or for cosmetics products, according to the bio-circular economy principles. In our case study, such oils produced in an organic processing facility are analysed. The chromatographic analysis showed a balanced ratio of unsaturated fatty acids (omega6 / omega3). After processing the aerial part of the hemp plant *(herba*) to obtain CBD (cannabinoid) oil, the remains are used as the plant base for the production of bio-compost, and after the cold pressing of seeds, the resulting parts are dried and ground. The resulting powder, which represents a rich source of quality, easily digestible proteins, can be used in the bio-economic circuit for obtaining premixes (for human and veterinary use), bakery products, protein bars and various functional foods.

Key words: hemp oils, extraction, bio-circular economy.

JEL Classification: Q57.

1. INTRODUCTION

In many countries, hemp (*Cannabis sp. – Fam. Cannabaceae*) is grown for industrial and food purposes, and different parts of the plant can be also used for medicinal purposes. There are two main cultivated hemp species: *Cannabis sativa* and *Cannabis indica*.

Cannabis sativa, the hemp cultivated in Romania, needs 112 days to grow, goes up to 7 m high, and the content of THC (tetrahydro cannabinol – the hallucinogenic

component) is very low (0.01–0.02%), thus often undetectable. The seeds, leaves and stems do not contain THC, only the buds in the flowering phase, and for 1–3 days only.

In contrast, *Cannabis indica* is a bush of maximum 1 m high that needs 220 days at temperatures of 32°C to grow, and the THC content varies between 5–20%. Historically, it has been used as a relaxant in countries where religion has banned alcohol (Lumea_satului, 2021).

Historically, hemp is known to mankind and has been domesticated and used for at least 6000 years (Fleming and Clarke, 1998). Other authors (McPartland et al., 2018) say that cultivation of hemp for fibre was present in China as early as 2800 BCE, and in the Copper or Bronze Age in Europe.

In temperate regions, hemp was among the main cultivated fibre crops in the XVI–XVIII-th centuries, due to its multiple uses, such as textile for clothing, for ships (sailcloth, ropes), and for paper production, due to its high cellulose content (before being replaced in the 19th century by wood as raw material) (Small, 2017). Its uses for clothing decreased gradually due to replacement by cheaper fibres produced in semi-tropical and tropical regions, increased use of cotton and emergence of synthetic fibres in the 20th century, while its uses for ships decreased sharply with the development of motorised ships.

After the Second World War, large-scale cultivation of industrial hemp almost ceased worldwide, but resumed in the 1990s and 2000s in some developed countries in the temperate climate zones, driven by the increasing consumer demand for more sustainable products, as well as by the economic need to find profitable crops and natural materials (Table 1). Seeds – accounting for 11% of harvested volume, and straw – accounting for 89% of harvested volume – represent 21% and 79% respectively of the economic value of the harvest (Interchanvre, 2023).

Table 1

Areas under Cannabis sativa and its main uses in 2016-2019

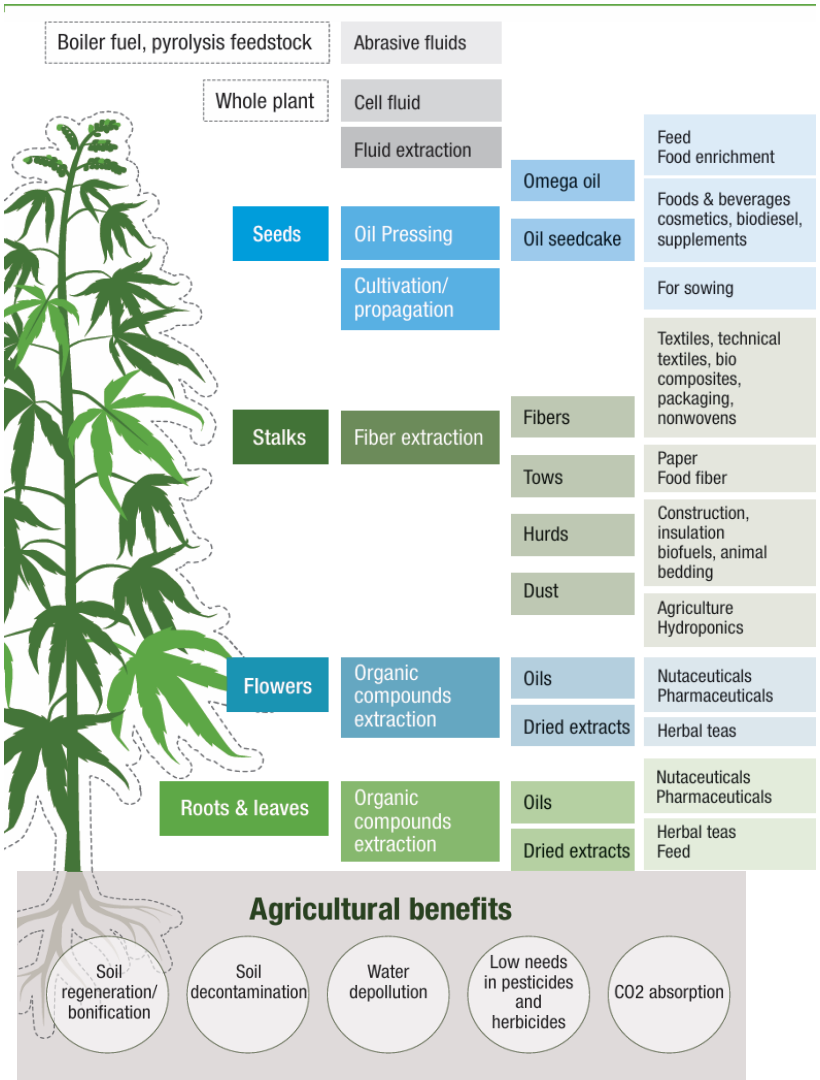
Geographical area	**2016**		**2020**	
	Area (ha)	**Uses**	**Area (ha)**	**Uses**
TOTAL area	99,000		221,561	
Europe	33,000	paper, constructions, cars, food	54,481 (of which 18,000 ha in France only)	constructions, food, paper, textiles, plastic materials
Canada	31,000	food	22,243	food, recreational cannabis
USA	50,000	food, pharmaceuticals	29,137	CBD, food, pharmaceuticals
China	45,000	textiles, food, feed, pharmaceuticals	65,400	textile (30% of the area), food, pharmaceuticals
Russia	na	–	13,300	seeds and fibre
Other countries (Australia, Egipt)	na	–	37,000	various

Note: na = not available
Source: Interchanvre, 2023.

2. STATE OF KNOWLEDGE

Currently, the industrial hemp (Cannabis sativa) has various uses (Figure 1).

There are four different production targets: fibre, seeds, cannabinoids and dual purposes (fibre and seeds). For each, different cultivars are used, and lately hemp breeding has been oriented towards the development of monoecious cultivars that are considered suitable for producing fibre and seed simultaneously.



Source: United Nations (2022). Commodities at a glance. Special issue on industrial hemp, p. 14.

Figure 1. Major uses and agricultural benefits of *Cannabis sativa L.*

Hillig and Mahlberg (2004) show that the final use of the crop (fibre, seeds or for cannabinoid-related uses) will affect several parameters such as varieties / cultivars, growing methods and timing of their harvest.

Hemp fibres are obtained from the stems of the plant, they have natural antifungal and antibacterial properties, and are extremely long, resistant, and much more durable compared to sisal, jute, manila or cotton. The products obtained from hemp fibres are biodegradable and can be used in many fields; among them, quite an important use would be in paper production, from high-quality papers (made of short fibre), and cigarette papers, to heavy-duty cardboard, food packaging, sanitary and other absorbent products, as well as for filtration. Hemp paper is particularly durable and tear resistant compared to wood-based types of paper. It can be recycled more often (7–8 times versus 3–5 times) and requires less cultivation area than wood: the hemp crop only needs 4 months to reach harvest time, and from an area of 4,000 m^2 one can get four times more paper than one would get from the same forested area.

The hemp fibres have many new uses in industry and constructions. They can be used to produce plastic materials, with properties similar to synthetic plastic, but which are completely biodegradable. They can also be used to produce a material similar to steel, which is ten times stronger and six times more efficient in construction. If in the future hemp will also be used in this direction, the effects will be seen in the considerable reduction of the negative impact of the emissions of polluting substances in the air and water in steel production. The extraction of hemp fibres and their processing can replace the use of wood in many areas by making various products, floors, roofs, insulation and other construction materials.

Hemp can also be used to produce two types of fuel, namely biodiesel from hemp seeds and ethanol obtained from the fermentation of its stems.

Seeds are used for extracting oil, which can be used directly in food and in margarine production. The unrefined/drying oil is used in producing paints, varnishes, in the preparation of fine soaps and in the pharmaceutical industry.

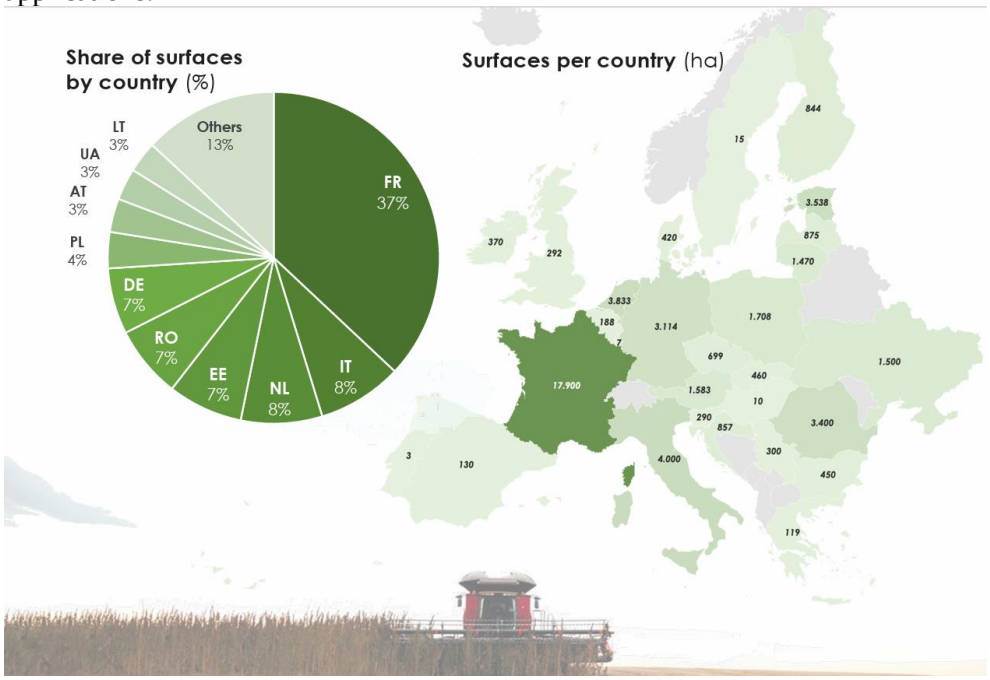
The cakes resulting are a valuable animal feed. A quantity of 600 g of hemp cakes is equivalent in nutritional value to 1000 g of cereal grains. The hemp oils have stronger antioxidant properties as compared to other oleaginous resources. According to the EFSA Regulation, since 2015 hemp has been re-included in the list of feed raw materials that can be used in feeding animals. The use of hemp seeds in certain proportions in the feed for sows, fattening piglets and farrowing piglets brings benefits in the pig health and development and pork quality (Lumea_satului, 2017, 2020).

The chaff resulting from the seed processing is a valuable fertiliser: 10 t of chaff is equivalent to 40 t of manure.

For medicinal hemp, as well as for industrial hemp for nutraceutical, nutritional, cosmetic and other cannabinoid-reliant purposes, specific practices are needed (Small, 2017). If the end use is for medicinal purposes, production methods must comply with the Good Agricultural Practices (GAP) defined by the FAO (2017).

In agronomical terms, hemp is a good precursor plant for most crops because it leaves the land structured, free of diseases and pests. The growth rate of hemp for fibre is fast and covers well the ground, crops are tall, have thick foliage and can be seeded at a higher density to suffocate and destroy resistant weeds, while reducing the weed reserve in the soil. Using hemp in this way can help farmers to avoid using herbicides, achieve organic certification and produce crop rotation benefits. Both crops for fibres and seed are a precursor for autumn cereals and fodder crops (alfalfa, rapeseed, fodder, cereals) because they clear the land in late August – early September and soil works can be carried out in good conditions. In addition, the strong hemp pivot root penetrates deep, mobilising nutrients and better resisting to soil drought.

According to EIHA (European Industrial Hemp Association), in Europe, areas under industrial hemp have increased in recent years, up to 50,000 ha in 2018, but only a few countries grow hemp on more than 1,000 ha: France, Italy, Netherlands, Estonia, Romania, Germany, Poland, Austria, Ukraine and Lithuania (Figure 2). More than half (58%) of the flowers and leaves traded in Europe are used for the production of food supplements, including CBD extracts, 20% for essential oils, 6% for tea, 1% for medical applications, and 15% for other applications.



Source: EIHA, 2019.

Figure 2. Areas under hemp in Europe

According to the same source (EIHA, 2019), industrial hemp is also beneficial in terms of environmental externalities. It contributes to healthy soils (dense leaves provide natural soil cover, thus reducing water loss and erosion; removes heavy metals from soil; facilitates higher yields in subsequent crops); contributes to biodiversity (has little or no need for chemicals; produces large amount of pollen, vital for bees in times of floral scarcity); and contributes to cleaner air by capturing 8.9–13.4 t CO_2 per hectare.

In Romania, hemp has always been cultivated to obtain fibres and seeds. The oil obtained by cold-pressed hemp seeds does not contain THC.

Until 1990, Romania was the third world hemp producer, but the EU legislation included hemp on the narcotic plants list (without distinction between industrial hemp and hemp for marijuana). As a result, hemp crop almost disappeared in Romania, similar to other EU countries, to be re-discovered a decade later, but with small progress, due to unclear and unprofessionally designed legislation. The latest statistical data (Tempo-online, 2023) on hemp crop do not show data for industrial hemp, but just for fibre hemp (areas under hemp for seeds are not included). The area under hemp totals 1,300 ha, with a total production of 2,600 t, and a yield of 2.5 t/ha (2017–2021 averages).

This plant oil, obtained from organic hemp crops and extraction technology, is a direct natural source of essential fatty acids (omega 6 and omega3, in an optimally balanced ratio of 3:1) that can support normal functioning of the heart and brain, with beneficial effects in numerous imbalances and diseases. Products may be marketed as "full-spectrum" formulas, dietary supplements, hemp oils or CBD-enriched products in the form of oils, balms, sprays, capsules, gels, gums and even chew toys for pets.

Cannabidiol (CBD) is the most well-studied phyto-cannabinoid and this research will focus on it, because it is the main ingredient in most hemp products.

Oils derived from the hemp plant (*Cannabis sativa*) and the marijuana plant (*Cannabis indica*) differ, particularly in their chemical composition. Although these plants are from the same family, they have different characteristics, leading to significant differences in the composition of their oils.

Depending on the part of the plant from which it is extracted, the composition of hemp oil has different components. Thus, phyto-cannabinoids such as THC and CBD, terpenoids such as β-caryophyllene (BCP) and limonene, are accumulated in flowers and leaves (Grof, 2018)

Cannabis sativa seeds contain little or no phyto-cannabinoids, being rich in omega-6 and omega-3 essential fatty acids, substantial amounts of γ-linolenic acid, and other nutritious antioxidants (Callaway, 2004).

In addition, there is also "cannabis oil", derived from the marijuana plant (*Cannabis indica*), with high THC levels (Grof, 2018) (Table 2).

Table 2

Variation in the composition of hemp oils according to the species and part of the plant used

Variables	**Hemp seed oils** (Callaway, 2004)	**Hemp/CBD oils** *(C. sativa)* (Potter, 2009)	**Cannabis oils** *(C. indica)* (Grof, 2018; Russo, 2011)
Part of the plant extracted	Seeds	Flowers and leaves of the hemp plant	Flowers and leaves of marijuana plant
Main components	Omega-6 and omega-3 fatty acids, γ-linolenic acid, nutritious antioxidants	Mostly CBD and BCP with other smaller-quantity phyto-cannabinoids and terpenoids	Mostly THC with some CBD and other phyto-cannabinoids and terpenoids
THC levels	None	<0.3% dry weight	>0.3% dry weight (often very high amounts such as 80%)
CBD levels	Little to none	More than average cannabis plants (12–18% CBD, often higher due to post-extraction enrichment)	Lower levels (10–15%)

Source: VanDolah et al., 2019.

One can generally find three different types of CBD oils on the market:
- *full-spectrum CBD oil*, which contains all compounds of the cannabis plant, including THC (but at a very low level);
- *broad-spectrum CBD oil*, which contains several compounds but not THC;
- *CBD oil* made using CBD isolate, which contains only CBD.

Customers should always check the Certificate of Analysis (COA) of CBD products. Usually, a third party would conduct this specific testing.

3. MATERIAL AND METHOD

The documentation part of this paper is based on a PubMed search using the following terms: CBD (cannabidiol), THC (tetrahydrocannabinol), hemp oil, and medical marijuana. Articles were screened for relevance and the most up-to-date information was selected for inclusion. The abbreviations and acronyms used are: BCP (β-caryophyllene), CBD (cannabidiol), ECS (endocannabinoid system), THC (tetrahydrocannabinol), FDA (Food and Drug Administration). Various other national and international sources on cannabis were consulted.

For the case study, the plant material (*Cannabis sativa*, var. *Eletta campana*) was provided by Alcos Farm (Siriu village, Constanța county), which grows organic certified hemp on 35 ha. The plant material was submitted to physical and chemical analyses (Table 3).

Table 3

Methods used for physical and chemical composition of hemp seeds and oils

	Item	**Method used**
Seeds[1]	Foreign matter	European Pharmacopoeia, edition in force, chapter 2.8.2
	Loss on drying	European Pharmacopoeia, edition in force, chapter 2.2.32
	Heavy metals (Pb) content	atomic absorption spectrometry, in accordance with the European Pharmacopoeia, current edition, chapter 2.4.27
	Total ashes	European Pharmacopoeia, edition in force, chapter 2.4.16
	Fatty oil content	Soxhlet method, Romanian Pharmacopoeia, 10-th Edition
Oils[2]	Polyunsaturated fatty acids	European Pharmacopoeia, edition in force and the Romanian Pharmacopoeia X, chapter IX. D.1
	Cannabinoids in CBD oils	carried out by a third-party laboratory (CanX CBD SRL, Iași, Romania), authorised to issue a Certificate of Analysis (COA) based on specific, internationally validated analysis methods

Notes:
[1] The analysis of the chemical composition of the hemp seeds was carried out by the standard operating procedure based on own technical specification of SC Alcos Bioprod SRL (Samurcași village, Crevedia, Dâmbovița county, Romania) and of the monographs from the European Pharmacopoeia, edition in force.
[2] Hemp seed oil was obtained by cold pressing method in the plant drying/processing hall of S.C. Alcos Bioprod SRL.
Source: authors' research

4. RESULTS AND DISCUSSIONS

4.1. HEMP SEEDS

Hemp seeds presented a high content of proteins (25%) of high biological quality and easily digestible, over 30% lipids, a significant amount of vegetable fibres, antioxidants and vitamins (lecithin, choline, inositol, phytosterols and vitamins A, D, B complex, folic acid and a significant amount of vitamin E in 5 forms: α-tocopherol, β-tocopherol, ɤ-tocopherol, Δ-tocopherol and α-tocotrienol), and mineral salts (potassium, magnesium, iron, zinc, calcium, sulphur, phosphorus, etc.).

4.2. HEMP SEED OIL

Hemp seed oil was obtained by cold pressing, to protect the chemical structures such as vitamins, enzymes, unsaturated fatty acids – sensitive to the temperature parameter. It was physically and chemically characterised (Table 4).

Organic hemp seed oil contains approx. 90% unsaturated fatty acids, of which 50–60% linoleic acid (omega-6), 15–20% alpha-linolenic acid (omega-3), approx. 2–6% gamma-linolenic acid (GLA – essential fatty acid with an important role in the body, similar to vitamins) (Table 4).

Table 4

Physical-chemical characteristics of organic hemp seed oil

No.	Characteristics	Admissibility limits	Result
1	***Description:*** colour smell taste	oily, slightly opalescent liquid yellow-greenish characteristic slightly bitter	**adequate**
2	***Identification:*** A: chromatographic profile	 Positive	 **adequate**
3	***Refraction index***	1,465–1,480	**1,473**
4	***Acidity index***, max.	6.0	**3.5**
5	***Peroxide index***, max.	10.0	**1.2**
6	***Relative density***, *d20 20*	0.9000–0.930	**0.913**
7	***Chromatographic profile*** – linoleic acid (Omega 6) % – linolenic acid (Omega 3) % – oleic acid (Omega 9) %	 50.0–70.0 5.0–25.0 10.0–25.0	 **51.34** **16.24** **17.47**
8	***Alkaline impurities:*** – volume of HCl 0.01M, mL, max.	0.1	**0.03**

Source: S.C. Alcos Bioprod SRL; Data files, 2022–2023.

Chromatographic analyses reveal the ratio of unsaturated fatty acids, omega-3 / omega-6 in an optimal proportion (<3.5), this ratio being a balanced one, clearly superior to fish oil (omega 3 / omega 6 ratio = 1 / 4–5) (Table 5).

Table 5

The content of unsaturated fatty acids determined in organic hemp seed oil

Characteristics	Accessibility limits	Results*	Results**
Chromatographic profile:			
Palmitic C16:0%	–	8.94	7.73
Palmitoleic C16:1%	–	0.08	0.87
Stearic C18: 0%	–	3.52	2.62
Oleic C18: 1%	–	18.01	26.38
Cis Vaccenic C18: 1%	–	–	0.99
Linoleic C18: 2%	–	52.42	53.66
Linolenic-α C18: 3%	–	13.49	6.95
Arachic C20: 0%	–	0.11	0.36
11-Eicosaenoic C20: 1%	–	–	0.12
Behenic C22: 0%	–	0.11	0.31
Dosage:			
– α linoleic acid (omega 6), %, min.	30	–	32.4
– α linolenic acid (omega 3), %, min.	10	–	11.41
Ratio Ω6 / Ω3, max.	**3.5**	**–**	**2.84**

Notes:
* Analysis performed using the method in European Pharmacopoeia, edition in force and the Romanian Pharmacopoeia X, chapter IX. D.1
** The sample was analysed by coupled gas chromatography with mass spectrometry
Source: S.C. Alcos Bioprod SRL, Data files, 2022–2023.

4.3. HEMP OIL WITH CBD (CANNABIDIOL)

For hemp oil with CBD, the determination of cannabinoids was outsourced, being carried out by an authorised, third-party laboratory (Figure 3).

CANNABINOID PROFILE

Cannabinoid	% w/w
Cannabidiol (CBD)	30.11
Δ^9-Tetrahydrocannabinol (THC)	ND
Cannabidivarin (CBDV)	0.15
Cannabichromene (CBC)	ND
Cannabigerol (CBG)	0.24
Cannabinol (CBN)	ND

Abbreviations: % w/w = weight percent; LOQ = Limit of quantitation (0.1% w/w); LOD = Limit of detection (0.05% w/w); ND = not detected; n/a = not available.

Source: CanX CBD SRL, Iași, Romania

Figure 3. Certificate of Analysis (COA)

5. CONCLUSIONS

The oils from the organic hemp plants, with their complex composition, being non-toxic and processed by modern technologies, can be used as raw materials for the manufacture of phyto-medicines and food supplements or for cosmetics products, according to bio-circular economy principles. The processing remains are used as plant- based bio-compost production, and after the cold pressing of seeds, the resulting parts are dried and ground. The resulting powder, which represents a rich source of quality, easily digestible proteins, can be used in the bio-economic circuit for obtaining premixes (for human and veterinary use), bakery products, protein bars and various functional foods, being an example of integral capitalisation of hemp oils in accordance with bio-economy principles.

The analysed variety (*Eletta campana*), according to the obtained results, qualifies as a legal variety of hemp because the level of THC (tetrahydrocannabinol) is zero (in the USA and Canada, the limit is below 0.3%, in the European Union <0.2% of dry weight of reproductive part of female flowering plant).

Hemp seeds are an excellent source of complete protein, omega-3 and omega-6 fatty acids, vitamins and minerals such as magnesium, phosphorus and zinc. They can contribute to a complex and healthy nutrition when added to diet regularly.

The obtained results support the opportunity to create natural products in the form of food supplements with formulas in which hemp plant oil replaces fish oil (also a source of omega 3 and omega 6), which is currently contaminated with

heavy metals and other toxic substances from the polluted aquatic environment (heavy metals are not metabolised, bio-accumulating).

In Europe, because CBD (cannabidiol) and hemp seed oil do not contain intoxicating amounts of THC, no drug registration is required to purchase and consume them. In the US, CBD oil is currently under investigation to renew the authorisation of the drug 'Epidiolex', as the FDA no longer considers it legal to use it in dietary supplements and foods (US FDA, 2018). In Romania, legislation needs substantial improvement, by distinguishing between industrial hemp and marijuana hemp, thus allowing Romania to re-enter the European market for industrial hemp and products, as well as to enjoy all their the agronomic, environmental and economic benefits.

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