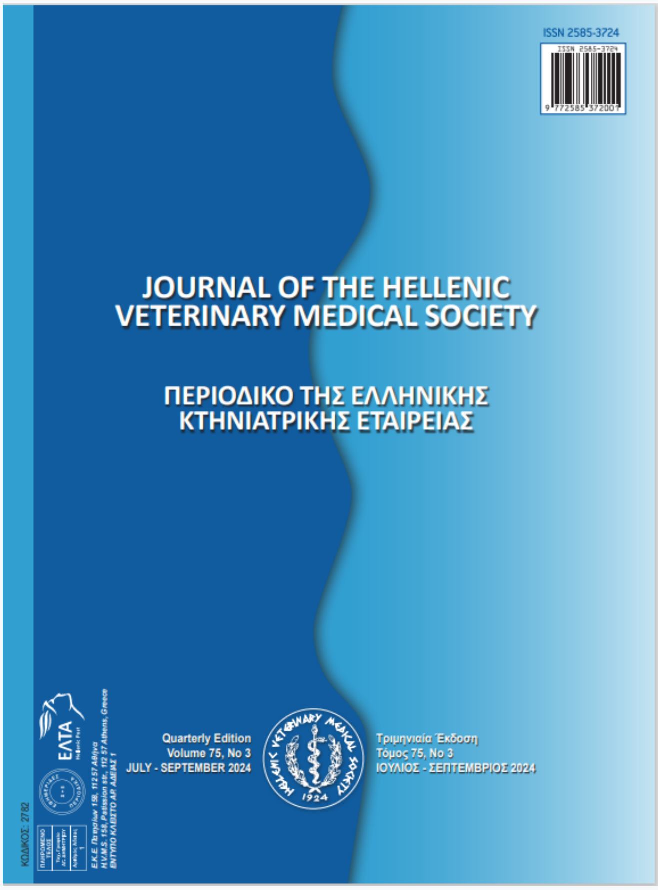
Περιοδικό της Ελληνικής Κτηνιατρικής Εταιρείας

Τόμ. 75, Αρ. 3 (2024)



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doi: [10.12681/jhvms.36360](https://doi.org/10.12681/jhvms.36360)

Βιβλιογραφική αναφορά:

Niyonshuti, E., & Kirkpinar, F. (2024). Comparison of nutrient composition and potential feed value of different cakes obtained by cold pressed method. *Περιοδικό της Ελληνικής Κτηνιατρικής Εταιρείας*, *75*(3), 8017–8026. https://doi.org/10.12681/jhvms.36360

J HELLENIC VET MED SOC 2024, 75 (3): 8017-8026
ΠΕΚΕ 2024, 75 (3): 8017-8026

Research article
Ερευνητικό άρθρο

Comparison of nutrient composition and potential feed value of different cakes obtained by cold pressed method

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ABSTRACT: This study aimed to determine nutrient composition and chemical properties of some cakes obtained by cold pressed method proposed as alternative protein sources, and to reveal their usability in animal feeding. The feed materials used in this study are safflower, black cumin (e and m), flaxseed (e and m), carrot seed, walnut, hempseed, and camelina seed cakes. The proximate analysis, metabolic energies, total phenolic content, total flavonoid and antioxidant activity of these cakes were determined and compared. The average percentage nutrients content of the cakes varies from 95.8 (walnut cake) to 91.9 (flaxseed cake e) for dry matter, from 13.1 (carrot seed) to 3.9 (safflower cake) for crude ash, from 23.5 (flaxseed e cake) to 5.5 (hempseed cake) for ether extract, from 46.8 (flaxseed cake m) to 20.0 (safflower cake) for crude protein, from 45.4 (walnut meal) to 21.9 (safflower cake) for nitrogen-free extract, and from 9.4 (flaxseed m) to 2.2 (safflower cake) for sugar. Starch content was below detectable level in all feed samples. The highest crude fiber was at 37.1, neutral detergent fiber at 52.7, and acid detergent fiber at 40.4 were found in safflower cake. The highest metabolizable energy for poultry (12.8 Mcal kg^{-1}) and for ruminants (14.01 Mcal kg^{-1}) were obtained from black cumin seed cake (e). The highest total phenolic content (3.15 mg GAE/g) and total flavonoid (2.64 mg QE/g) were found in walnut cake. The antioxidant activity (%) varied from 31.3 for black cumin seed cake (m) to 6.7 for camelina seed cake. Considering the high amount of crude protein (>20%) in the investigated cakes, it is concluded that they can be recommended as alternative protein sources for feeding livestock.

Keywords: By-products; nutritional characteristics; poultry; ruminant

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Date of initial submission: 27-12-2023
Date of acceptance: 28-02-2024

INTRODUCTION

The consumption of animal products is expected to continue growing in the coming years. The World Health Organization (WHO) report in 2019 estimates a per capita consumption of 134.8 kg/year of livestock products by 2030, which is increased approximately 18% compared to 1999 (Patsios et al., 2020). With increasingly growing world population and consumers demand for animal products, the production of sufficient protein from livestock, poultry, and fish represents a big challenge for the future particularly, in the developing countries (Makinde, 2015). Nutrition could be a serious constraint to animal production, especially when feed resources are inadequate in both quality and quantity (Tona, 2018). In animal production systems, it is customary to provide livestock with conventional feeds such as cereals, oil cakes and meals. However, a major gap exists between the demand and supply of conventional feed resources for feeding livestock worldwide (Amata, 2014).

Protein is accepted as a limiting compound in animal feed production. Today, vegetable proteins are used as the main protein source in animal nutrition (Patsios et al., 2020). Soybean and soybean meals contain high protein and energy content than any other vegetable. Soybean meal contains 2,460 metabolizable energy (ME) kcal/kg and 44-48% crude protein with an excellent balance of highly digestible amino acids except for methionine which tends to be low (Nahashon and Kilonzo, 2011). Soybean meal is rich in the essential amino acids such as lysine, tryptophan, threonine, isoleucine, and valine which are deficient in cereal grains such as corn and sorghum mostly utilized in poultry and swine diets (Nahashon and Kilonzo, 2011). However, soybean and cereal grains are also important in human nutrition. This results in a big competition between the food and feed sectors, causing an increased animal feed price which creates a challenge in profitable livestock, especially in poultry meat and egg production.

There is a need to exploit non-conventional feedstuffs in order to advance livestock production and productivity in the world. Non-conventional feed resources (NCFR) generally refer to all those feeds that have not been traditionally used for feeding livestock and they are not commercially used in the production of livestock feeds. The term NCFR has been frequently used to describe feed sources such as single-cell proteins, crop residues, and all agro-industrial by-products of plant and animal origin (Areaya, 2018). With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of unconventional feed resources. Thus, non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self-sufficiency in nutrients from locally available feed sources. It is therefore imperative to examine nutrient composition of cheaper non-conventional feed resources that can improve intake and digestibility of low-quality feedstuffs (Onte et al., 2019).

In animal nutrition, it is also important to determine the effects of alternative feedstuffs on animal performance and health (Dahouda et al., 2009) and especially their effects on animal products quality for consumers. For all these reasons, new alternative feed sources shall be examined from different perspectives. In this study, chemical properties of flaxseed, camelina seed, hemp seed, carrot seed, black cumin, walnut and safflower seed cakes resultant from oil extraction by cold press method are investigated. These feeds can be a good alternative protein source and can be included in ruminant and monogastric feeds, contributing to the national economy and environmental safety. Therefore, the aim of this study is to determine dry matter (DM), crude ash (CA), ether extract (EE), crude protein (CP), sugar, starch, crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), total phenolic content (TPC), total flavonoids (TF), antioxidant activity (AA), estimates for metabolizable energy for poultry (MEP) and metabolizable energy for ruminant (MER) of safflower seed cake, black cumin seed cake (e and m), flax seed cake (e and m), camelina seed cake, walnut cake, carrot seed cake and hemp seed cake produced by cold press method.

MATERIALS AND METHODS

Feeds

Nine different types of by-product feedstuffs; safflower (*Carthamus tinctorius*) seed cake, black cumin (*Nigella sativa*) seed cake (e), flax seed (*Linum usitatissimum*) cake (e) and camelina (*Camelina sativa*) seed cake produced by cold press method at Ege University, Faculty of Agriculture, Menemen Research, Application and Production Farm (Menemen, İzmir, Türkiye) and walnut (*Juglans regia*) cake, black cumin seed cake (m), carrot (*Daucus carota*) seed cake, hemp (Cannabis sativa) seed cake and flax seed cake (m) produced by cold press method at Mecitefendi Company (Kemalpaşa, İzmir, Türkiye). Each by-product consists of five different samples; each one is analyzed in five replicates one by one for each parameter. Feed materials were dried at room temperature, and ground in a mill with a sieve diameter of 1 mm before analyzing them and stored at 4°C in a refrigerator until analysis.

Feeds analysis

In this study, the proximate analysis, MEP and MER, TPC TF and AA of the feed materials mentioned above have been determined.

Nutrient contents of air-dry samples were analyzed according to the methods reported in AOAC (1997), and all data were presented on a dry matter basis. DM was determined by drying the samples at 105 °C for 16 h (method 934.01) in the oven (Heraeus, Germany). Kjeldahl method (method 990.03) (for wet burning, distillation and titration used equipment VELP Scientifica, Italy) was used to determine the nitrogen (N) content, and then CP content was calculated according to the formula N x 6.25. CA content was determined by burning the feed sample at 550 °C for 16 hours (method 942.05) in a muffle furnace (Heraeus, Germany). The EE analysis was determined by Soxhlet extraction using anhydrous diethyl ether (method 920.39, equipment VELP Scientifica, Italy). The sugar content of the materials was determined by the Luff-Scroll method and the starch determination by the polarimetric (WXG-4, SOIF Optical Instruments, Chinese) method, AOAC (1990). The CF was determined by using 12.5% H_2SO_4 and 12.5% NaOH solutions according to Naumann and Bassler (1993). NDF, ADF and ADL contents were determined using the methods by Van Soest et al. (1991). Gerhardt FBS6 analyzer was used for CF, NDF, ADF and ADL determination. NFE was calculated according to the formula: 100 - % (moisture+CP+EE+CF+ CA). Estimates for MEP were based on CP, EE, starch and sugar levels determined from the samples using a prediction equation (TSI, 2004); (AOAC, 1990).

MEP, Mcal kg^{-1}= (3.69 x CP + 8.18 x EE + 3.99 x Starch + 3.11 x Sugar)

Estimates for MER were based on CP, CF and EE levels determined from the samples using a prediction equation (TSI, 2004);

MER Mcal kg^{-1}= ((3260 + (0.455 x CP + 3.517 x EE - 4.037 x CF)) and CP, EE, CF quantities in OM (g kg^{-1}). All nutritional parameters, mineral contents, and energy values of the samples are given on a dry matter basis.

In the experiment, TPC determination was done with little modification to the Folin-Ciocalteu method applied by Singleton and Rossi (1965). Determination of TF content was done based on the method used by Zhishen et al. (1999). The percentage of AA of each feed sample was evaluated by 2,2-difenil-1-pikrilhidrazil (DPPH) free radical analysis, with minor modifications to the method developed by Brand-Williams et al. (1995). Amersham Biosciences Ultrospec 2100 UV/Visible spectrophotometer (UK) was used for TPC TF and AA determination.

Statistical analysis

All data from the experiment were subjected to ANOVA with the GLM procedure (JMP statistical package, SAS Institute, 2000). Duncan multiple comparison test was used to determine the significance level of the differences.

RESULTS

Chemical Composition and Metabolizable Energy of the Cakes

Table 1 presents the results of the nutritional composition and metabolizable energy of cakes obtained by cold pressed method of oil extraction. Nutrient compositions among feedstuffs used in this study differed significantly ($P<0.05$). For all feed samples, CP and EE content were found to be greater than 20% and 5%, respectively. Starch was found to be below detectable levels in all samples. Black cumin cake (e) and (m) were found different in terms of nutrient composition, except for CF content. The same was observed for flaxseed cake (e) and (m), with all their values being significantly different ($P<0.05$). MEP was significantly different ($P<0.05$) for all cakes. On the other hand, MER obtained from flaxseed (e and m) and hempseed cakes were not significantly different ($P>0.05$).

Total Phenolic Content (TPC), Total Flavonoids (TF), and Antioxidant Activity (AA)

Table 2 shows the results of the TPC, TF and AA of cakes obtained by cold pressed method of oil extraction. TPC, TF and AA were found statistically different for all samples ($P<0.05$).

Table 1. Nutritional composition (%) and metabolizable energy (Mcal kg^{-1}, in DM) of cakes obtained by cold pressed method of oil extraction

Cakes	DM	CA	EE	CP	NFE	Sug	Stc	CF	NDF	ADF	ADL	ME_P	ME_R
Safflower	94.5^{c}	3.9^{f}	11.5^{d}	20.0^{g}	21.9^{g}	2.2^{g}	ND	37.1^{a}	52.7^{a}	40.4^{a}	18.7^{c}	7.3^{g}	8.9^{e}
Walnut	95.8^{a}	4.8^{e}	5.6^{g}	28.1^{e}	45.4^{a}	3.1^{f}	ND	11.9^{e}	39.5^{c}	26.7^{b}	23.5^{ab}	6.7^{h}	11.9^{c}
Black cumin (e)	94.9^{b}	5.8^{c}	22.7^{b}	28.1^{e}	29.1^{d}	5.1^{c}	ND	9.1^{f}	26.4^{e}	15.7^{g}	10.50^{de}	12.8^{a}	14.0^{a}
Black cumin (m)	92.9^{e}	6.4^{b}	8.1^{f}	35.1^{b}	34.8^{c}	5.9^{b}	ND	8.5^{f}	31.6^{d}	17.5^{f}	14.0^{cd}	9.0^{e}	12.1^{c}
Carrot seed	94.6^{c}	13.1^{a}	10.0^{e}	23.4^{f}	27.8^{d}	3.1^{f}	ND	20.3^{b}	46.2^{b}	24.3^{c}	28.6^{a}	7.5f^{g}	10.1^{d}
Hempseed	93.4^{d}	5.9^{c}	5.5^{g}	33.2^{c}	39.0^{b}	3.7^{e}	ND	9.8^{ef}	38.4^{c}	19.1^{e}	12.3^{de}	7.5^{f}	11.8^{c}
Flaxseed (e)	91.9^{g}	5.4^{d}	23.5^{a}	22.8^{f}	24.7^{ef}	4.4^{d}	ND	15.5^{c}	29.2^{de}	15.4^{g}	7.0^{e}	12.2^{b}	12.8^{b}
Flaxseed (m)	92.1^{f}	5.7^{c}	8.1^{f}	46.8^{a}	23.3^{fg}	9.4^{a}	ND	8.1^{f}	14.2^{f}	11.4^{h}	8.4^{de}	11.3^{d}	12.9^{b}
Camelina	93.3^{d}	4.9^{e}	18.3^{c}	29.1^{d}	26.9^{df}	5.8^{b}	ND	14.2^{c}	42.0^{cc}	20.6^{d}	11.2^{de}	11.6^{c}	12.7^{b}
SEM	0.07	0.07	0.08	0.24	0.85	0.11	-	0.78	1.52	0.38	1.3	0.047	0.132
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

e, Samples collected were supplied from Ege University, Faculty of Agriculture, Menemen Research, Application and Production Farm (Menemen, İzmir, Türkiye); m, Samples were supplied from Mecitefendi Company; $^{a, b, .., f}$, Means within a column in each variable with no common superscript differ significantly (P<0.05); SEM, Standard error of means pooled, P, Probability value; ND, Not detected; DM, Dry matter; CA, Crude ash; EE, Ether extract; CP, Crude protein; NFE, Nitrogen free extract; Sug, Sugar; Stc, Starch; CF, Crude fiber; NDF, Neutral detergent fiber; ADF, Acid detergent fiber; ADL, Acid detergent lignin; ME_p, Metabolizable energy poultry; ME_R, Metabolizable energy ruminant

Table 2. Total phenolic content, total flavonoid and antioxidant activity of cakes obtained by cold pressed method

Cakes	TPC (mg GAE/g)	TF (mg QE/g)	AA%
Safflower	1.74^{d}	1.65^{d}	27.03^{e}
Walnut	3.15^{a}	2.64^{a}	26.97^{e}
Black cumin (e)	1.97^{c}	2.15^{b}	29.38^{c}
Black cumin (m)	1.20^{h}	0.87^{h}	31.29^{a}
Carrot seed	1.25^{g}	1.30^{f}	30.25^{b}
Hempseed cake	1.55^{e}	1.33^{f}	27.87^{d}
Flaxseed (e)	1.44^{f}	1.17^{g}	26.43^{f}
Flaxseed (m)	1.53^{e}	1.44^{e}	24.05^{g}
Camelina seed	2.24^{b}	1.96^{c}	6.67^{h}
SEM	0.008	0.0021	0.174
P	<0.0001	<0.0001	<0.0001

e, Samples collected were supplied from Ege University, Faculty of Agriculture, Menemen Research, Application and Production Farm (Menemen, İzmir, Türkiye); m, Samples were supplied from Mecitefendi Company; $^{a, b, .., f}$, Means within a column in each variable with no common superscript differ significantly (P<0.05); SEM, Standard error of means pooled, P, Probability value; TPC, Total phenolic content; TF, Total flavonoid; AA, Antioxidant activity

DISCUSSION

Safflower seed cake

During this study, safflower cake was found to contain 94.5% DM, 3.9% CA, 20.0% CP, 11.5% EE, 2.2% sugar, 21.9% NFE, 37.1% CF, 52.7% NDF, 40.4% ADF and 18.7% ADL. The similar values have been reported by many authors (Kohler et al., 1966; Dajue and Mündel, 1996; Lardy and Anderson, 2009; Farran et al., 2010; Heuzé et al., 2012). In general, nutrients content of safflower cake are highly variable and depend on whether the cake is obtained from a hulled or unhulled safflower, and also the oil extraction method used (Peng et al., 2010). According to Farran et al. (2010) a hulled sufflower cake contains 93.8% DM, 20.5% CP, 3.78% EE, 35.3% CF and 2.58 CA. The oil content can vary from 15% for mechanically extracted safflower cake to 1% for solvent-extracted safflower meal, while the protein content is about 40% in dehulled meal and 20-25% in hulled meal (Kohler et al., 1966; Dajue and Mundel, 1996). The values obtained in this study are compatible with previously reported values. Safflower cake has been reported to contain high fiber content. Previously found CF values 35.5% by Farran et al. (2010), and 24.9-39.9% by Heuzé et al. (2015) are closely related to 37.12% found in this study. According to Özek, (2016), the use of a safflower cake containing CF at this level may be extremely limited, especially in poultry feed. When the hulls are incorporated into raw safflower during extraction, the resulting cake is relatively high in fiber and relatively low in energy (Peiretti, 2017). Safflower cake was found to contain 7.3 Mcal kg^{-1} for poultry and 8.9 Mcal kg^{-1} for ruminants which are the lowest metabolic energies compared to the other cakes analyzed. Previous studies on the total phenolic content and total flavonoids of safflower cake could not be obtained. However, safflower cake is ranked fourth among the cakes analyzed in this study in terms of TPC and TF content. In conlusion, safflower cake obtained by cold pressed method can be classified as an alternative protein source. However, due to its high fiber content, low energy, and some limiting amino acids such as lysine and methionine, safflower cake is more suitable for ruminants than monogastric animals.

Walnut cake

In this study, walnut cake was found to contain 95.8% DM, 4.8% CA, 5.6% EE, 28.1% CP, 3.1% sugar, 45.4% NFE, 11.9% CF, 39.5% NDF, 26.7% ADF and 23.5% ADL. Many authors reported similar values for DM, crude ash, NDF, and ADF (Mir et al., 2015; Héuze, et al., 2017a; Ancuta and Sonia, 2020). The CP content (28.1%) obtained in this study is closer to 27.2% found by Heuzé et al. (2017a), but it is higher compared to 15.2% obtained by Mir et al. (2015). EE and CF values obtained in this study are lower compared to 11.7% EE and 30.9% CF values reported by Heuzé et al. (2017a). According to Ancuta and Sonia (2020), walnut cake contains 7.95-36.80% EE, 6.79-18.15% CF and 17.4-49.75% NFE. These values are compatible with the values found in the current study. The TPC in walnut pulp is 3.15 mg GAE/g. This value is lower compared to 58207.3 mg GAE/kg obtained by Bakkalbaşı, (2019). The difference among cakes may be due to walnut varieties, solvent used, and extraction method. In comparison with other cakes of this study, walnut cake contains the lowest MEP (6.7 Mcal kg^{-1}). However, this energy is higher compared to 2.2 MJ/kg reported by Héuze et al. (2017a). The MER was found to be 11.9 Mcal kg^{-1}. Conclusively, walnut cake is classified as a protein source feedstuff due its CP content which is greater than 20%.

Black cumin cake

Black cumin cake (e) and (m) were found statistically different in terms of nutrients content with an exception on CF. A notable difference between these two cakes is on CP and EE content; 28.1% CP and 22.7% EE for black cumin seed cake (e) and 35.1% CP and 8.1% EE for black cumin seed cake (m). The CP content of both cakes is higher compared to 18.44% and 19.29% reported by Thilakarathna et al., (2018). However, Abdel-Magid et al., (2007), Mahmoud and Bendary, (2014) and Obeidat, (2020) reported that black seed cake contains 37.40%, 33.0%, and 33.13% CP respectively. These values are closer to 35.1% CP value of black cumin cake (m). Generally, the chemical composition of black cumin seed cake is highly variable (Table 3). The nutrients variability is influenced by the processing methods used, processing factors, climate and weather conditions under which black cumin is planted, time of harvest, and storage time before processing (Thilakarathna et al., 2018; Obeidat, 2020). According to Table 3, black cumin cake is good source of protein (>20%) and carbohydrates, and it contains less CF (<18%). During

Table 3. Chemical composition (%) of black cumin cakes by different authors

Cakes	CP	EE	CA	NFE	CF	References
Black cumin (e)	28.1	22.7	5.8	29.1	9.1	Present study
Black cumin (m)	35.1	8.1	6.3	34.8	8.5	Present study
Black cumin	29.9-34.1	15.2-18.7	5.5-9.5	23.5-33.2	10.5-14.3	El-Deek et al., 2009
Black cumin	37.40	9.24	8.94	35.81	8.61	Abdel-Magid et al., 2007
Black cumin	33.13	12.72	8.45	34.76	10.96	Mahmoud and Bendary, 2014
Black cumin	19.29	16.13	4.98	23.13	6.03	Thilakarathna et al., 2018

e, Samples collected were supplied from Ege University, Faculty of Agriculture, Menemen Research, Application and Production Farm (Menemen, İzmir, Türkiye); m, Samples were supplied from Mecitefendi Company; CP, Crude protein; EE, Ether extract; CA, Crude ash; NFE, Nitrogen free extract; CF, Crude fiber this study, black cumin cake (e) was found to contain the highest MEP and MER; 12.8 Mcal kg^{-1} and 14.0 Mcal kg^{-1} respectively. These values are comparable to 11.2 MJ/kg and 13.4 MJ/kg respectively MEP and MER contained in soybean meal (Héuze et al., 2021). The TPC determined in our study is 1.97 mg GAE/g for black cumin cake (e), and 1.20 mg GAE/g for black cumin cake (m). Mariod et al., (2009) reported low values in their study about AA and phenolic content of phenolic rich fractions obtained from black cumin. The results of their study revealed that TPC of black cumin cake is 78.8, 27.8, 32.1, 12.1 mg GAE/g when extracted in ethyl acetate, methanolic extract, water and hexane respectively.

Carrot seed cake

According to this study, carrot seed cake contains 94.6% DM, 13.1% CA, 10.0% EE, 23.4% CP, 3.1% sugar, 27.8% NFE, 20.3% CF, 46.2% NDF, 24.3% ADF and 28.6% ADL. Carrot seed cake contains higher amounts of CA and ADL compared to other cold pressed cakes examined in this study. Previous work on this by-product was not found. However, compared to the 4.5% HP and 5-6% CA content of carrot by-products from the juice industry, the CP and CA of cold-pressed carrot cake are higher. In contrast, those juice industry by-products contain higher amounts of CF (37-48%) and NFE (71.6%) compared to carrot seed cake (Bao and Chang, 1994). MEP and MER were estimated at 7.5 Mcal kg^{-1} and 10.1 Mcal kg^{-1} respectively. In this study, high AA was found for carrot seed cake, second place to black cumin cake (m).

Hempseed cake

In this study, the CP content of hempseed cake was found to be 33.2%. This value is similar to 33.5% and 30.7% values reported by Callaway, (2004). The obtained values for CA (5.9%), EE (5.5%), and NDF (38.4%) are lower compared to 7.2% CA, 16.4% EE, and 41.7% NDF reported by Silversides, (2010). While the NFE value was found to be 39.0% in this study, it was reported as 42.6% by Callaway, (2004). According to Ancuta and Sonia (2020), cold pressed hempseed cake contains 86.39%-93.65% DM, 23.25%-33.35% CP, 0.51-14.02% EE, 3.30-9.78% CA, 17-41-60.38% cellulose and 2.80-48.54% NFE. On the other hand, in this study, MEP and MER was determined as 7.5 Mcal kg^{-1} and 11.8 Mcal kg^{-1} respectively. Hempseed cake's MER is very similar to the ME of oilseed meals mostly used in animal nutrition (Dryden, 2008). While in this study, 1.55 mg GAE/g TPC, 1.33 mg QE/g TF and 27.87% AA was revealed. Teh et al., (2014), reported 351.33 g GAE/kg TPC, 0.81 mg LUE/100 g TF and 3.09% AA.

Flaxseed cake

The nutrient composition was found to be different between flaxseed cake (e) and flaxseed cake (m). As shown it is illustrated in Table 3, the nutrient content for flaxseed cake (e) was determined as 22.8% CP, 23.5% EE, 24.7% NFE, 15.5% CF and 5.4% CA, while for flaxseed cake (m) 46.8% CP, 8.1% EE, 23.3% NFE, 8.1% CF and 5.7% CA were obtained. CP value (22.8%) for flaxseed cake (e) obtained in this study is lower compared to the CP values; 27.7%, 32.47% and 43.3% respectively reported by Gutiérrez et al., (2010), Sobczak et al., (2020), and Mueller et al., (2010). On the other hand, Singh et al., (2011) reported that flaxseed cake can contain between 43% and 47% CP. These values are compatible with 46.82% CP for linseed cake (m). The values for EE (23.5% and 18.3%) are higher than 11.1% EE declared by Sobczak et al. (2020). Héuze et al., (2018) reported that, on average, cold pressed flaxseed cake contains 90.6% DM, 34.1% CP, 10.2% EE, %, 25.4% NDF, 15.3% ADF, 6.2% ADL and 6.3% CA. CF for flaxseed cake is usually less than 18%. However, CF values from the present study 15.45% and 8.08% for faxseed cake (e) and (m) respectively are different from 7.02%, 9.5% and 10.5% respectively values reported by Gutierrez et al. (2010), Newkirk, (2015), and Heuzé et al. (2018). With a CF content less than 18% and a CP content of more than 20% flaxseed is classified as a protein feedstuff. The nutritional composition of flaxseed meal is greatly affected by the seed variety, the soil, the oil extraction method used, and whether the flaxseed is de-oiled before processing (Gutiérrez et al., 2010). MEP was 12.2 Mcal kg^{-1} and 11.3 Mcal kg^{-1} for flaxseed cake (e) and (m), respectively. These values are compatible with 12.6 MJ/kg reported by Heuzé et al. (2018). On the other hand, MER is 12.8 Mcal kg^{-1} and 12.9 Mcal kg^{-1} for flaxseed cake (e) and (m) respectively. TPC and TF of flaxseed cake (m) (1.53 mg GAE/g and 1.44 mg QE/g respectively) are higher than those found in flaxseed (e) (1.44 mg GAE/g and 1.17 mg QE/g for TPC and TF respectively). AA of flaxseed cake (m) (24.05%) is lower than that found in flaxseed (e) (26.43%). According to this study, flaxseed cake (e) values for TPC and flavonoids are lower to the values 2.66 mg GAE/g

TPC and 1.32 mg CAE/g flavonoids reported by Tavarini et al., (2021). However, TF value of flaxseed cake (m) is higher to the value reported by Tavarini et al., (2021).

CAMELINA SEED CAKE

In this study, camelina seed cake was found to contain 93.3% DM, 4.9% CA, 18.3% EE, 29.1% CP, 5.8% sugar, 14.2% CF, 42.0% NDF, 20.6% ADF and 11.2% ADL. Except for NDF (41.8%), Aziza et al., (2010a) reported different values for CA (6.5%), CP (35.2%), and CF (4.9%). EE was found similar to 18.04% reported by Ryhänen et al., (2007), but higher to 6-12% value obtained by Cherian, (2012). According to Karvonen et al., (2002) and Kahindi et al., (2014) a cold pressed camelina cake may contain 30% CP and 10-30% EE, and therefore it would be a good source of protein and energy in rations. 14.2% CF found in this study, is greater than 11.27% and 12.0% respectively reported by Ryhanen et al. (2007) and Woyengo et al., (2016). NDF and ADF values determined in this study are closer to 38.3% and 21.3% respectively reported by Woyengo et al. (2016). ADL (11.2%) was found to be higher to 6.4% previously reported by Heuzé et al. (2017b). ME values; 11.5 MJ/kg for poultry and 12.74 Mcal kg^{-1} for ruminants are slightly higher to 9.9 MJ/kg ME for poultry and 12.6 Mcal kg^{-1} ME for ruminants reported by Héuze et al., (2017b). TPC (2.24 mg GAE/g) and TF (1.96 mg QE/g) found in this study were lower to 6.63 mg GAE/g and 5.82 mg CAE/g respectively for total phenolics and flavonoids values determined by Tavarini et al. (2021). In this study, the AA of camelina seed cake was found to be 6.67%. Aziza et al., (2010b) reported an AA of 99.2% in solvent-extracted camelina cake. They concluded that TPC, TF and AA in camelina seed cake may be lower or higher depending on the camelina seed varieties, growing conditions, storage conditions, and extraction method used.

This study was carried out to determine the nutrient composition, some chemical properties, and potential feed value of some cakes obtained by cold pressing method which are by-products of oil extraction from oilseeds. In general, nutrient composition, ME, TPC, TF and AA were found statistically different among feed samples. The difference among samples depends on plant varieties, soil fertility, climate, harvesting time, storage conditions, lengh of storage time, and oil extraction method used. Differences may also be due to the methods and chemicals used during feed analysis. All the examined cakes in this study were found to contain more than 20% protein. Considering the shortage of conventional protein sources, especially in the developing countries, these cakes can be used as alternative protein source in animal nutrition. However, with the exception of flaxseed (m), the protein content of these cakes is lower than that of oilseed meals, which are frequently used in animal nutrition. In addition, some researchers reported that these alternative feeds are insufficient in terms of essential amino acids such as lysine and methionine. All cakes were found to contain higher amounts of crude fiber (5.5-23.5%), which can contribute more energy to the diet but could also reduce their utilization during feed formulation. These cakes should be used as soon as possible to avoid fat oxidation and rancidity. Generally, the cold pressed extraction method produces cakes with a higher ether extract content compared to the solvent extraction method. In addition, some of these cakes contain high crude fiber content, which can limit feed consumption and digestibility especially for monogastric animals. The metabolic energies for ruminant (8.9-14.0 Mcal kg^{-1}) of cakes used in this study are similar to the MER values (9.8-13.1 Mcal kg^{-1}) of the oilseed meals. At the same time, the MER values of these cakes are similar to the MER values of cereal grains (10-13 MJ/kg).

CONCLUSION

The antioxidant activity of the feed is positively correlated with the amount of TPC and TF contents. However, this study revealed that some feeds with high amount of phenolic compounds may exhibit low antioxidant activity. The future studies should be carried out to determine inhibitors and anti-nutritional substances contained in these cakes, to evaluate amino acids profile and its digestibility, and to determine the inclusion rate of these cakes in different animal rations and their effects on growth and production performances. The effective use of these feed sources will significantly reduce the costs of expensive protein feedstuffs, reduce competition between humans and animals for soybean and grains, contribute to sustain animal feed resources, benefit animal feed producers and significantly reduce the amount of waste products released into the environment. Therefore, it is recommended that the cold pressed cakes examined in this study can be used as substitute for cereals to increase the protein content of the ration without greatly reducing the metabolic energy of the ration.

ACKNOWLEDGMENTS

This research was supported by the Scientific Research Projects Coordination of Ege University. Project number FYL-2020-22213.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare

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