OPEN ACCESS JOURNALS

Indiana Journal of Agriculture and Life Sciences
Abbriviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/10.5281/zenodo.15106640

INDIANA PUBLICATIONS
PRODUCTIVE AND QUALITY RESEARCH

Review Article

Volume-05|Issue-02|2025

The healthy and nutritional benefits of adding flaxseed to farm animal feeding on nutrient utilization, blood biochemical components, productive and reproductive efficiency and sheep wool characteristics

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Article History
Received: 25.02.2025
Accepted: 15.03.2025
Published: 29.03.2025

Citation
Habeeb, A. A. M. (2025). The healthy and nutritional benefits of adding flaxseed to farm animal feeding on nutrient utilization, blood biochemical components, productive and reproductive efficiency and sheep wool characteristics. *Indiana Journal of Agriculture and Life Sciences*, *5*(2), 7-23.

Abstract: Traditionally, industrial applications crush flax to produce linseed oil, and livestock feeds use the resulting flaxseed meal as a protein supplement. The most frequently employed percentages are 28 percent dietary fiber, 20 percent protein, and 41 percent oil. Owing to its high lignin level, protein, alpha-linolenic acid, and viscous fiber components, flaxseed has notable micronutrients. Flaxseed protein, especially elevated amounts of cysteine and methionine, enhances antioxidant capacities, so the scavenging of free radicals by acids confers upon their antioxidant properties. In addition, carotenoids in flaxseeds act as secondary antioxidants and scavenge singlet oxygen for capturing lipid-free radicals. Flaxseed is also a significant source of flaxseed oil. The quantity of oil in flaxseed varies, ranging from 38 to 45%. A significant portion of the total fatty acids in flaxseed oil (around 55%) are α-linolenic acid. Juices, dairy products, cereals, and meat products have all used flaxseed oil as a useful food component. The high concentration of lignin and omega-3 in flaxseed oil is primarily responsible for its physiological advantages. The omega-3 fatty acids and lignin in flaxseed oil have antioxidant activity and function primarily as hydroxyl radical scavengers. Therefore, flaxseed constituents are very important for the feeding of farm animals.

Keywords: Flaxseed, alpha-linolenic acid, dietary fiber, lignans, healthy benefits, farm animals.

Brief: **ALA**: α- linolenic acid, **LA**: linoleic acid, **PUFAs**: Poly unsaturated fatty acids, **EPA**: eicosapentaenoic acid, **DHA**: docosahexaenoic acid, **SECO**: secoisolariciresinol, **SDG**: secoisolariciresinol diglucoside, **SOD**: superoxide dismutase, **CAT**: catalase, **GSH**: glutathione peroxidase, **MDA**: Malondialdehyde

INTRODUCTION

One of the world's ancient oilseed crops, flaxseed, is also known as linseed (*Linum usitatissimum)*, has been cultivated for years and utilized for both food and fiber **(Figure 1).** Many regions of the world grow flaxseed for its nutritional value, therapeutic properties, and fiber oil. Although it originated in Egypt, flaxseed is now grown for its oil and fiber in India, Holland, Russia, and Britain (**Soni *et al.*, 2016).** The average flaxseed cultivation area worldwide between 2016 and 2020 was 3.39 million hectares (**Cui *et al.*, 2022**). Flaxseed meal still has significant nutritional value despite the by-product, the beneficial component, being extracted (**Shim *et al.*, 2015**).

Flaxseed **(Figures 2 and 3)** has a long history of usage, including as a laxative and a component in bread and breakfast cereals. For flax intended for human consumption**,** North Americans use the name flaxseed, while Europeans prefer the term linseed (**Vaisey-Genser and Morris, 2003**). Since the 1990s, a lot of goods made with flaxseed have been created, mostly for the health food industry. Flaxseed's potential health benefits have sparked renewed interest as a dietary supplement (**Thompson, 2003**). Crushed flax is used to produce linseed oil for industrial purposes (Figure 4), and the resultant flaxseed meal is fed to cattle as an extra source of protein. Flaxseeds used in animal food have been created by the interest in α-linolenic acid, lignin, protein, and dietary fiber. One of the most important omega-3 fatty acids in flax is alpha-linolenic acid which contributes to the formation of EPA, which in turn contributes to the creation of eicosanoids, hormone-like substances that are crucial for immune response (**Maddock *et al.*, 2005**). Furthermore, flax is the most plentiful plant source of lignin, an SDG precursor that may be utilized to treat cancer because rumen bacteria convert it to mammalian phytoestrogens. Growing flax and feeding it to cattle is becoming increasingly popular (Maddock *et al.*, 2004). Since animals are unable to produce omega-3 fatty acids, mammals must depend on feed sources to provide them with the shorter-chain omega-3 fatty acids they need to make the longer-chain omega-3 fatty acids (EPA and DHA). However, **Anderson and David (2009)** showed that this alteration is incredibly inefficient, with just 5% of ALA being converted into EPA and 0.5% into DHA. Several studies have provided ample evidence of the functional and physiological significance of omega-3 fatty acids in animal feeding. Flaxseed is an oilseed that comprises between 38 and 45% oil, with PUFAs making up 52 percent of the oil's fatty acids. Flaxseed oil is a significant basis of supplementary n-3 PUFAs and is mostly produced by pressing and extracting flaxseed **(Figure 5).** Sections of the flax plant (Fibers) are used in several industries, including cloth, ink, and typist-paper, fishing nets, soap, hairspray, and banknote papers **(Figure 6).**

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Information regarding flax's usage in animal feeding is also required. This review discusses the healthy benefits of adding flaxseed to farm animal nutrition on nutrient utilization, blood biochemical components, productive and reproductive efficiency, and wool physical characteristics.

Figure 1: Light blue flowering flax plants

Figure 2: Golden flax seeds

Figure 3: Brown flax seeds

Figure 4: Crushed flax seeds

Figure 5: Flaxseeds oil

Figure 6: Flax fibers

Nutritive values of flaxseed

The highest plant source of omega-3 fatty acids is flaxseed, which has a low percentage of saturated fatty acids (9%), a moderate amount of monounsaturated fatty acids (18%), and a high percentage of polyunsaturated fatty acids (73%) as presented by **Tourre and Xueming (2010).** Flaxseeds are rich in thiamine, magnesium, phosphorus, dietary fiber, protein, and B vitamins. High in linoleic acid, an important omega-6 fatty acid, and α-linolenic acid, an essential omega-3 fatty acid, flax is a good source of PUFAs. The nutritive values of flaxseed detail are presented in **Table 1.**

Nine percent of flax seeds are made up of saturated fat, of which 54% are omega-3 fatty acids (mostly ALA), including 5% are palmitic acids, 18% are omega-9 fatty acids (oleic acid), and 6% are omega-6 fatty acids (linoleic acid, LA) *(***USDA National Nutrient**

Database, 2015). According to **Petit (2003**), flax contains 41% oil, 20% protein, and 28% dietary fiber, and 18.8 to 24.4% of the total is protein. **Baby (2022)** mentioned that the nutrients of flaxseeds are typically included in a 100-g serving of flaxseed: 534 calories, 18.3 g of protein, 42.2 g of fat, 28.9 g of carbohydrate, 27.3 g of fiber, and 1.55 g of sugar. The same authors reported that thiamine, riboflavin, niacin, vitamin B6, folate, and choline are all nutrients found in flaxseed, along with minerals including calcium, iron, magnesium, phosphorus, salt, zinc, copper, and selenium. Mineral content of flaxseed meal is shown in **Table 2.**

Table 1: The nutritive values of flaxseeds

Nutrient content per 100 g of edible flaxseed*			
DM	94%	Crude fiber	27.30 g
TDN	110%	Total sugars	1.55 g
Water	6.96 g	Sucrose	1.15 g
Energy	534 kcal	Glucose	0.40 g
Crude protein	18.29 g	Total saturated fatty acids	3.66 g
Crude fat	42.16 g	Total monounsaturated fatty acids	7.53 g
Ash	3.72 g	Total polyunsaturated fatty acids	28.73 g
Carbohydrate	28.88 g		

Sources of Data: * Flax Council of Canada (1997), ** Nutrient Data Laboratory (2003)

Table 2: Mineral content of flaxseed meal

Mineral content of flaxseed meal			
Minerals	Mineral content of flaxseed as %*	Minerals	Mineral content of flaxseed as dry matter basis**
Calcium	255 mg	Calcium	0.23%
Iron	5.73 mg	Iron	50.00
Magnesium	392 mg	Magnesium	0.43%
Phosphorus	642 mg	Phosphorus	0.62%
Potassium	813 mg	Potassium	0.83%
Sodium	30.00 mg	Sodium	270.0 ppm
Zinc	4.34 mg	Zinc	40.0 ppm
Copper	1.22 mg	Copper	10.0 ppm
Manganese	2.48 mg	Manganese	30.0 ppm
Selenium	25.40 ug		

Sources of Data: * Flax Council of Canada (1997), ** Nutrient Data Laboratory (2003)

Flax also includes antioxidants like vitamin C, lutein and zeaxanthin, vitamin E, and K. Vitamin content of flaxseed meal is presented in **Table 3.** The two main types of proteins in flaxseed are albumin and globulin-like proteins. According to **Marcone *et al.* (1998**), albumin makes up around 26.6% of total protein, whereas the globulin fraction accounts for 73.4% of it. Flaxseed proteins include a fair amount of arginine, aspartic acid, and glutamic acid, but the limiting amino acids are cysteine, methionine, and lysine **(Table 4).** The composition of flaxseed protein meal (g/100 g) was aspartic acid 9.76%, glutamic acid 26.92%, arginine 10.36%, cysteine 3.80%, and methionine 2.20%, according to **Guimarães *et al.* (2017).** Aspartic acid, glutamic acid, and arginine are abundant in flaxseed protein, and elevated amounts of cysteine and methionine found in flaxseed enhance antioxidant capacities (**Singh *et al.*, 2012**). According to **Daun *et al.* (2003),** the neutral lipid fraction of flaxseed meal included 95–98% triacylglycerol, which are the main lipid in flaxseed. Flax includes a combination of fatty acids. Animals need these two polyunsaturated fatty acids because their bodies need them. The highest concentration of α-linolenic acid is found in flax, which contains linoleic acid and α-linolenic acid, which make up 57% and 16.0% of the total fatty acids, respectively. **Oomah *et al.* (1997**) discovered that flaxseed contains tocopherols, which are effective antioxidants. The same authors also discovered that the predominant isomer in Canadian flaxseed cultivars was γ-tocopherol (9.04 mg/100 g seed) and that the values of both total and γ-tocopherol were correlated with the amount of seed oil present. Beta-carotene was found in flaxseed, and carotenoids may act as secondary antioxidants and scavenge singlet oxygen. In the absence of singlet oxygen, carotenoids can act as antioxidants by capturing lipid-free radicals (**Belitz *et al.*, 2004**). The total phenolic acids varied from 790 to 1030 mg/100 g, with EPA making up 48–66% of the total SDG. SDG is the primary lignin in flaxseed. The main reason these compounds are significant is that they are precursors to mammalian lignin, which has beneficial effects on animal health (**Muir *et al.*, 2000**).

Table 3: Vitamin content of flaxseed meal

Vitamins	Vitamin content of flaxseed meal	
	Vitamin content per 100 g of edible flaxseed*	Vitamin content of flaxseed meal (mg/kg as fed)**
Vitamin C (Beta carotene)	0.60 mg	0.20
Thiamin	1.64 mg	7.50
Riboflavin	0.16 mg	2.90
Niacin	3.08 mg	33.00
Pantothenic acid	0.99 mg	14.7
Vitamin B-6	0.47 mg	6.00
Folate (Folacin)	87.00 ug	1.30
Choline	78.70 mg	1512
vitamin E (Alpha-tocopherol)	0.31 mg	2.00
Biotin	3.10 mg	0.41
Vitamin K	4.30 ug	

Sources of Data: * Flax Council of Canada (1997), ** Nutrient Data Laboratory (2003)

Table 4: Amino acids content of flaxseed

Amino acids content of flaxseed (g/100 g protein)			
Arginine	9.2	Methionine	1.5
Cysteine	1.1	Phenylalanine	4.6
Histidine	2.2	Threonine	3.6
Isoleucine	4.0	Tryptophan	1.8
Leucine	5.8	Valine	4.6
Lysine	4.0		

Source of Data: Oomah and Mazza (1993).

Nutritive values of flaxseed oil

Flaxseed seeds contain between 35% and 45% oil, up to 50% of which is omega-3 fatty acid, a beneficial unsaturated fat with a number of therapeutic benefits according to **Baby (2022). Table (5)** and **Figure (5)** illustrate the flaxseed oil's chemical make-up. Omega-3 fatty acids makes up 53% of the total fatty acids in flax seed oil, which also includes 13% of omega-6 fatty acids is an excellent source of omega-3 (**Mustafa *et al.*, 2002**). Moreover, the oil form of flaxseed is thought to have more α-linolenic acid than milled seed, and both the oil and crushed seed have higher bioavailability than complete seed (**Shakir and Madhusudan 2007).** The fatty acids omega-3 and omega-6 come in two varieties. Omega-3 and omega-6 reduce the risk of cardiac disease. Linolenic acid, EPA, and DHA are three kinds of vital omega-3 fatty acids and are crucial for animal nutrition.

Table 5: The chemical composition of flaxseed oil

Chemical composition of flaxseed oil as %		Chemical composition of flaxseed oil as %	
Crude protein	22.80	Potassium	0.83
Net energy	4.78 Mcal/kg	Iron	50 ppm
Calcium	0.24	Manganese	30 ppm
Magnesium	0.43	Sodium	270 ppm
Phosphorus	0.62	Zinc	40 ppm
Copper	10.00 ppm		

Sources of Data: Flax Council of Canada, 1997 and Lardy and Anderson, 1999.

Flaxseed and oil health benefits

Numerous studies show that flax and/or its components are good for animal health. These studies show that flax reduces the hazard of heart disease, modifies autoimmune diseases, and lowers the incidence of several malignancies (**Thompson *et al.*, 2004**). Animals must receive omega-3 from food or some other source because their bodies are unable to manufacture them on their own. The high quantities of omega-3, lignin (SDG), phytoestrogens, and lignins are primarily responsible for flaxseed oil's physiological advantages. Phytoestrogens are known to have antioxidant properties, particularly as hydroxyl radical scavengers. **Drouillard *et al.* (2002)** discovered that heifers fed control diets had greater occurrences of bovine respiratory illness than heifers treated with flax and flax oil. **Farren *et al.* (2002)** discovered that the blood levels of haptoglobin, a sign of a healthy immune system, were higher in the blood of the flax-fed steers than in the tallow-fed steers and concluded that dairy rations supplemented with flaxseed may be good for the animal's immune status and protect against heat stress. The richest source of plant lignin is flaxseed, which also contains phytoestrogens that act as precursors to the formation of lignin in animals. Intestinal flora transforms the lignin in flaxseed into mammalian lignins **(Wang *et al.*, 2000**). Therefore,

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flaxseed was very important and interested in enhancing the well-being of the animals (**Barclay, 2013).** Dietary omega-3 fatty acids are required to produce eicosanoids, which regulate several biological processes, preserve the integrity of cell membranes, and improve the absorption of liposoluble vitamins (**Ponnampalam *et al.*, 2001**). According to **Zhang *et al.* (2008**), the oil extracted from flaxseed contains significant amounts of omega-3 (n-3) fatty acids such as ALA, which is crucial for supporting animal health. Owing to its high omega-3 content, abundance of dietary soluble and insoluble fibers, and abundance of lignans, which serve as phytoestrogens and antioxidants, flaxseed may have additional health advantages beyond nutrition. The body may convert α-linolenic acid into DHA (ω-3) and EPA (ω-3) via metabolism. All three ω-3 fatty acids (ALA, EPA, and DHA) have been linked to a number of health advantages, including protection against several diseases (**Simopoulos, 2000**). A diet high in flaxseed products can satisfy the requirement for ALA, an important fatty acid **(Morris 2003).** Rich in oleic and linolenic acids, flaxseed contributes significantly to the integrity of cell membranes (**Kasote, 2013**). The scavenging of free radicals by acids confers upon them antioxidant properties. Lipid peroxidation results in the formation of certain chemicals. The identification of these compounds in biological systems might yield important details on the degree of cell harm produced by free radicals. The degree of oxidative stress in biological systems may also be calculated from variations in the activity of antioxidant enzymes (**Touré and Xueming, 2010**). Additionally, in the intestines, bacteria can change the SDG content of flaxseed to produce enterolactone and enterodiol, which have a number of progressive health effects (**Touré and Xueming 2010**). Flaxseeds are a rich source of ω-3 fatty acids, PUFAs, soluble and insoluble fibers, a phenolic substance (SDG), proteins, and a variety of antioxidants **(Singh *et al.*, 2011**). The ALA fatty acid is transformed into the beneficial EPA and DHA by the animal body. ALA, EPA, and DHA are three omega-3 fatty acids that have been linked to better animal health. Furthermore, ingesting flaxseed oil, a vital source of α-linolenic acid, may reduce low-density lipoprotein, one of the key risk factors for heart disease **(Pan *et al.*, 2012; Magee, 2015**). Because flaxseed has three key bioactive components: dietary fiber, lignans, and alpha-linolenic acid, it is regarded as a functional food, but the primary ingredient that makes flaxseed useful is alpha-linolenic acid. Alpha-linolenic acid is the sole source of omega-3 fatty acids and the precursor to the PUFAs, DHA and EPA, according to **Kajla *et al.* (2015).** Regular consumption of flaxseed yields substantial levels of omega-3 fatty acids, lignans, ALA, SDG, soluble fiber, and phenolic components (**Lu *et al.*, 2020**). Therefore, dairy cattle's health is improved by feeding extruded flaxseed products into their diets (**Moats, 2015**). Flaxseeds have several applications and health advantages, including reducing inflammation and preventing oxidative damage, which is a result of their excellent nutritional content and possible health advantages. Flaxseeds contain vitamins, omega-3 fatty acids, fiber, and beneficial plant components (**Hussain *et al.*, 2021**). Lignans are plant molecules with antioxidant properties, and flaxseed has one of the highest concentrations of these compounds. Lignans, are the plant equivalent of the female hormone oestrogen**.** Flaxseed contains antioxidants like the vitamins C, E, and K, as well as polyphenols like lutein and zeaxanthin and lignans like SDG; therefore, flaxseed has the potential to be a useful food (**Baby, 2022**). Because ALA in flaxseed is altered to EPA and DHA in the body, flaxseed lowers cholesterol, consequently improves heart health, and enhances brain health and memory because memory and brain health depend on EPA and DHA (**Baby, 2022**). Because flaxseeds include a range of bioactive components, including lignans, polyphenols, dietary fiber, vitamins, and minerals, that are used as animal feed and as a source of nutritional fiber (**Rizvi *et al.*, 2022).** The importance of flaxseed oil as a useful food has grown as a consequence of its several health benefits, which include lowering triglycerides and bad cholesterol (**Hadi *et al.*, 2020**). Flaxseed oil also has high-quality protein, soluble fiber, α-linolenic acid, lignans, ω-3 fatty acids, flavonoids, phytoestrogens, and phenolic-substances, which are often responsible for these advantageous qualities on animal health (**Rizvi *et al.*, 2022**). Rich in linoleic acid (ω-6) and α-linolenic acid (ω-3), flaxseed oil controls prostaglandin production **(Raole & Raole, 2022**). Regular flaxseed eating assists in decreasing blood pressure, fasting glucose, and insulin resistance index. Additionally, flaxseed oil has 19% oleic acid and 53% ALA, making it the richest plant source of these compounds. Because it contains a lot of ALA, flaxseed oil has a good n-6: n-3 fatty acid ratio of around 0.3:1 (**Nowak and Jeziorek, 2023**). Three different forms of omega-3 fatty acids, α-linolenic acid, EPA, and DHA, stay vital for nourishment and must thus be included in the diet of animals. In addition, flaxseed-infused food products can also have good consumer suitability and nutritious welfare (**Raole and Raole, 2022**). Animals cannot benefit from flax seeds, as the richness of flax seeds in Omega-3 and Omega-6 is considered a treasure to protect against future diseases. Together with dissolving internal fat and lowering blood cholesterol levels, these two substances dissolve body fat and lower the risk of developing heart and artery disorders. It is very beneficial for patients with high blood pressure, diabetes, cardiovascular disease, and cancer. Seeds contain 98% of anti-cancer lignans and 97% more fiber and omega-3. These substances are useful in reducing cholesterol, premenstrual symptoms, and diabetes, as well as treating liver diseases (**Nowak and Jeziorek, 2023**). The seeds of this plant are oily, with 40% of the oil comprising a significant amount of Omega-3, 22% proteins, and 4% minerals. Elevated levels of Omega 3 in flax oil can help lower cholesterol (**Rizvi *et al.*, 2022)**.

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The importance of dietary flaxseed on animal performance

The usage of flaxseed as animal feed has just lately become more widespread, even though it has been known for almost 100 years that it improves animal health. It is necessary to quantify the advantage to animal health. The qualities of the final product and animal output have both increased, according to certain research (**Maddock *et al.*, 2005**). According to a different study, giving cattle flax seeds may improve the meat's marbling and omega-3 content. Flaxseed has a high protein level, is highly nutritious, and is a brilliant basis of vitality and necessary fatty acids. Omega-3 fatty acids can also be added to the diet by using flax seed (**Maddock *et al.*, 2006**). Cattle feed contains flaxseed meal as an extra source of protein, but it contains a lot of fat, which is bad for ruminants and therefore can only be added in smaller amounts. Cattle fed flaxseeds have positive outcomes, possibly as a consequence of the mucilage, which may help in delaying digestion and giving extra period for nutrients to be absorbed (**Maddock *et al.*, 2012**). Feeding flax to cattle enhances the amount of alpha-linolenic acid, an important omega-3 fatty acid, in the meat, milk, and eggs that are produced. Since flaxseed meal contains a significant amount of protein, up to 30% of the total protein content of these components, it may be employed as a source of high-quality protein for animal feed (**Xu *et al.*, 2022**). Additionally, proteases have the ability to hydrolyze flaxseed proteins into physiologically active peptides, and these active peptides have characteristics that have antioxidant effects. Flaxseed meal, when added in the right quantity, can boost an animal's immunity, which in turn improves production efficiency and the flavor of associated livestock products (**Marambe *et al.*, 2008).** The main reason flaxseed oil has physiological advantages is because of its high ALA concentration.

a) Blood biochemical components

The oral administration of flaxseed oil to ewes at a dosage of 25 ml per day per sheep considerably enhanced the levels of total protein, albumin, and globulin and improved the daily dry matter intake (DMI) glucose, total cholesterol, high density lipoprotein (HDL), and low density lipoprotein (LDL) levels, which dropped significantly while estradiol-17 and triiodothyronine hormone (T_3) levels rose significantly. In addition, the therapy with flaxseed oil for ewes did not impact the level of the cortisol hormone (**Habeeb *et al.*, 2021**). The improvement in dry matter intake and nutritional feed digestibility may contribute to the increase in protein fractions. Protein in flaxseed may affect blood glucose concentration by encouraging insulin secretion, which results in a decreased glycemic reaction, as well as by interacting with polysaccharides; therefore, flaxseed mucilage also lowers blood glucose levels **(Zhang *et al.*, 2008)**. According to **Habeeb *et al.* (2021a**), rabbits given 100 µl and 200 µl of omega-3 orally showed significant increases in concentrations of protein fraction, uric acid, and creatinine as well as alanine aminotransferase activity, T3, and progesterone levels. The same authors found that total lipids, triglycerides, and total cholesterol concentrations were significantly decreased, and there were no adverse effects on liver and kidney function. **Habeeb *et al.* (2021)** concluded that the major reduction in the levels of total cholesterol, HDL cholesterol, and LDL cholesterol in sheep fed flaxseed oil may be attributable to the fact that alpha-linolenic acid-rich flaxseed oil causes a higher secretion of cholesterol into bile, which depletes the intra-hepatic pool of cholesterol and increases cholesterol synthesis and turnover, both of which indicate reduced liver cholesterol content as cleared by **Morise *et al.* (2004**). Alpha-linolenic acid lowers hepatic lipid buildup by promoting oxidation, decreasing the synthesis of fatty acids, and reducing the production of cholesterol in the liver of animals (**Murase *et al.*, 2005**). Because it contains lignan, fiber, and omega-3 fatty acids, which all contribute to reducing cholesterol; flaxseed has hypolipidemic and cholesterolemic effects on animals (**Cunnane *et al.*, 2004**). By avoiding the rate-limiting enzyme from altering cholesterol into primary bile acids, lignin in flaxseed oil may potentially have an impact on cholesterol homeostasis. The highest concentration of lignans may be found in flaxseed, and these compounds have been shown to have antioxidant and hypolipidemic properties (**Newairy and Abdou, 2009**). **Pan *et al.* (2012**) showed that nutritional flaxseed lignans caused lower glucose concentrations, total cholesterol, and LDL cholesterol. **Eid *et al.* (2010)** reported that flaxseed oil had a positive effect on the composition of the lipid fraction of rabbit meat. As a result, the amount of cholesterol and total saturated fats in the meat and blood significantly decreased. Additionally, linoleic (ω-6) and α-linolenic acid (ω-3) fatty acids, which are PUFAs, significantly increased. Flaxseed oil high in linoleic acid has lower blood cholesterol levels in rabbits. Additionally, n-3 fatty acids lower plasma triglyceride levels by reducing the formation of endogenous LDL (**Eid *et al.*, 2010**). The later authors reported that linseed oil, at 2% added to the diet of Californian rabbits, dramatically reduced triglycerides, LDL cholesterol, and total cholesterol while considerably raising HDL levels. Adding n-3 polyunsaturated fatty acids to the diet of rabbits leads to hypolipidemic conditions because omega-3 has lower total cholesterol and HDL (**Francisco, 2017).** According to **do Prado *et al.* (2016),** feeding flaxseed to dairy cows during the changeover period increased the concentrations of glycogen in the liver after calving, as well as antioxidant activity and lowered triglyceride levels. These findings suggest that flaxseed can help avoid the progress of fatty liver in cows. **Sahoo and Ranveer (2015)** found that blood lipids are enhanced by flaxseed's alpha-linolenic acid. Alpha-linolenic acid lowers total cholesterol, LDL cholesterol, and very LDL cholesterol. **Morshedzadeh *et al.* (2021)** observed a substantial increase in blood HDL levels and a significant decrease in serum concentrations of triglycerides and total cholesterol in the group that received ground flaxseed powder. Consuming flaxseed oil may lower total and LDL cholesterol because of its high content of PUFAs and low level of saturated fat content (**Naik *et al.*, 2020**). Due to the fact that ALA in flaxseed is transformed to EPA and DHA in the animal body, flaxseed lowers cholesterol. Adding flaxseed oil to the diet of sheep does not influence their liver or kidney functions, as measured by urea and creatinine concentrations and ALT and AST enzyme activity, respectively. Therefore, the author concluded that renal function can be significantly improved by eating flaxseed, which delays the loss of renal function and lessens glomerular damage (**Habeeb *et al.*, 2021**). The T_3 hormone level dramatically rose in sheep given flaxseed oil orally, according to **Habeeb *et al.* (2021b),** and this rise may be due to flaxseed oil activating thyroid gland function.

b) Body gain and dry matter intake (DMI)

Flax has been used in beef feedlot feed in several trials, with varying degrees of success. The total means of daily body gain and DMI rose markedly when flaxseed oil supplements were given orally to sheep. The increases in body gain due to additives in flaxseed oil may be linked to enhancements in nutrient digestibility and food stuffs nutritive values and an increase in feed intake due to additives **(Habeeb *et al.*, 2021b)**. The addition of flaxseed oil considerably enhanced feed conversion as measured by DMI/g gain by 27.8%, and it is possible that this improvement is more a result of better DMI than an increase in daily body gain **(Habeeb *et al.*, 2021b**). Rabbits fed diets with 2% linseed oil demonstrated greater feed conversion than those on the control diet, as well as enhanced digestibility of ether extract and nutritive values for total digestible nitrogen and digestible energy **(Eid *et al.*, 2010**). When compared to corn-based diet, **Maddock *et al.* (2004**) found not any changes in DM consumption and substantial gains in gain efficiency. When whole or processed (rolled or ground) flaxseed was given, it accounted for 8% of the diet's dry matter. The study's findings imply that processing flax is necessary to maximize growth and nutrients uptake. The latter writers concluded that feeding ground or rolled flax was superior to feeding whole flax in terms of gain and efficiency.

The great levels of fiber, antioxidants, and omega-3 fatty acids in flaxseed oil are what give it its health advantages **(Petit, 2002**). Adding flax to beef feedlot diets at 5% of diet DM led to higher consumption of DM **(Drouillard *et al.*, 2004)**. In another study, **Maddock *et al.* (2006)** found that flax inclusion increased significantly each of average daily gain, feed efficiency, apparent dietary metabolizable, and net energy but had no effect on DMI. Increasing the quantity of accessible energy and improving gain efficiency in feedlot heifers by 8% resulted in higher efficiency and gain. Consequently, the authors concluded that feeding 8% flax enhanced the amount of omega-3 fatty acids in fresh beef. Both soluble and insoluble fibers are contained in flaxseeds, and the mucilaginous fiber increases intestinal absorption of nutrients as well as the transit of food through the intestines (**Anderson *et al.*, 2009).** The lowering of the n-6/n-3 ratio in flaxseeds enhanced feed efficiency as well as the efficiency of retaining nitrogen and digestible energy in the body and carcass of rabbits **(Delgado *et al.*, 2018**). Additionally, due to flax's relatively high protein content (22.8%) and high oil content (35%) in cattle diets, flax is regarded as a source of fat (**Kajla *et al.*, 2015)**. **Daun *et al.* (2003)** noted that flax may be considered a source of supplementary protein, consequently increasing the nutritional value of beef and encouraging the synthesis of n-3 PUFAs in muscle tissue. By adding flaxseed to their diets, Hereford and Angus cattle had considerably higher levels of n-PUFAs in their longissimus muscles (**Loor *et al.*, 2005).** The nutritional potential of flaxseed meal, on the other hand, is fully utilized and is beneficial for increasing the immune systems of animals, improving feed palatability, and fostering growth performance in livestock **(Kronberg *et al.*, 2006)**. On the other hand, the beneficial bacteria in the fermentation process can work well with a range of active substances in flaxseed meal. This will increase the value of flaxseed meal and create a number of good microbial metabolites, which will improve the feeding effects and preserve the original beneficial nutrients in flaxseed meal (**Xu *et al.*, 2022).** The addition of n- PUFAs to the diet increases animal growth and fatty acid metabolism, which raises the nutritional value of animal products and also offers potential options for flaxseed meal for the creation of useful livestock products (**Cui *et al.*, 2022). Habeeb *et al.* (2021a)** report that giving 100 and 200 µl of omega-3 to rabbits orally increased both the weight of the pregnant does and the size and weight of their litter at birth. Meat quality is enhanced by dietary supplementation with flaxseed oil as a source of omega-3 fatty acids because meat has less lipid oxidation and contains more of these fatty acids (**Petracci *et al.*, 2009**). In young animals, nutritional omega-3 fatty acids are too necessary for optimal improvement and metabolism (**Van West and Maes, 2003).** Although adding flaxseed or flaxseed meal to beef cattle diets is thought to be generally beneficial, large doses of flaxseed meal can limit feed consumption. A maximum of 5% flaxseed should be used for cattle concentrate feed, 7.5% flaxseed meal for calves' diets, and 20% flaxseed for yearlings' feed, according to recommendations for animal safety (**Cui *et al.*, 2022). Drouillard *et al.* (2002**) investigated the timing of flax addition by feeding flax at 5% (diet DM) at different times and found that all treatments had similar growth, DM intake, and gain efficiency. When fed at 5% of diet DM, flax increased DM intake but had no effect on gain or gain efficiency. **Drouillard *et al.* (2004**) found that DM consumption dropped linearly as flax levels grew, since flax was given at 0, 5, 10, and 15% of diet DM. The latter authors concluded that in ruminant diets, flax may be supplemented at a rate of 12 to 14% (DM basis) according to this regulation. **El-Diahy *et al.* (2016**) found that feed conversion and economic efficiency improved significantly in Friesian cows that received 2% of DM intake flaxseed oil compared to non-received flaxseed oil.

c) Milk production and composition

The primary purpose of feeding flaxseed meal to ruminants is to benefit dairy cows. Providing dairy cows with the proper diet during milk production is extremely important since food affects the nutritional content of milk. Feeding flaxseed or any other unsaturated oil to cattle is challenging due to the animal's digestive system. The fat has to be in a protected condition in the rumen to prevent problems with digestion. To allow the lipids to be incorporated into the milk, they must also be in a form that is simple for the small intestine to digest. Studies involving dairy cows have yielded conflicting results about the role of flaxseed in milk production and composition. Overall, the composition of milk can be affected by the inclusion of flaxseed in the diet of dairy cows. **Ward *et al.* (2002**) found that dairy cows given a diet containing 8% flax increased the milk's alpha-linolenic acid level, but there were no alterations in milk production or fat content, while protein content was lower in milk from cattle fed a diet containing flaxseed. Another study by **Goodridge *et al.* (2001**) found that alpha-linolenic acid levels in milk rose linearly with aggregate food flax addition, and cows given flax produced milk that was richer in protein compared to cows fed casein-protected linola. In comparison to other fat sources**, Petit *et al.* (2001**) fed lactating dairy cows 17% formaldehyde-protected whole flax and observed an increase in milk alpha-linolenic acid levels and also noted a decrease in milk output and milk fat content. As opposed to the control diet, **Petit (2002**) discovered that eating whole flaxseed increased milk output and protein composition. According to **Gonthier *et al.* (2005),** giving flaxseed decreased milk production and energy-corrected milk by 1.8 and 1.4 kg/d, respectively, and cows fed flaxseed diets produced less milk protein and casein than those that were not given flaxseed. **Moats (2015**) found that fat-corrected milk output and milk constituents were unaltered, and no variations in rumen fermentation characteristics were revealed after analyzing the effects of flaxseed addition. Using flaxseed oil in the diet may increase milk production and the amount of beneficial fatty acid α-linolenic acid found in milk fat because flaxseeds contain around 32% oil, which is a good feed element to improve dietary nitrogen absorption (**Pi *et al.*, 2016)**. According to **Sarrazin *et al.* (2004),** adding dietary fat derived from flaxseeds, which is high in PUFAs, can be used to manipulate the fatty acid composition of cow's milk by increasing the amounts of long-chain and unsaturated fatty acids and decreasing the levels of short-chain and saturated fatty acids. In other words, oilseeds appear to be potential feed ingredients to control protozoa populations in ruminants. Thereby, it increases the dietary protein utilization because flaxseed oil typically contains high concentrations of oleic and linoleic acids, which are potent antiprotozoal agents **(Habeeb *et al.*, 2021b**). Increased milk yield, higher percentages of functional fatty acids, and lower percentages of saturated fatty acids were observed when flaxseed oil was added to cow's foods (**Mueed *et al.*, 2022**). In a different study, **Moallem *et al.* (2020**) investigated the effects of supplementing α-linoleic acid from flaxseed on the health of cows getting ready to give birth. The authors discovered that ALA decreased the risk of metritis, ketosis, and calves' deaths while increasing milk yield, the percentage of unsaturated fatty acids, and fertility. Evaluate the quality of anhydrous milk fat in lactating cows and buffaloes supplemented with 2% flaxseed oil, as studied by **Shazly *et al.* (2023).** The authors found that diets with flaxseed oil decreased saturated fatty acids while improving the unsaturated fatty acids in milk from cows and buffalos. According to **Badinga & Caldari-Torres (2017)**, giving omega-3 supplements to dairy cows may help boost their immune systems and regulate how animals' immune systems work. Other research has focused on the period of time when dairy cows shift from late gestation to lactation. Dairy cows are most in danger of metabolic and viral illnesses, as well as ultimate mortality, at this time. Flaxseed is frequently utilized as a source of fatty acids and may help reduce the negative energy balance of early nursing cows. In dairy cows in the transition period, using flaxseed as a source of fatty acids boosted antioxidant action and lowered triglyceride contents, which possibly will aid in avoiding the formation of fatty liver **(Gandra *et al.*, 2016**). Consequently, adding flaxseed to dairy cow diets has the potential to alter the fatty acid composition of milk, reduce lipid accumulation in the liver, and prevent the development of fatty liver, all of which are directly linked to flaxseed's ability to improve cow health (**do Prado *et al.*, 2016**). In conclusion, the flaxseed's inclusion in bovine meals and the cattle's assimilation of the flaxseed are likely to blame for the contradictory observations about production and the contents of the fat and protein. In any event, adding flaxseed to dairy cattle's diets will result in milk with increased omega-3 content. Completely, studies agreed that including flaxseed in cow diets increased milk's omega-3 content. The general health of high-yielding dairy cows, which are vulnerable to immunological deficiencies shortly after calving, was enhanced by omega-3. According to **Ababakri *et al.* (2021**), adding 10% extruded flaxseed to the meals of transition ewes improved animal performance and improved the profile of fats in their milk. In cows fed linseed, **Meignan *et al.* (2019)** observed a linear rise in milk production at the rate of +0.00, +0.59, +0.90, and +1.13 kg/day for low, medium, high, and very-high linseed intake, respectively. **Leduc *et al.* (2017**) discovered that dietary flax seed and oil supplementation decreased DMI, actual and energy-corrected milk output, and fatty acid profile in dairy cows when compared with non-supplemented cows while having no effect on the efficiency of DM or energy utilization. From 45 days before to 120 days after giving birth, Friesian cows receiving 2% of DMI flaxseed oil had considerably greater daily milk output and 4% fat-corrected milk compared to those that did not get the oil. These differences were 19.37 and 29.99%, respectively. The percentages of fat, lactose, and total solids were greater in the Friesian cows that got 2% of DMI flaxseed oil than in the cows that did not. However, the percentages of protein and solids rather than fat were comparable in the two groups **(El-Diahy *et al.*, 2016).**

d) Reproduction efficiency

In female

According to **Petit *et al.* (2001**), dairy cows fed 17% flax had greater first-service conception rates (87.5%) than dairy cows not fed flax (50.0%). The scientists explained this response by noting that the cows on the flax diet had a better energy balance. **Moats (2015**) found that including flaxseed in the diet improved the herd's reproduction ability and increased early embryonic survival. According to **Habeeb *et al.* (2021b**), oral administration of flaxseed oil to sheep significantly increased estradiol-17β hormonal levels. According to **Hutchins and Slavin (2003**), the authors speculate that this oil may promote the synthesis of sex hormones. Moreover, lignin, an oestrogen component found in flaxseed oil, has the potential to convert into estradiol$_{17\beta}$, which might account for the increases in estrdiol$_{17\beta}$ hormone levels in those who use flaxseed oil (**Habeeb *et al.*, 2021b)**. However, **Rodriguez *et al.* (2017**) found no effect on the endocrine or reproductive health of female rabbits and their progenies while feeding them a diet enhanced with omega-3 throughout their first reproductive sequence. Using flaxseeds or oil flaxseeds can help animals function better in these settings because high ambient temperatures have a detrimental effect on ruminant reproductive efficiency (**Habeeb *et al.*, 2023).** Lignans, which are estrogenic plant chemicals found in flax seeds, may help maintain the appropriate balance of hormones during pregnancy. The fact that flax seed supports a healthy immune system is one of its other significant advantages during pregnancy. Antioxidants, vitamins, and minerals abound in flax seeds, which support and enhance the immune system. Dietary fiber, which improves digestive health and encourages regular bowel motions, is abundant in flax seeds. Dairy cows are the major target of flaxseed meal application in ruminants. Since the nutritional content of milk is influenced by food, it is especially crucial to give dairy cows the right feed throughout the milk production period. It is well known that flaxseed contains a lot of n-3 PUFAs, which are good for animal health. Consequently, there has been an increasing interest in animal production for the production of n-3 PUFA-rich milk with the addition of flaxseed to the diet in order to promote human health. Numerous research investigations have demonstrated the effectiveness of adding flaxseed to the diets of dairy cows to raise the amounts of n-3 PUFA in their milk (**Huang *et al.*, 2022).** Flaxseed is widely utilized as a source of FA and may assist early lactation cows with their negative energy balance, according to **Gandra *et al.* (2016**). According to **Xu *et al.* (2022),** adding flaxseed to dairy cow diets may enhance the health of the cows by lowering lipid increase in the liver, delaying the progress of fatty liver, and altering the fatty acid content in milk. These are just a few of the ways that flaxseed may benefit cow health. The study conducted by **Didarkhah *et al.* (2020)** revealed that the ewes given 12% flaxseed had the shortest gap between the onset of estrus and the regulated internal drug release removal, ranging from 30 to 40 hours. Among the other groups, the control group had the fewest follicles on the day of estrus. In addition, compared to the other groups, the ewes given 10% and 12% flaxseed had the greatest rates of ovulation, pregnancy, and lambing. In summary, the results showed that feeding 10% and 12% flaxseed to the ewes improved their ability to reproduce. In comparison to other oilseeds, **Swanepoel and Robinson (2019)** discovered that flaxseed has an extremely high content (55% of total fatty acids) of the omega-3 (n-3) PUFA α-linolenic acid. Longer chain n-3 FA, like EPA and DHA, acts as a precursor to ALA and has been shown to reduce $PGF2_{\alpha}$ synthesis and consequently increase the conception rates in dairy cattle (**Petit *et al.*, 2001**). This improvement in conception rates may be attributed to an increase in ovulatory follicle size and a decrease in pregnancy losses (**Ambrose *et al.*, 2006**), while longer chain n-3 FA, like ALA, acts as a predecessor to these compounds. By lowering early embryonic losses, compounds also increase pregnancy rates (**Petit and Twagiramungu, 2006).** But when given mechanically pressed feed, it is doubtful that many of the PUFA would escape the rumen intact owing to rumen hydrogenation. According to **Sirotkin (2023),** flaxseed, including its active molecules, is initiated beneficial for improving the reproductive efficiency of dairy cattle. The fertility of cows was not impacted by linseed supplementation, according to **Meignan *et al.* (2019).** In the control and linseed populations, the return-to-service rates were 48.4 and 49.2%, respectively, between 18 and 78 days following service. The duration from calving to conception was shortened by feeding linseed, from 110 to 107 days, by cutting the time from 91 to 90 days for the first insemination. Remarkably, cows fed the lowest linseed dosage (0–5 g) had a bigger influence on the period from calving to conception than cows at higher doses. Awassi ewes in the second and third treatments, which received dosages of flaxseed oil at rates of 6 and 8% per kg of feed, respectively, had fertility rates that were 66.66% higher than those of the cows that did not receive flaxseed oil in the feed (55.55%), according to **Noaman *et al.* (2022).** Pregnant Holstein cows fed additional oilseed pre-partum had longer gestations and heavier babies than cows fed no oilseed, and the birth weight of calves was noticeably higher in the oilseed-fed cows. In cows fed additional oilseed, the overall rate of reproductive abnormalities tended to be higher than in cows fed no oilseed (42 vs. 23%). Pre-partum oilseed supplementation (6.2 to 7.4% ether extract, % of dietary DM) reduced milk output during early lactation in multiparous cows and increased calf birth weight, with no appreciable benefit in ovarian function or reproductive efficiency (**Salehi *et al.*, 2016).** Cows on diets high in flaxseed oil had higher numbers of ovarian follicles (**Moallem *et al.*, 2013)**. Lower NEFA and beta-hydroxyl-butyrate concentrations and higher glucose levels were signs of favorable energy balance in cross-bred cows fed with 750 g of crushed flaxseed throughout the transition period. In the cows given flaxseed, uterine involution was well completed (100%) after 30 days postpartum, compared with 61.5% in the control groups. Higher plasma progesterone concentrations were the consequence of the flaxseed group's considerably larger corpus luteum and dominant ovarian follicle in comparison to the control group. Compared to control cows, cows fed diets supplemented with flaxseed showed signs of postpartum heat earlier and a reduction in the time until the entrance into the next reproductive cycle. Flaxseed supplementation promoted early cyclist resumption, uterine involution, and early breeding, leading researchers to conclude that flaxseed may be safely added to a transition diet to regulate reproductive processes (**Ulfina *et al.*, 2015**). **Jahani-Moghadam *et al.* (2015)** also observed a reduction in the postpartum period. The incidence of cystic follicles may be reduced by flaxseed; however, the overall rate of pregnancy did not increase. Moreover, a diet rich in flaxseed alpha-linolenic acid has been shown by **Ambrose *et al.* (2006)** to lower the frequency of pregnancy losses in cows. First service conception rate increased from 50 to 87.5% in the UK when nursing cows were fed formaldehyde-treated flaxseed at 17% of a ryegrass silage-based diet between 9 and 19 weeks postpartum (**Petit *et al.*, 2001**). The investigators noted that the cows on the flax diet had a better energy balance, which helped explain this reaction. The indigenous ewes of South Africa had a higher conception rate when fed flaxseed oil at the rate of 5%. Compared to both the normal diet (71%) and basal diet (79%), **Ngcobo *et al.* (2023**) found that the conception rate was greater in 5% flaxseed oil (94%), and 5% flaxseed oil with 4% ascorbic acid (100%). Feeding fats enriched in omega-3 fatty acids appears to improve pregnancy rates and reduce embryonic losses. Feeding lipids, particularly those rich in polyunsaturated fats (PUFAs), stimulates the ovaries after birth, encouraging the growth of ovarian follicles. The health, productivity, and reproductive responses of the milking dairy cow may all benefit from giving omega-6 and 3-PUFAs at different intervals (**Thatcher *et al.*, 2008**).

In male

It has been demonstrated that adding fatty acids, such as omega-3, to diets may enhance sperm motility, sperm membrane fluidity, and reproductive performance in bulls, rams, and buffalos **(Ahmad *et al.*, 2019);** moreover, it can lower the age at puberty in buffalos and increase their testosterone concentration (**Tran *et al.*, 2017**). Concerned about male fertility, **Abu-Heakal *et al.* (2016)** found that omega-3 fatty acids boost male rabbit fertility by enhancing sperm concentration, motility, grade activity, viability, and decreasing abnormalities. According to **Perumal *et al.* (2019**), flaxseed oil affected the testicular biometrics, endocrinological profiles, amount, quality, and freezability of semen produced by bulls. Cattle's testicular growth, spermatogenesis, sperm motility and viability, and post-thawed sperm quality were all enhanced by supplementing diets with fatty acids such as omega-3 (**Khan *et al.*, 2015).** According to **Souza *et al.* (2020),** adding flaxseed to sheep's diet enhanced the amount and quality of sperm, prolonged the quality of semen after the breeding season, promoted the growth of seminiferous tubules, and increased the quantity of Sertoli cells. Goats fed flaxseed had younger ages at puberty and had better sperm motility and concentration (**Mahla *et al.*, 2017**). According to **Ngcobo *et al.* (2021**), flaxseed oil can help farm animals produce more and better-quality semen by acting as an alternate supply of omega-3 and n-6 fatty acids. The relationships between DHA and testicular cells and spermatogenesis are two examples of these. The inclusion of 5% flaxseed oil improves the quality of semen produced by native South African rams, according to **Ngcobo *et al.* (2023**), who found that supplemented flaxseed oil (5%) plus ascorbic acid (4%) led to improved semen volume (1.05 ml), intact sperm membranes, total sperm motility (95.81%), and testosterone concentration (26.31 ng/ml). The enzymes known as antioxidants take the form of tiny molecular mass scavengers that can stop chain reactions driven by free radicals, superoxide anion, hydrogen peroxide (H_2O_2), and other potentially fatal reactive oxygen species (ROS) (**Anane and Creppy, 2001).** The glutathione peroxidase system, and catalase, is the enzyme antioxidant involved in the metabolism of H_2O_2. Superoxide dismutase, and sometimes indoleamine dioxygenase are participants in the superoxide anion process. Furthermore, several polyphenols, including vitamins C and E, are categorized as small molecular mass scavengers that help break chain events driven by free radicals (**Anane and Creppy, 2001**). Enzymes that can stop potentially fatal ROS, such as H_2O_2, superoxide anion, and tiny molecular mass scavengers that can end chain events driven by free radicals, are examples of antioxidants (**Anane and Creppy, 2001**). The glutathione peroxidase system or catalase is the enzyme antioxidants involved in the metabolism of H_2O_2. Superoxide dismutase and/or indoleamine dioxygenase are among those implicated in the superoxide anion. Furthermore, according to **Anane and Creppy (2001**), vitamins C and E, as well as a range of polyphenols, are categorized as small molecular mass scavengers that help stop chain reactions driven by free radicals. The role of several polyphenols, including vitamins C and E, is to shield ejaculated spermatozoa from the harmful effects of ROS (**Burnaugh *et al.*, 2007).**

e) Physical properties of sheep wool

The characteristics of sheep's wool were found to benefit from flaxseed oil. According to **Habeeb *et al.* (2021b),** flaxseed oil increased the amount of fleece produced overall as well as the wool's quality. The wool properties of sheep treated with flaxseed oil showed significant improvements, as reported by **Habeeb *et al.***

(2021b). These improvements included increases in raw fleece weight, clean fleece weight, clean fleece weight percentage, and length of wool fiber, which increased by 45.50, 59.70, 9.80, and 27.00%, respectively. Furthermore, the proportion of shrinkage had a notable decline, dropping from 46.79 to 35.31 (24.5%). The significant increases in these wool qualities in sheep fed flaxseed oil can be explained by the omega-3 fatty acids in the oil nourishing wool follicles and promoting the formation of healthy wool (**Sahoo and Soren, 2011**). Flaxseed oil also contains high levels of protein and selenium, two nutrients necessary for the growth of healthy wool (**Rogers and Schlink, 2010**). Moreover, the omega-3 fatty acids in flaxseed oil may reduce the inflammation caused by dandruff, hair loss, and other undesirable scalp disorders. The vitamin E content of flaxseed oil, according to **Liu and Masters (2014**), may provide wool follicles with more nutrition and moisturize the fibers. Flaxseeds are an excellent source of protein, calcium, zinc, magnesium, pyridoxine, copper, zinc, folic acid, and iron, all of which are required for the growth of wool, according to **Holman and Malau-Aduli (2012**). Flax seeds support healthy skin and hair since they are an excellent source of vitamin E. Additionally, it supports the development of the fetus's healthy skin and hair. The essential amino acids that restrict the development of wool are the ones that include sulfur. The properties of the fleece and the pace at which fiber is produced can both be significantly impacted by changes in the nutrients that are accessible to the follicles. Both the total quantity and quality of fleece generated per animal are increased by flaxseed oil (**Khan *et al.*, 2012**). Omega-3 fatty acids, which are abundant in flaxseeds, improve wool's elasticity and make wool more resilient and unlikely to break (**Edel *et al.*, 2015).** Folic acid did not affect the characteristics of wool, while flaxseed oil increased the overall amount of fleece produced as well as the wool's quality **(Habeeb *et al.*, 2021b).**

CONCLUSION

The nutritional composition of 100 g of flax plant seeds is as follows: 18% fat, 29% carbs, 42% protein, and 7% water. Flax seeds have a high content of dietary fiber, protein, and B vitamins. Flaxseed is an essential nutrient that has to be fed to agricultural animals. High quantities of amino acids—found mostly in flaxseed protein—in flaxseed increase its antioxidant properties by scavenging free radicals. The lignin extract from flaxseed increases HDL cholesterol while lowering blood levels of triacylglycerol, LDL cholesterol, glucose, and total cholesterol. Vitamins C, A, and E, lignin, polyphenols, dietary fiber, essential amino acids, and minerals are among the many bioactive components found in flaxseeds that promote the formation of wool. Up to half of the oil comprising 35% to 45% of flaxseed seeds is composed of omega-3 fatty acid, a healthy unsaturated fat that offers several advantages. The main reasons flaxseed oil has physiological benefits are because of its high levels of omega-3, lignin, and phytoestrogens. Based on the study's findings, adding flaxseed to cattle feedlot diets can boost their intake of omega-3 fatty acids and improve their overall performance.

Acknowledgments: This work was supported by Biological Application Department, Radioisotopes Applications Division, Nuclear Research Centre, Egyptian Atomic Energy Authority.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The researcher concurred that no financing was given to complete this publication.

Conflicts of Interest: The author declares that there is no conflict of interest. The author indicated that they had no actual or prospective conflicts of interest. There are no conflicts regarding the publication of this manuscript.

Disclosures and declarations: My study-specific requirements are approval by the appropriate ethics committee of the Egyptian Atomic Energy Authority for research involving animals and a statement on the welfare of animals. My work submitted for publication does not have any implications for public health or general welfare.

Permission to publish: The author's work was approved for publication after it was submitted. Before submitting the manuscript, the Egyptian Atomic Energy Authority was consulted, and all authors expressly consented to doing so.

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