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Use of Camelina (*Camelina sativa*) in Poultry and Ruminant Feeds, Production of Biodiesel and Use as an Alternative Fuel to Petroleum

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ABSTRACT

Camelina plant (*Camelina sativa*) is an oilseed that can adapt to a wide range of agricultural conditions and is an environmentally friendly product that has been used by humans for decades. By-products from oil extraction are high in protein and are used in ruminant animal rations. However, considering the antinutritional factor content of these by-products, more research is needed on their nutritional value. Studies have investigated the effects of camelina seed on feed intake, digestion and metabolism at higher intake levels. In addition, the ever-increasing energy demand due to global population growth, decreasing fossil fuel reserves and environmental concerns; The necessity of obtaining renewable and sustainable alternative energy sources from non-food products has emerged. Biodiesel, a renewable, non-toxic and biodegradable fuel, can be used in diesel engines without engine modifications. But bioenergy feedstock crops can compete with food and forage crops in agricultural areas, resulting in increased food prices and potentially significant economic destabilization. Therefore, it has been proposed to use marginal agricultural lands for the production of bioenergy raw materials. The seeds of the camelina (*Camelina sativa*) plant, which is very suitable for marginal areas, have come to the fore in recent years as an important biofuel source. Camelina seeds' high oil content (25-48%) and low production cost are an important advantage. In this review, a summary of international studies on the use of camelina in ruminant feeding, the conversion of camelina to biofuel, the properties of the obtained fuel, its usage areas, standards and environmental impact is presented.

Ketencik bitkisinin (*Camelina sativa*) Kanatlı ve Ruminant Yemlerinde Kullanımı, Biyodizel Üretimi ve Petrole Alternatif Yakıt Olarak Kullanımı

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ÖZET

Camelina sativa, çok çeşitli tarım koşullarına uyum sağlayabilen yağlı bir tohumdur ve insanlar tarafından onlarca yıldır kullanılan çevre dostu bir üründür. Yağ ekstraksiyonundan elde edilen yan ürünler protein açısından yüksektir ve geviş getiren hayvan rasyonlarında kullanılır. Ancak bu yan ürünlerin antinutrisyonel faktör içeriği göz önüne alındığında, besin değerleri konusunda daha fazla araştırmaya ihtiyaç vardır. Çalışmalar, keten tohumunun daha yüksek alım seviyelerinde yem alımı, sindirim ve metabolizma üzerindeki etkilerini araştırmıştır. Ayrıca, nüfustaki yükselme, yenilenemeyen enerji kaynaklarındaki azalma ve çevre kirliliğine yönelik endişeler sebebiyle enerji talebindeki artış; hem bitmeyen hem de devamlılığı olan enerji seçeneklerinin insan beslemede kullanılmayan mahsullerden elde edilmesi gerekliliği ortaya çıkmıştır. biyodizel hem bitmeyen hem de devamlılığı olan, zehirli olmayan ve biyolojik anlamda kolay yok olabilen bir yakıt olup, motorda herhangi bir değişiklik yapılmadan dizel motor ile çalışan araçlarda kullanılma olanağı sunmaktadır. Bununla beraber biyokütle enerjisi elde edilen ürünlerin ekili yerlerdeki hem yemeklik hem de yem olarak kullanılacak ürünlerle yarış etmesi sonucu, fiyat artışı söz konusu olacak ve ekonomik anlamda bir düzensizlik olacaktır. Bundan sebeple çevresinde tarım arazisi olmayan arazilerin biyokütle enerjisi için gerekli olan ürünlerin üretimi için kullanılmasının avantajlı olacağı düşünülmektedir. *Camelina sativa* (ketencik)' nın tohumundan elde edilecek yağın biyoyakıt olarak kullanılmas potansiyeli olduğu ve bu bitkini tarım arazisi dışında kalan alanlarda (marjinal) ekime uygun olacağı ile ilgili son zamanlarda gündeme gelmiştir. *Camelina sativa* tohumlarının %25-48 oranında içerdiği yağ ve az maliyetle üretiminin yapılması bir avantajdır. Bu çalışmada, ketencik bitkisinin kanatlı ve ruminant beslemede kullanımı, ketencik bitkisinden biyoyakıt eldesi ile bu yakıtın içeriği, kullanıldığı alanlar, standart ölçütleri ve çevreye olan etkileri ile ilgili yapılan ulusal ve uluslararası çalışmaların bir derlemesi sunulmaktadır.

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1. INTRODUCTION

Increase in world population, the problem of nutrition supply and safety for humans and the use of foods used in human nutrition as a feed source in animal nutrition have also brought competition (Mottet et al., 2017). This situation has increased the studies on alternative plants to be used in animal nutrition. *Camelina sativa*, which belongs to the Brassicaceae family and an oil seed herb that is used both as an alternative to animal nutrition and for biofuel production. Constrat to others conventional oil seed products (e.g. poppy and linen), the camelina plant has many agrotechnical (the product is easy to grow, environmentally conscious; no herbicides/pesticides need to be applied; the plant can adapt to marginal farmland, shows well fertility and is suitable for biofuel manifacture in marginal farmland) is beneficial (Colombini et al., 2012).

Ruminants have lower feed utilization ability. However, ruminants can produce high-quality products from nutrition sources or farming by-products that are low in quality and not competitive with humans. (Sızmaz et al., 2021). This capability of ruminants could be further developmented by the use of non-nutrition either farm-industrial by-products. In most of the countries, the protein content of feeds is low, and research on alternative feed sources has intensified as countries have to importation soybeans or other rich of protein sources and finding a protein source is an expensive endeavor. The use of alternative feed sources are attached to the nourishment habit, the beast's reaction to feeding, the damage and the environmental effect (Paula et al., 2019).

Poultry is not capable of synthesizing multiple unsatiated fat acids, so it condition given with nutrition. It has been reported in recent studies that the compound of fat acids in chicken body may be changed comparatively readily with regimen (Dal Bosco et al., 2022). The pulp of the camelina plant contains protein, oil and necessary omega-3 and omega-6 fat acids. Besides this rich content, it is also used in poultry feeds as it is an energy source (Ayaşan, 2014).

Biodiesel, which is an important biofuel because it is renewable, biodegradable and does not harm the environment, has shown the possible use as an alternative to traditional methods petro-diesel. Naturally, biodiesel, which has similar fuel specifications to petroleum-basis diesel, is suitable for use on many areas like auto, agrarianl machine, constant strenght also warmht production. In the researches, the camelina plant has been used as a hopeful and sustainment oil seed crop for biodiesel production (Krohn and Fripp, 2012).

Camelina sativa germs have a loud fat ingredient (35-43% on dried substance based) (Jiang et al., 2014) also Camelina plant contains a large amount of unsaturated fatty acids, approximately 90%. The fatty acid profile Table 1 of *Camelina sativa's* plant is given below (Riaz et al., 2022).

Table 1. Fatty acid profile of *Camelina sativa* seed, meal, expeller, cake, and forage *(% total fatty acid)*

Fatty Acid, %	Camelina Seed	Camelina Meal	Camelina Expeller	Camelina Cake	Camelina	Camelina Oil
Myristic (C14:0)	0.09–0.2	0.17	-	0.13–0.14	0.63	0.06
Pentadecylic (C15:0)	-	-	-	005–0.06	-	-
Palmitic acid, (C16:0)	5.1–10.3	9.12–9.19	7.22–14	7.19–7.46	18.59	5.2–7.00
Palmitoleic (*cis*-9 C16:1)	0.1–0.9	0.32-.52	0.16	-	-	0.08
Stearic (C18:0)	2.19–2.81	2.27–2.9	2.02–2.64	-	0.1	2.2–3.08
Elaidic (*trans*-9 C18:1)	12.14–19	-	13.14	-	-	10.57–19.37
Oleic (C18:1)	11.9–19.9	17.71–21.7	23.7	-	7.9	15.10–18.70
Linoleic (C18:2)	13.5–20.9	24.35–28.8	22.34–31.1	-	13.5	16.00–19.60
Linolenic (ALA) C18:3)	28.6–41.3	24.2–46.3	14.3–31.98	-	43.25	28.00–38.10
Arachidic (C20:0)	1.2–1.8	1.17	0.81–15.3	-	3.23	1.22–2.33
Eicosenoic (C20:1)	13.3–25.4	10.1–13.3	11.93	-	-	11.60–15.1
Gondoic (C20:1 n-9)	11.9–15.57	11.23–13.3	-	10.18–10.56	0.2	10.56–15.19
Behenoic (22:0)	0.3–6.2	-	3.4	0.36–0.38	0.75	0.26–0.44
Erucic (C22:1 n-9)	1.6–4.2	0.77	2.86	2.84–3.32	-	1.6–4.2
Lignoceric (C24:0)	0.2	-	-	0.25–0.28	-	0.13–0.28
Nervonic (C24:1 n-9)	0.6–0.7	-	-	0.64–0.8	-	0.48–0.79
Total SFA	9.04–13.13	9.67–9.86	-	-	-	10.2–11.3
Total MUFA	31.0–37.7	33.5–33.87	-	-	-	31.6–34.6
PUFA	51.8–57.4	-	-	-	-	55.2

The fatty acid profil of Camelina seed oil various by distinct growing statuses like genom type, place, environment cases and manure entries (Jiang et al., 2014). *Camelina sativa* has a brief expanding time and is dry, chilly air and pest tolerant, so making it a appealing and nominal-expense raw material for biodiesel manufacture (Iskandarov et al., 2014). In addition, Krohn and Fripp, (2012) specified that camelina biodiesel is lot environmental suitable according as conventional soybean and canola biodiesel for inferior living period vigor requirements and less glasshouse gas emission while terrain usage modify is taken in account.

This review, studies on the usage of camelina plant ruminant and poultry nutrition and the use of biodiesel obtained from camelina plant as an alternative to petroleum are discussed.

1.1. Herbal Plant of Brassicaceae Family

Within the Brassicaceae family, there are many species with economic value such as industrial and edible oil plants, vegetable species, forage plants and spice plants. Contains. In addition to the Brassica napus species known as canola (rapeseed) or oil turnip, which is an important edible oil plant in the Brassicaceae family, *Brassica nigra* (black mustard) and *Sinapis alba* (white mustard) seeds are also used. Among the spice plants, *Brassica juncea* (Indian mustard), *Erysimum ssp.* (wallflower) and *Sinapis alba* (white mustard) species are also used. In addition to Brassica oleracea varieties such as Chinese cabbage, cauliflower, leaf cabbage, broccoli, and brussels sprout, species such as garden cress, radish, turnip and arugula are also frequently used among vegetables. Species such as *Brassica carinata* (Ethopian mustard), *Camelina sativa* (california), *Eruca vesicaria* (arugula) have serious potential as edible oil, biodiesel fuel plants and in terms of molecular agriculture (Sıralı et al., 2013; Ülgen, 2019).

In recent years, this family has become the focus of attention, because it has been shown that frequent consumption of their vegetables reduces the risk of many cancers, especially lung, prostate and bladder cancer (Boscaro et al., 2018). The Brassicaceae family has a very important place in people's balanced nutrition and also has an important potential in terms of antioxidant content. It has been reported that 80% of the total antioxidant capacity of vegetables belonging to the Brassicaceae family consists of vitamin C and phenolic compounds (Ülgen, 2019).
In addition, external effects such as the type of plant, agricultural stage, climatic conditions, light, time of harvest and storage may cause changes in the polyphenol content in plants (Ülgen, 2019).

2. STUDIES WITH CAMELINA IN RUMINANT AND POULTRY ANIMALS

2.1. Studies with Ruminant Animals

In a study on dairy cows, the addition of camelina meal and byproducts to the diet reduced ruminal cellulolytic bacteria and biohydrogenation, resulting in an environmentally beneficial reduction in ruminal methane content and an increase in desirable fatty acids. It has been reported that there is a decrease in the saturated fatty acids in the milk of cattle fed with this diet content. Therefore, it has been reported that Camelina side-productions could be used in dairy cows under suitable conditions (Riaz et al., 2022).

As a result of the study investigating the effect of *Camelina sativa* cake on the fatty acid content (linoleic acid monoenes and conjugated isomers) in kefir made from goat milk, it was observed that the total saturated fatty acid concentration decreased and the mono- and polyunsaturated fatty acid concentration decreased. It has been reported that fatty acids increased in milk obtained from goats enriched with *Camelina sativa* cake and in the kefir product made using this milk (Pikul et al., 2014).

In another study comparing the rumen, physiological and performance responses of calves receiving control rations and grain-based supplements containing camelina flour, a decrease in total dry matter consumption was reported in calves receiving grain-based supplements containing camelina flour compared to the control group (P=0.01) (Cappellozza et al. 2012).

In the study comparing the growth performance, metabolic profile and nutrient utilization of dairy heifers fed camelina meal (CAM), flaxseed meal (LIN) and soluble distilled dried grains (DDGS), 10% of the diet was supplemented with CAM, LIN or DDGS (on a dry matter basis). At the end of the study, it was reported that dry matter intake and average daily gain were similar between rations, and insulin concentration in CAM-fed heifers was lower than other rations. This study shows that CAM can be used as a protein source in the rearing of dairy heifers (Lawrence et al., 2016).

In the study comparing the effects of feeding lactating dairy farm cows with dried distilled grains and soluble substances (corn), camelina expeller, whole flaxseed and whole camelina seed on milk yield and composition, 18% DDGS, 9.5% camelina expeller and 4% camelina expeller were added to the diet, respectively. .2 whole camelina seeds and 4.7% whole flaxseed (on a dry matter basis) were added. The milk yield of cows fed with whole camelina seed (36.5 kg/day) was higher than that of cows fed with whole linseed (35.6 kg/day), and the fat-corrected milk yield was higher than that of camelina expeller (29.8 kg/day). It was determined to be higher with (Sarramone et al., 2020).

It has been reported that camelina oil reduces methanogens, protozoa, bacteria, Prevotella, and also increases the Firmicutes/Bacteroidetes ratio of the camelina oil groups, as well as Pseudobutyrivibrio and Ruminobacter. (Ebeid et al., 2020).

Similar to the above study, it was reported that adding 60 g of camelina oil to the ration had a reducing effect on ruminal CO_2 and CH_4 production, and had no effect on total fungi, protozoa, bacteria and methanogens (Bayat et al., 2015).

Steppa et al. (2017) reported that camelina cake applied to dairy sheep changed the fatty acid content and concentration of hormones and biochemical parameters in the blood.
Camelina seed and meal, when used in the diets of dairy cows (Bos primigenius), have been shown to reduce milk fat and make it softer (Seydoşoğlu et al., 2019).

Dai et al. (2017) in a study investigating the effects of camelina seed (CS) supplementation at different oil levels on the ruminal bacterial community composition, adding 7.7% and 17.7% CS to the diet prevented Ruminococcus spp., Fibrobacter spp. and Butyrivibrio spp. number decreased, accordingly propionate increased and acetate concentration decreased; It has been reported that CS supplementation may be energetically beneficial to dairy cows by increasing propionate-producing bacteria and suppressing rumen bacteria associated with biohydrogenation.

In the study conducted to determine the chemical composition and in vitro degradation of camelina meal (CM) compared to soybean meal, the in vitro digestions of camelina meal and soybean meal were determined. It has been reported that soybean meal shows higher dry matter (DM) and NDF (neutral detergent fiber) degradation compared to camelina meal, that camelina meal fully increases CP degradation, and thus CM can be used in ruminant feeds together with soybean meal, which is widely used in rations (Sizmaz et al., 2016).

In the study conducted to determine the effect of diets in which two doses of *Camelina sativa* (100 and 200 g in concentrated dry matter, respectively) were given as the primary source of UFA (unsaturated fatty acids), C18:2 c9t11 or C18:2 t10c12 were found in the fatty acid content in the longissimus dorsi muscle of lambs. isomers, as well as an increase in the content of vaccenic acid (VA), arachidonic acid (AA), eicosapentaenoic acid (EPA) and docosapentaenoic acid (DPA), and *C. sativa* supplementation resulted in higher linoleic, oleic and alpha linolenic acid content in lamb muscles. has been reported to cause (Cieslak et al., 2013).

In the study, where the effects of dietary supplement containing *Camelina sativa* fresh feed were examined on the chemical and fatty acid composition and sensory properties of milk and Caciotta cheese, goats were given fresh *Camelina sativa* feed (500 g/person/day) and the milk production in goats fed with this feed was higher ($p < 0.05$) indicates the dry matter, fat, lactose content and concentrations of C6:0, C11:0, C14:0, C18:2 n-6, CLA and PUFA, while the amounts of C12:0, C18:0 and saturated long chain FA (SLCFA) was reported to be lower ($p < 0.05$) (Colonna et al., 2021).

2.2. Studies with Poultry

In the study conducted to define the impact of adding *Camelina sativa* oil or pulp as a resource of polyunsaturated fat acids (PUFA) to the diets of broilers on growth performance, fatty acid profile and sensory quality of meat, 60 g/kg A standard grower-finish feed mix containing rapeseed oil, to the other groups, camelina oil (group II) and camelina meal (group III), fed a wheat and soybean-based diet at 40 and 100 g/kg, respectively, as a feed component The use of camelina oil and pulp did not have a significant effect on the growth performance of chickens, analysis of the fatty acid profile in the lipids of breast muscles revealed that the content of monounsaturated fatty acids of camelina oil and pulp ($p < 0.05$), but n-3 polyunsaturated fat acids, especially a-linolenic It has been reported that the acid (C18) content increases ($p < 0.01$), as a sensory analysis, camelina oil has a positive effect on the juiciness of the meat, while the camelina pulp slightly worsens the flavor of the meat (Orczewska-Dudek et al., 2019).

In the study conducted to determine the effect of camelina oil on meat quality, 6% rapeseed oil was given to the control group, and 3% canola oil, 3% camelina oil and 6% camelina oil were given to the other groups, respectively. Blood samples were taken to determine total fat, triglyceride, cholesterol and their fractions, and meat samples were subjected to sensory evaluation by analyzing dry matter content, total protein and crude fat, fatty acid composition and malonic aldehyde (Tba) in muscle samples. It has been reported that it has no negative effects in terms of rearing variables and carcass quality in broilers. An increase in the total protein content of breast meat was observed in the group fed with feed containing 3% camelina oil, and it was determined that the addition of 6% camelina oil significantly reduced the total cholesterol content and fractions in blood plasma compared to the other group. It has also been reported that enriching meat with PUFA does not have a negative effect on flavor properties. (Pietras et al., 2013).

The effects of camelina oil and seeds on performance, meat quality, immunity and plasma were investigated. For this purpose, Control group 1 (2.5% camelina oil), Control group 2 (5% camelina seed) and Control group 3 (10% camelina seed). The addition of 2.5% camelina oil and 5% camelina seed did not have a negative effect on performance and body characteristics (body efficiency, thigh, breast proportions). There was a significant decrease in body weight ($P< 0.001$) and a significant decrease in abdominal fat ($P<0.05$) in chickens fed the diet containing 10% CS seeds, but diets containing CS oil and seeds showed a significant decrease in the omega n-3 fatty acids profile in breast muscle, mainly α -linolenic acid ($P< 0.0001$), eicosapentaenoic acid ($P< 0.0301$), docosapentaenoic acid ($P< 0.0123$) and docosahexaenoic acid ($P< 0.0026$) led to significant increases (Ciurescu et al., 2016).

In the study using 3-week-old broiler chicks, inclusion of 2 different camelina meal (100 and 200 g/kg of each) in 3 levels (0, 100 or 200 g/kg) corn-soybean meal-based ration, dry matter intake, energy and IDE linearly reduced ileal digestibility ($P < 0.001$), while camelina meal supplementation linearly decreased dry matter intake, nitrogen and energy retention ($P < 0.001$), where energy and nitrogen usage was low in camelina-fed carnivorous chicks, low in jejunal digestion. It has been reported that the high viscosity and total glucosinolate in camelina meal may contribute to poor energy and nitrogen utilization (Pekel et al., 2015).

Another study reported that adding camelina seeds, oil, and cake to poultry diets resulted in 1.32 to 7.23 times higher ALA content in chicken muscles compared to traditional chicken diets (Juodka, et al., 2022).

Feeding camelina meal to broiler chickens and laying hens can increase feed layers by up to 10 percent without compromising poultry performance, while potentially increasing omega-3 fatty acid content by 3-fold in meat and 8-fold in eggs. Additionally, 10 percent dietary camelina meal is an important inhibitor of lipid oxidation products. It has been reported that it leads to a decrease and an improvement in γ-tocopherol content and antioxidant activity in dark meat (Cherian, 2012).

Aziza et al. (2014), in the study investigating the gastrointestinal morphology, fatty acid profile and production performance of broiler chickens fed with camelina meal (CAM) or fish oil, the ration content given to chickens was: corn-soybean meal based with 3.2% corn oil (control), control + %. 10 CAM was 10% camelina meal + 3.2% fish oil (CAM + FISH) and 3.2% fish oil (FISH). As a result, villous height (VH) was lowest in the jejunum of FISH and CAM + FISH ($p<0.04$). Crypt depth (CD) was lowest in Control and CAM jejunum ($p<0.002$). Villous perimeter was higher in control and CAM compared to CAM + FISH and FISH ($p = 0.02$). No difference was observed in villus width, surface area and muscularis thickness, and total omega-6 fatty acids were higher in the duodenum of control and CAM than in the FISH and CAM + FISH diets ($p<0.0001$). Long-chain (>20-C) omega-3 fatty acids were higher in CAM + FISH and FISH ($p<0.0001$). It was reported that no significant difference was detected in the total saturated and total monounsaturated fatty acid content in the duodenum ($p>0.05$). It was also reported that adding fish oil reduced feed consumption ($p = 0.019$).

Ja'skiewicz et al. (2014) in the study where they compared the effects of broiler chickens on growth performance and essential fatty acid levels in their tissues, adding 6.1% camelina oil, rapeseed oil or soybean oil to the diet showed no difference in terms of growth performance, but the diet supplemented with camelina oil improved the muscle tissues and abdomen compared to the other two diets. They reported that it significantly increased the α-linolenic acid content in oil.

3. BIODIESEL PRODUCTION AND ITS USE AS AN ALTERNATIVE FUEL TO PETROLEUM

Biodiesel, which is a renewable, biodegradable and environmentally harmless biofuel, has been shown in studies to have a great potential to be used as a replacement for traditional petro-diesel. It has fuel properties comparable in nature to petroleum-based diesel and is suitable for use in various fields such as automobiles, agricultural machinery, constant power and heat generation (Xue et al., 2011). More than 95% of biodiesel is obtained from edible vegetable oils such as soybean, canola and sunflower, but this contest by the nutrition, nourish supply, raising a fervent discussion about fuel or food. Thus, much research has been done to seek and/or develop alternative oil crops that can compete less with conventional oil crops in terms of cultivation needs (soil, water and nutrient requirements) and minimize adverse effects on the food chain. Among traditional oilseed crops, camelina is seen as an energy product that can be used due to its high oil content. Overall, evaluation of all camelina biomass will yield valuable products such as oil and flour, food and feed, biofuels and other high value-added industrial products (Mofijur et al., 2012 and Meher et al., 2013).

It is used in many industries, in nutraceutical and biomedical products, and as animal feed, more specifically as a biofuel containing renewable jet fuel, green diesel and biodiesel, as well as in processed foods. The use of camelina oil for edible purposes is very limited, so it can be used as a non-food competitor oil crop to meet biofuel demand (Veljkovic et al., 2022). Also, the use of inedible oilseeds for biofuel production is highly desirable to maintain balance with food production. In this regard, camelina oil is one of the best non-food oils (in terms of human consumption) compared to other common oilseeds and is considered an attractive renewable feedstock for biofuel production. Recently, it has been reported that the use of camelina oil as a new renewable raw material for biodiesel and jet fuel production is increasing (Mupondwa et al., 2016).

With improved seed quality and the development of new high-yielding varieties resistant to disease and insects, camelina could be a promising crop for the biodiesel industry as a future renewable raw material (Chaturvedi et al., 2019). Progress in genetics, genomics and breeding has accelerated the development of engineered camelina (Berti et al., 2016) and has led to the production and phenotyping of new lines, and therefore the introduction of many metabolic pathways into camelina to produce new lipids makes it an ideal plant for biological lipid synthesis. pointed to its potential and versatility to become a global phenomenon (Faure & Tepfer, 2016).

The camelina plant has the potential to produce more biodiesel with minimal input than most other crops (Aslam et al., 2019). Cayenne oil is considered an advanced biofuel with biodiesel, while the by-product bagasse can be used locally for livestock (Dangol et al., 2015). These two main crops of processed camelina have great commercial value and potential to benefit farmers, companies and national economies (Mupondwa et al., 2016). In addition, camelina cultivation offers the advantage of saving in greenhouse gas emissions. For example, camelina jet fuel saves about 84% in greenhouse gas emissions compared to petroleum jet fuel (Aslam et al., 2019).

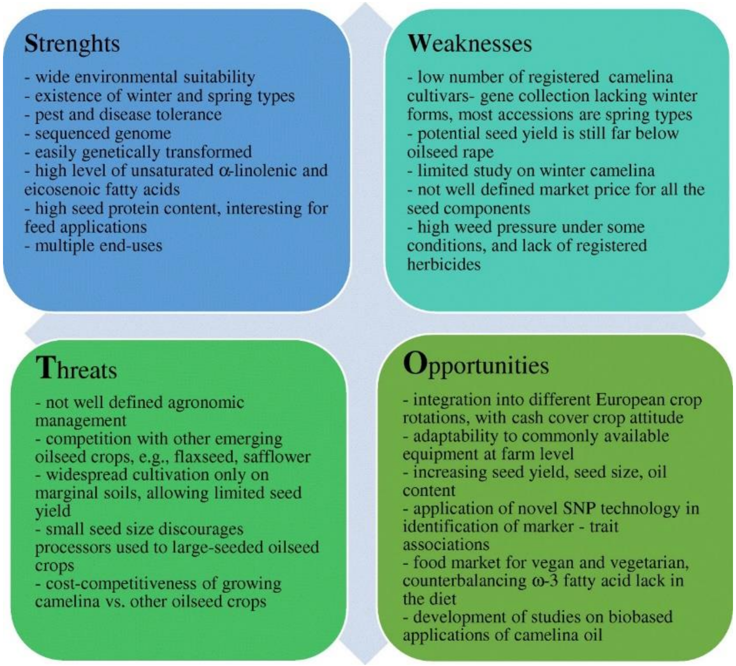
In a study in which a compression ignition engine filled with camel oil and standard diesel fuel was investigated, it was reported that it is possible to fill the engine with this alternative fuel, but refueling requires certain engine settings. The structure of camelina oil, especially its high linolenic acid content, which makes it susceptible to oxidation, makes the combustion process different from that of diesel oil. This can be seen especially at lower engine speeds where the injection has to be slightly delayed compared to the injection timing of diesel oil. In addition, the dose of camelina oil should be limited to keep the excess air coefficient above 1.25. Due to the properties of pure camelina oil, it has been reported that it is a fuel that can be used for selected engine applications such as stationary engines or agricultural machinery, but some changes in engine control and the need to change the engine maintenance procedure, as it may cause problems in the fuel system (Kruczyński, 2013).

In the study examining the emission properties and performance of neem tree seed and camelina-based biodiesel in a diesel engine, the engine test was carried out in diesel fuels of (Neem biodiesel) NB5, NB10, (cayenne biodiesel) CB5 and CB10's Neem and camelina plant oil methyl esters (B0), % It was carried out using mixtures of 5 and 10% (volume). The engine performance of these fuels has been tested in the 1.9 Multijet diesel engine. Mixtures met EN 14214 and ASTM D6751 standards. Emissions test results show the average CO emissions of NB5, CB5, NB10 and CB10 fuels as 4.84%, 8.79%, 10.77% and 12.09%, 6.48%, 12.96%, and 6.48% of the emissions for HC and CO_2. 16.67, 20.37%; compared to diesel fuels, the NOx emissions of the mixtures are reduced by 2.64%, 4.55%, 5.72%, 6.74%, for NB5, CB5, NB10 and CB10 fuels 18.7%, 3.14%, compared to conventional fuels, with higher emission values of 19.33% and 19.78%, CB10 produces lower emissions than other biodiesel fuels, thus reducing major pollution and ensuring environmental safety. It has been reported that CB10 can be used as a substitute for diesel fuels in unmodified engines (Oni et al., 2020).

3.1. Strengths, weaknesses, opportunities and threats (SWOT) of camelina plant

Despite the extensive attention in the literature on camelina, this crop is still a niche oilseed species. Camelina has many of the relevant characteristics to become a "real product", as it can meet the requirements of different actors along the value chain, offer unique agronomic properties, offer multiple end-uses. With its undeniable powers linked to both agronomic traits and seed composition traits, camelina still presents some fundamental bottlenecks. Compared to the oilseed rape and sunflower, the two most widely grown oilseed crops in Europe, camelina has some indisputable advantages.

Particularly compared to oilseed rape, camelina has significantly lower input requirements in terms of both fertilizer and chemicals, lower breakdown losses and shorter crop cycles. Otherwise, compared to sunflower, autumn-planted camelina may represent a suitable alternative in regions where spring sunflower suffers greatly from heat and drought stress. However, it drives market prices and thus the economic income of farmers who are very interested in growing camelina from agricultural and ecosystem-related aspects; However, a stable market price will be essential in the next development step of the camelina value chain. This features of SWOT analysis showed to Picture 1 (Zanetti et al., 2021).



Picture 1. *Camelina sativa'*s SWOT analysis

4. CONCLUSIONS

This review presents studies on camelina as an important, underutilized oilseed crop with great potential as a raw material in biodiesel production and other industrial applications. The cayenne plant is a promising non-food energy crop with low input requirements and numerous benefits. Due to this feature, it is a plant that is used in animal nutrition and is not competitive compared to other plants as both human and animal food. This makes the camelina plant an alternative feed source. Cayenne seed is rich in oil and protein. The oil contains a high percentage of polyunsaturated fatty acids (especially ω-3 fatty acids) and is also a valuable source of natural antioxidants such as flavonoids, tocopherols, phenolic acids and flavonoids. These unique properties make flax a potential renewable raw material for commercial biofuel, industrial scale production of value-added products, and potentially as an edible food ingredient. Among the multiple end-use applications of camelina oil, the focus has been on the production of biofuels, which have a lower carbon footprint compared to mineral and other plant oil-derived fuels. However, more innovative research is needed to improve performance characteristics. Through further research, undiscovered monomers from camelina fatty acid triglycerides may offer potential bioderived functionalities as building blocks for the development of sustainable polymers. In addition to the agricultural industry, extensive research efforts are required to use camelina oil as a promising raw material in the production of bio-based products such as films, adhesives, coatings, plastics, composites, lubricants, cosmetics, packaging and polymeric equipment.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

The contribution of the authors is equal.

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