ANIMAL SCIENCE AND GENETICS
Published by the Polish Society of Animal Production
vol. 18 (2022), no 1, 33-44
DOI: 10.5604/01.3001.0015.7906

Research Article ***Open Access***

The chemical composition, nutritional value, and potential use of *Cannabis sativa* L. seeds in animal nutrition

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SUMMARY

Hemp has great potential as a useful plant. The seeds are a rich source of protein, fat, dietary fibre, and health-promoting biologically active substances. In this study, three types of hemp seeds were compared. Hemp seeds available on the market were shown to differ significantly in chemical composition, fatty acid profile, and content of active substances. The hemp seeds tested contained an average of 25% crude fibre, 24% crude protein, and approx. 30% crude fat. Hemp protein is rich in arginine but poor in sulphur amino acids. The fat has a high proportion of polyunsaturated fatty acids (almost 80%), with about 60% linoleic acid, and the n-6/n-3 ratio is 3,3:1; which is beneficial for health. Significant differences were found in the content of active substances in the seeds. The content of phenolic acids was on average 623mg/100 g, while that of flavonoids was approx. 600mg/100 g. Catechins, which have strong antioxidant and pharmacological properties, made up the largest share. Significant discrepancies were found between the declared and actual protein and fat content, ranging from 5 to 15 pp This indicates the need to test raw material for its intended use. Compared to other popular oilseeds, hemp seeds have higher protein content than rapeseeds and higher fat content than soybeans, but contain more fibre, arginine, and polyunsaturated fatty acids. Based on the analyses and a review of the literature, it can be concluded that hemp seeds have high nutritional potential and can be used as a source of protein and fat in animal nutrition.

KEY WORDS: hemp seeds, nutritional value, fatty acids, antioxidants, animal nutrition

INTRODUCTION

Hemp (*Cannabis sativa* L. subsp. *sativa*) seeds show great nutritional potential, as they provide high-quality protein, fat, and many vitamins and minerals (Kaniewski et al., 2017). The high protein

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Received: 28.12.2021 Received in revised form: 03.02.2022
Accepted: 15.02.2022 Published online: 01.03.2022

content, on average 25%, can correct deficiencies of essential amino acids, while the fat, which constitutes over 35% of the seeds, has a highly favourable fatty acid profile consisting of over 80% essential unsaturated fatty acids with beneficial health-promoting properties (Klir et al., 2019). Hemp seeds also contain approx. 25% fibre and are a rich source of biologically active substances, such as polyphenols (Callaway, 2004). Polyphenols are natural antioxidants that improve antioxidant potential and positively affect cholesterol and lipid metabolism in the body (Szajdek and Borowska, 2004; Izzo et al., 2020). They include antibacterial phenolic acids (p-coumaric, vanillic, and caffeic), homeostatic and antiseptic acids (gallic acid), and flavonoids, which exhibit antioxidant, anti-inflammatory, anti-mutagenic, antibacterial, and anti-carcinogenic properties (Parus, 2013). Another group of compounds with psychoactive and therapeutic effects is cannabinoids, such as tetrahydrocannabinol (THC), which is mainly responsible for the narcotic properties of cannabis, and cannabidiol (CBD), with a primarily relaxing effect. The content of both compounds varies depending on the species and variety. In *Cannabis indica* L., THC content exceeds 0,2% on a dry matter basis, while in the *Cannabis sativa* L. plant CBD, which has therapeutic effects, is dominant (Kaniewski et al., 2016). Only the seeds of *Cannabis sativa* subsp. *sativa* are permitted in animal feed (Act of 29 July 2005; Journal of Laws of 2019, items 852, 1655, 1818) on counteracting drug addiction). The pharmaceutical and cosmetic industries are interested in hemp seeds (Kaniewski et al., 2016; Della Rocca and Di Salvo, 2020). Oils obtained from the seeds are a rich source of biologically active substances whose uses include food preservation, combating pathogenic microorganisms and pests, and aromatherapy, as compounds with relaxing and calming effects (Kaniewski et al., 2016). In the diet of farm animals, hemp seeds can be used as an alternative to soybeans, which are more expensive and contain more anti-nutritional substances. In addition, over 80% of soybeans grown worldwide are genetically modified, and the use of GMOs is not allowed on organic farms or in GMO-free products (Klir et al., 2019). Hemp seeds, rich in fibre, may also enrich the diet of animals requiring a higher proportion of this nutrient, such as sows, and the fat from the seeds may modulate the composition of milk or meat (Khan et al., 2009; Klir et al., 2019).

Studies of various plant species indicate that their chemical composition can vary significantly depending on their variety and origin (Ramonet et al., 1999). Little is known of the differences in the chemical composition of hemp seeds of different origin or their content of active substances, as many papers only present selected substances. However, this is an important issue due to the effectiveness of natural products in improving the composition of animal diets and the quality of animal products. If the starting material is of poor quality, the beneficial effects shown in research may not be achieved or repeated. Therefore, the research aimed to compare the nutritional value and content of selected active substances in different commercially available hemp seeds and to determine their nutritional potential by comparing them with similar products commonly used in animal nutrition.

MATERIAL AND METHODS

Three types of seeds from three different suppliers were purchased and designated as No. 1, 2, and 3. Table 1 presents the characteristics of the seeds as declared by the producers. The seeds were chosen based on their price and the presence of information regarding their nutrient contents and origin. Only unprocessed seeds were used.

Table 1

Nutritional value of *Cannabis sativa* seeds

Nutritional value (100g)	Seeds No. 1	Seeds No. 2	Seeds No. 3
Gross energy (kcal)	463,0	463,0	580,0
Fat (g)	27,9	27,9	45,0
Carbohydrates (g)	8,7	24,0	7,0
Sugars (g)	1,5	NA	NA
Fibre (g)	4,0	22,7	3,0
Protein (g)	31,7	30,0	37,0
Salt (g)	0,050	0,005	NA

NA – not given

CHEMICAL ANALYSIS

The samples were ground to pass through a 0,5-mm sieve for chemical analyses. The seeds (n = 3) were analysed in duplicate for dry matter, crude protein, crude fat, crude fibre, crude ash, acid detergent fibre (ADF) and neutral detergent fibre (NDF) using methods 934,01; 976,05; 920,39; 978,10 (AOAC, 2007), EN ISO 16472 and EN ISO 13906, respectively. The amino acid content was determined with an AAA-400 Automatic Amino Acid Analyzer (Prague, Czech Republic) using ninhydrin (Sigma-Aldrich, Munich, Germany) for post-column derivatization. Before analysis the samples were hydrolysed with 6 N HCl (POCH, Gliwice, Poland) for 24h at 110℃ (method 942,05; AOAC, 2007). Digestible protein was determined following pepsin digestion in diluted HCl according to the Kjeldahl method, based on the PN-ISO 6655 standard, with the Kjel-Foss Automatic 16210 analyser. Calcium and phosphorus were determined according to AOAC (2007) using procedure 984,27 (ICP-OES, Candela) and 965,17 (colorimetric analysis with ammonium molybdate), respectively. Flavonoids and phenolic acids were analysed as described by Kurasiak-Popowska et al. (2019). Phenolic acids were extracted from the inorganic phase using diethyl ether, hydrolysed, and evaporated to dryness in a stream of nitrogen. Before analysis the samples were dissolved in 1 mL of methanol. An Acquity H class UPLC system equipped with a Waters Acquity PDA detector (Waters, Milford, MA, USA) was used for the analyses. An Acquity UPLC® BEH C18 column (100mm × 2,1mm, particle size 1,7µm) (Waters, Dublin, Ireland) was used for chromatographic separation. The concentrations of phenolic compounds were measured using an internal standard at wavelengths of λ = 320nm and 280nm. Compounds were identified by comparing the peak retention time with the standard retention time and by adding a specific amount of the standard to the samples and repeating the analysis. Fatty acid profile was determined according to Stuper-Szablewska et al. (2014). The samples were irradiated (370W) twice for 20s, neutralized and extracted. The fatty acid profile was analysed using an Acquity UPLC H-class system with a Waters Acquity PDA detector (Waters, USA). An Acquity UPLC® BEH C18 column (150mm × 2,1mm; particle size 1,7µm) (Waters, Ireland) was used for chromatographic separation. Compounds were identified by comparing the retention times of the examined peak with that of the standard and by adding a specific amount of the standard to the test sample (FAME).

STATISTICAL ANALYSIS

The contents of nutrients in the seeds were statistically analysed by one-way ANOVA with Duncan's test at a significance level of $P \leq 0,05$ (STATISTICA, ver. 8.0).

RESULTS

Table 2 shows the results of the analysis of the basic composition of the seeds. Significant differences were found between seeds for all parameters tested ($P \leq 0,01$). Seeds No. 2 had significantly higher dry matter content than the other seeds, and seeds No. 3 had higher content than seeds No. 2. Seeds No. 2 contained over 1 pp points more crude ash than the other seeds ($P = 0,001$). Seeds No. 1 had significantly higher ($P = 0,001$) crude and digestible protein content, while their content in seeds No. 3 was about 4 pp lower than in seeds No. 1 and about 3 pp lower than in seeds No. 2. Crude fat content differed significantly ($P = 0,001$); in seeds No. 2 it was about 2 pp higher than in seeds No. 1 and about 4 pp higher than in seeds No. 3. Crude fibre content oscillated within the range of 20,6-28,2%. In seeds No. 3 it was about 5 pp higher than in seeds No. 1 and about 8 pphigher than in seeds No. 2 ($P = 0,001$). A similar trend was observed for NDF. Seeds No. 1 and 3 had a significantly higher level of ADF than seeds No. 2 ($P = 0,01$). Seeds No. 2 and 3 had more calcium than seeds No. 1 ($P = 0,010$), but seeds No. 2 contained more phosphorus than the other seeds, and seed No. 1 contained more than No. 3.

Table 1

Composition of *Cannabis sativa* seeds

Component (g/100g)	Seeds No. 1	Seeds No. 2	Seeds No. 3	SEM	P
Dry matter	92,86^{C}	93,47^{A}	93,11^{B}	0,03	0,006
Crude ash	4,07^{B}	5,19^{A}	4,09^{B}	0,01	0,001
Crude protein (N × 6,25)	26,40^{A}	25,54^{B}	22,46^{C}	0,05	0,001
Digestible protein	22,94^{A}	22,10^{B}	18,96^{C}	0,05	0,001
Crude fat	31,06^{B}	33,24^{A}	29,47^{C}	0,04	0,001
Crude fibre	23,13^{B}	20,63^{C}	28,22^{A}	0,15	0,001
ADF	24,79^{A}	20,64^{B}	25,52^{A}	0,28	0,010
NDF	34,45^{B}	29,44^{C}	38,49^{A}	0,18	0,001
Calcium	0,16^{B}	0,19^{A}	0,20^{A}	0,00	0,010
Phosphorus	0,77^{B}	1,03^{A}	0,64^{C}	0,00	0,001

$^{A, B, C}$ – values in the same rows with different letters differ significantly at $P \leq 0,01$; ADF – acid detergent fibre, NDF – neutral detergent fibre, SEM – standard error of the mean

The content of amino acids in the seeds is presented in Table 3. No statistical differences were found in the amino acid composition of the protein, but seeds No. 1 had the highest content of aspartic acid, methionine, and arginine.

Table 3

Amino acid content in *Cannabis sativa* seeds

Amino acid (g/100g protein)	Seeds No. 1	Seeds No. 2	Seeds No. 3	SEM	P
Essential					
Phenylalanine	4,3	4,2	4,2	0,0	NS
Valine	4,8	4,6	4,5	0,1	NS
Methionine	1,7	1,7	1,5	0,1	NS
Lysine	3,6	3,7	3,5	0,1	NS
Leucine	6,2	6,0	6,0	0,1	NS
Isoleucine	3,7	3,6	3,6	0,1	NS
Histidine	3,0	2,8	3,0	0,1	NS
Threonine	3,4	3,5	3,4	0,1	NS
Non-essential					
Serine	4,4	4,2	4,3	0,1	NS
Aspartic acid	9,8	9,3	9,5	0,2	NS
Glutamic acid	14,2	14,5	13,4	0,6	NS
Proline	1,8	1,9	1,9	0,1	NS
Cystine	1,0	1,0	0,9	0,1	NS
Glycine	4,1	4,0	3,9	0,1	NS
Alanine	4,1	3,9	4,1	0,1	NS
Tyrosine	2,7	2,7	2,4	0,1	NS
Arginine	13,0	12,7	12,2	0,4	NS

NS – not significant, SEM – standard error of the mean

Table 4 shows the results of the fatty acid analysis. Significant ($P \leq 0,05$) differences in the content of myristic acid (C14:0), palmitic acid (C16:0), margaric acid (C17:0) and arachidic acid (C20:0) were found between the seeds. The highest share of myristic acid was recorded for seeds No. 3, while this acid was not found at all in seeds No. 1. The percentage of palmitic acid in the total acids ranged from 6,15% to 7,85% and was lowest in seeds No. 3 and highest in seeds No. 1. Seeds No. 2 contained about twice as much margaric acid than seeds No. 1 and 3, while there was more arachidic acid in seeds No. 1 and 2 than in seeds No. 3. The content of unsaturated (UFA) and polyunsaturated (PUFA) fatty acids was similar in all samples, but seeds No. 2 contained significantly more monounsaturated fatty acids (MUFA). The ratio of n-6 to n-3 acids ranged from 3,2 to 3,6; in seeds No. 1 it was significantly higher than in the other seeds.

Table 4

Fatty acid content in seeds

Fatty acid profile (% of FAME)	Seeds No. 1	Seeds No. 2	Seeds No. 3	SEM	P
C14:0	$0,00^{B}$	$0,08^{B}$	$0,85^{A}$	0,02	0,001
C15:0	0,06	0,09	0,06	0,07	NS
C16:0	$7,25^{B}$	$7,35^{A}$	$6,15^{C}$	0,29	0,001
C16:1	0,11	0,11	0,11	0,00	NS
C17:0	$0,16^{b}$	$0,24^{a}$	$0,12^{b}$	0,01	0,019
C18:0	2,50	1,40	1,30	0,52	NS
C18:1	9,00	9,50	9,45	0,07	NS
C18:2n6	61,94	59,76	60,86	2,44	NS
C18:3n6	0,35	0,45	0,65	0,03	NS
C18:3n3	17,13	18,85	19,05	2,10	NS
C20:0	$0,80^{a}$	$0,90^{a}$	$0,65^{b}$	0,02	0,020
C20:1	0,50	0,55	0,00	0,05	NS
C20:2	0,09	0,23	0,13	0,06	NS
Σ UFA	89,12	89,45	90,25	2,17	NS
Σ PUFA	79,51	79,29	80,69	1,58	NS
Σ MUFA	$9,61^{b}$	$10,16^{a}$	$9,56^{b}$	0,85	0,047
n-6/n-3	$3,60^{a}$	$3,20^{b}$	$3,20^{b}$	0,35	0,015

$^{A, B, C}$ – values in the same rows with different letters differ significantly at $P \leq 0,01$; $^{a, b, c}$ – values in the same rows with different letters differ significantly at $P \leq 0,05$; NS – not significant, FAME – standard, SEM – standard error of the mean, UFA – unsaturated fatty acids, PUFA – polyunsaturated fatty acids, MUFA – monounsaturated fatty acids

Table 5 presents the content of phenolic acids and flavonoids in the seeds. The three samples of hemp seeds differed substantially in the content of bioactive substances ($P \leq 0,05$), except for benzoic acid. Seeds No. 2 had the highest level of p-hydroxybenzoic, vanillin, p-coumaric acid, and sinapic acid. Seeds No. 3 contained the lowest level of p-hydroxybenzoic and p-coumaric acids, but a significantly higher level of ferulic acid than the other seeds. The content of catechins was highest in seeds No. 1, and in seeds No. 2 it was not much more than half as high as in the others ($P = 0,001$). Also, there was significantly more syringic acid in seeds No. 1 than in seeds No. 2 and 3. Among flavonoids, the content of rutin and quercetin was highest in seeds No. 3 and lowest in seeds No. 1.

The content of naringenin was significantly higher (P = 0,001) in seeds No. 1 and 3, while seeds No. 2 contained 6-7 times less of this compound than the other seeds.

Table 5

Content of selected phenolic acids and flavonoids in *Cannabis sativa* seeds

Parameter	Seeds No. 1	Seeds No. 2	Seeds No. 3	SEM	P
Phenolic acids (mg/100g)					
p-Hydroxybenzoic	5,80^{A}	6,25^{A}	4,70^{B}	0,06	0,004
Vanillic	1,15^{C}	2,20^{A}	1,90^{B}	0,04	0,009
p-Coumaric	1,60^{B}	2,60^{A}	1,10^{C}	0,05	0,002
Sinapic	3,05^{B}	3,42^{A}	3,00^{B}	0,19	0,005
Ferulic	1,15^{C}	1,40^{B}	1,62^{A}	0,02	0,004
Catechin	612,00^{A}	335,00^{C}	585,00^{B}	0,75	0,001
Syringic	72,00^{A}	58,00^{C}	68,00^{B}	0,02	0,001
Benzoic	30,00	36,00	32,00	0,67	NS
Flavonoids (mg/100g)					
Rutin	0,60^{B}	0,50^{C}	1,20^{A}	0,00	0,001
Naringenin	880,00^{A}	125,00^{C}	745,00^{B}	0,71	0,001
Quercetin	17,30^{B}	10,40^{C}	19,50^{A}	0,07	0,001

$^{A, B, C}$ – values in the same rows with different letters differ significantly at P ≤ 0,01; NS – not significant, SEM – standard error of the mean

DISCUSSION

The study showed that cannabis seeds can differ significantly in their nutrient content, fatty acid profile, and content of biologically active substances. The variation in crude ash content between the seeds was up to 25%, which was confirmed by the 25% difference in calcium content and 60% difference in phosphorus content. The hemp seeds showed substantial variation in total and digestible protein content (13% and 17% difference between the highest and the lowest value, respectively). On the other hand, the amino acid composition of the protein is a genetic feature, and no significant discrepancies were found among the seeds. The proportion of fat differed by about 11% between seeds No. 2 and 3. The greatest differences were found in the content of fibre, ADF, and NDF: 36%, 23%, and 30%, respectively. Seeds No. 1 had the best nutritional value, with the highest content of crude and digestible protein, while their levels of both crude fibre and fat were intermediate between those of the other seeds. The research of Klir et al. (2019) has also shown that hemp seeds can be an excellent source of protein and fat, with 25% and 32% content of these ingredients, respectively. Other authors have obtained similar results (Callaway, 2004; Mierlita, 2019). However, the seeds tested by the authors cited contained less NDF (30%) and ADF (approx. 21%) than in our research. The share of crude ash and crude fibre may significantly differ between seeds, as these parameters are mainly influenced by the environment, e.g. soil abundance of nutrients and weather conditions during the growing season (Irakli et al. 2019). In contrast, Irakli et al. (2019) found that the protein, oil, and carbohydrate content of hemp seeds and their fatty acids composition were mainly affected by genotype.

Comparison of the laboratory results with the values declared on the label revealed significant discrepancies. According to the information on the label, seeds No. 3 should contain 45% fat and 37% protein, whereas the chemical analyses showed 15 pp less of these ingredients. In seeds No. 1 and 2, the declared fat and protein values were higher than the actual values by about 5 pp However, the differences between actual and declared fibre and carbohydrate content may result from the terminology adopted and the research methodology.

Significant differences between the seeds were found for the content of myristic, palmitic, margaric acid, and arachidic acid; however, their share in the sum of total fatty acids is relatively small. As much as 90% of the sum of fatty acids is UFA, including 80% PUFA. The seeds did not differ in their content of UFA and PUFA, while content of MUFA was higher in seeds No. 2. Babiker et al. (2021) found that the share of MUFA in hemp seeds was approx. 16% and that of PUFA was approx. 74%, while in our research they were less than 10% and nearly 86%, respectively. According to the authors cited, α-linolenic acid constitutes approx. 16% of fatty acids, and linoleic acid accounts for 58%, while in our study the corresponding shares were 19% and 60%. The content of saturated fatty acids in both works was similar as well. The content of individual acids is linked to environmental conditions and the variety of hemp (Irakli et al., 2019). MUFAs include oleic acid, which reduces the loss of water through the epidermis, improves skin hydration, stabilizes its metabolism, and reduces inflammation (Zielińska and Nowak, 2014). PUFAs include n-6 acids, most importantly linoleic acid, from which other acids belonging to this group can be synthesized. The n-3 acids include α-linolenic acid, a component of the cell membrane which ensures normal intercellular transport and takes part in the transmission of stimuli in the nervous system (Zielińska and Nowak, 2014). Additionally, a diet rich in PUFA has been shown to reduce blood cholesterol levels (Lopez- Huertas, 2010; Bałasińska et al., 2010).

The content of individual phenolic acids and flavonoids in hemp seeds is widely studied, but the analysis is expensive and complicated. Phenolic acids give products a bitter and sour taste and exhibit strong antioxidant activity (Szajdek and Borowska, 2004). In our research, the dominant phenolic acid was catechinic acid, followed by syringic and benzoic acid. The content of catechins was highest in seeds No. 1, and in seeds No. 2 it was not much more than half as high as in the others, but seeds No. 1 contained more syringic acid than seeds No. 2 and 3. Thus, seeds No. 2 differed significantly from the other seeds in the content of active substances, which may indicate their poor quality or improper harvest or storage. In some cases this may be linked to the genotype (Irakli et al., 2019). Such seeds also have poorer health-promoting properties, and their use in the diet may not achieve the desired results. Catechins have many health-promoting properties, including antifungal, antiviral, and anti-inflammatory effects. They can have preventive effects by stabilizing the balance between oxidizing compounds in the body and their antagonists. For this reason, it is recommended to include products rich in catechins in the daily diet (Karimi and Hayatghaibi, 2006). Among flavonoids, the seeds contained mainly naringenin, but seeds No. 2 contained 6-7 times less than the other seeds. Naringenin has a broad spectrum of pharmacological activity and may also block liver enzymes that metabolize certain drugs (Błazińska and Sykuła, 2018). Literature sources sometimes report the total content of phenolic compounds in seeds without mentioning the individual groups they belong to (Mińkowski, 2013). Moreover, the content of these compounds in many studies shows significant discrepancies. Irakli et al. (2019) found that the growing year significantly affects the phytochemical components and antioxidant activity of the seeds. Taaifi et al. (2021) showed that total phenolic content ranges from 134,6 to 199,9mg/100g seeds. Babiker et al. (2021) reported only 16,7mg/100g seeds, while Bernate et al. (2020) determined that the content of phenols in hemp seeds was 46,7mg/100g of seeds. In our research, the sum of the analysed phenolic compounds in the seeds ranged from 445 to 726mg/100g, which is consistent with the work of Irakli et al. (2019), who reported 400 to 800mg of total phenolic content in hemp seeds. However, the scope of the substances included among phenolic compounds should be taken into account. In our research, only selected substances were analysed, and the differences between the results of different authors may be due not only to their content in seeds but also to differences in methods of analysis.

According to various authors, hemp seeds can be an alternative to soybeans or rapeseed (Gadkari and Balarman, 2015). Comparison of the mean composition of hemp seeds obtained in our research with the mean table composition of seeds of other oil plants (Strzeleski et al., 2014) indicates that hemp seeds contain slightly more total protein than rapeseeds, but much less than soybeans (24,8% vs. 23,4% vs. 34,6%). The amino acid profile of the plant is genetically determined. Compared to the most commonly used seeds, the level of arginine in hemp seeds is much higher (12,6% vs. 7,5% for soybeans and 6,7% for rapeseeds). Therefore, hemp seeds can be used to supplement this amino acid in the diet, especially for birds. For example, research in quails shows that higher content of arginine in feed for young birds improves dressing percentage and growth performance (Sychov et al., 2017). Arginine is also necessary for the synthesis of compounds such as ornithine, which is involved in removing excessive amounts of ammonia. Moreover, it exhibits strong catalytic properties in the release of insulin, growth hormone, and insulin-like growth factor into the blood (Wu et al., 2011). Hemp protein is poorer than soya and rapeseeds in threonine (3,4% vs. 4,2% vs. 3,5%), proline (1,8% vs. 6%), cystine (0,9 % vs. 1,3% vs. 3%) and lysine (3,6% vs. 6,1% vs. 6,5%). On the other hand, hemp seeds contain more crude fat than soybeans, but less than rapeseeds (31,25% vs. 19,9% vs. 43,4%). Their content of oleic acid is higher than in soybeans and similar to that of rapeseeds (8,8% vs. 5,2% vs. 8,9%), whereas linolenic acid content is highest in soybeans, followed by hemp and rapeseeds (68,0% vs. 60,8% vs. 18,8%). *Cannabis sativa* seeds also contain more PUFA than either soybeans or rape (85,8% vs. 73,2% vs. 27,7%), and the least MUFA (9,7% vs. 20,5% vs. 64,5%). The n-6/n-3 ratio is more favourable in hemp seed oil than in that of soya or rape (3,3 vs. 2,0 vs. 13,0) (Szydłowska-Czerniak et al., 2010; Ivanov et al., 2010).

The most important ingredient in hemp seeds is crude fibre. Its content is about twice as high as in rapeseeds and over three times as high as in soybeans. Hemp can therefore be an alternative raw material in the production of feed used to supplement the diet with fibre, especially NDF and ADF, e.g. for sows or dairy cows. Crude fibre is important for animals of different ages. A diet rich in crude fibre increases total small intestinal length and surface area. Minor, significantly unconfirmed changes in the length, diameter, surface area and number of villi were detected in the duodenum, jejunum and ileum in poultry receiving a fibre-rich diet (Varastegani and Dahlan, 2014). Fibre in the diet of pigs improves the functioning of the digestive tract and reduces the occurrence of cannibalism. Older animals, such as sows or boars, can utilize crude fibre fermented by colonic microflora. Microbial digestion results in the formation of volatile fatty acids which can be used for energy purposes (Moinard et al., 2003). Due to contact with water during food intake, the fibre swells, which limits the animals' appetite and thus the occurrence of aggression. The content of minerals in oilseeds varies widely, but they are generally not rich sources of these elements. Calcium content is lowest and phosphorus highest in hemp seeds compared to soybeans and rapeseed. Still, their content is closely linked to their abundance in the soil and to climatic conditions.

CONCLUSIONS

1. Commercially available hemp seeds may differ significantly in their nutritional value, particularly in the content of protein, fat, and fibre.
2. The share of individual polyphenolic acids and flavonoids may differ by up to several hundred per cent among seeds from different sources, probably due to their genotype and habitat conditions, which significantly affects their health-promoting properties.
3. The substantial differences observed between the composition declared by the manufacturers and our own laboratory results indicate the need to analyse materials before using them in practice, as reliable information on their chemical composition is essential to identify their potential applications in food and nutraceuticals.
4. Based on our own analysis and literature data, it can be concluded that hemp seeds have high nutritional potential; moreover, owing to their many advantages in comparison with other popular seeds, they can be used as a source of protein and fat in animal nutrition alongside rapeseed and soybeans.

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