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Review Article

Utilizing of Flaxseed on Rumen Digestion, Some Physiological Traits, and Milk Yield

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ABSTRACT

Flaxseeds are one of the potential oil seeds packed with excellent amount of nutrition and possess various health benefits. Interestingly, flax seeds' health benefits are mainly attributed to the omega-3 fatty acids, lignans and fiber they contain. It is used in different forms, such as whole and flour.This review provides an overview of the impact of flaxseed (Linum usitatissimum) on various aspects of health, including its effects on fermentation, volatile fatty acids, digestibility, milk yield, physiological action, ovarian and reproductive state, folliculogenesis, in vitro fertilization (IVF) performance, reproductive hormones, embryo production, and plasma and glucose levels in dairy cows. The impacts could be evaluated by flaxseed lignin, alpha-linoleic acid, and their derivatives. Flaxseed is abundant in α-linoleic acid (ALA) and can potentially enhance omega-3 polyunsaturated fatty acid in the milk of dairy cows. Nevertheless, the impact of various forms of flaxseed supplementation on rumen fermentation remains uncertain. Various intracellular signaling pathways, binding proteins, receptors, metabolic and reproductive hormones, and their overall behavior might be affected by alterations. Flaxseed oil did not affect the pH and NH3-N levels in the rumen. Additionally, consuming flaxseed may offer health advantages for humans. Their actions can be mediated by a variety of intracellular signaling pathways, including protein kinases, transcription factors that control cell proliferation, apoptosis, angiogenesis, and malignant transformation; alterations in general metabolism; reproductive and metabolic hormones; and receptors. The purpose of this study is to provide a general overview of the nutritional profile, health benefits, value-added products, and toxicity of flaxseeds.

1. Introduction

The global average cultivated area of flaxseed from 2016 to 2020 was approximately 3.39 million hectares[1]. Flaxseed meal (FSM) is a residual substance obtained while extracting flaxseed oil. Flaxseed oil, primarily derived through squeezing and pulling from flaxseed, is a significant source of additional n-3 polyunsaturated fatty acids[2]. The energy content of this substance is around 13.3 mega joules per kilogram of material that is dry, which is comparable to the density of wheat grain. This material has 32%–37% protein, like sunflower and rapeseed meals[3]. It also has an even distribution of essential amino acids and few rumen-degradable proteins[4]. Adding flaxseed to ruminant diets increases fat and may impair fiber digestion[5]. Nevertheless, the inclusion of fats in the diet increases the density of energy and minimizes energy losses during fermentation by decreasing the number of methane-producing microbes[6]. Consequently, this may have a beneficial effect on the magnitude of microbial production of proteins[7]. Omega-3-rich diets improved reproduction in rats[8]. The researchers attributed this improvement to female animals' higher energy and steroid hormone levels, specifically progesterone and estrogen. These hormones are necessary for fetal development and gestation. By inhibiting the production of prostaglandins from the uterine wall, this intervention effectively lowers the fetal mortality rate and enhances the amount of

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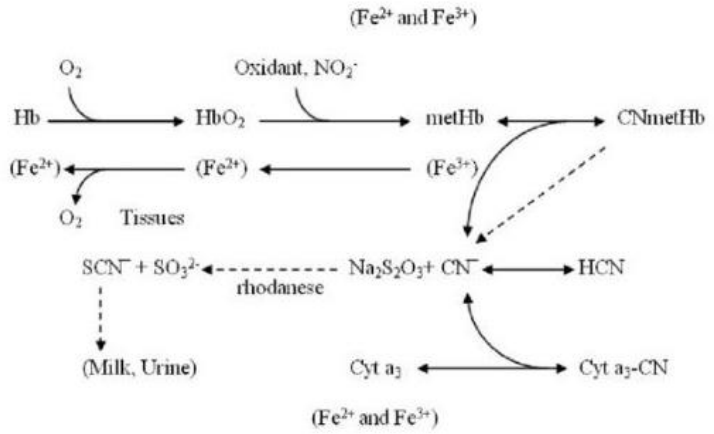

Figure 1. Neutralizations of hydrogen cyanide in animal, − Displacement of CN^- from Cyt a 3 ,-Conversion of CN-to SCN-, Hb = Hemoglobin, metHb = Methemoglobin, CNmetHb = Cyanomethemoglobin, HCN = Hydrogen cyanide, CN-= Cyanide ion, SCN = Thiocyanate, Cyt a 3 = Cytochome a 3 .

estrogen and progesterone, which are necessary for supporting gestation and facilitating initial fetal development[9]. The aim of this review is to provide a general overview of the nutritional profile, health benefits, value-added products, and toxicity of flaxseeds.

2. Effect of flaxseed on fermentation

Fermentation may minimize hydrogen cyanide (HCN) in animal feed while retaining nutritional value, optimizing fermentation efficiency requires organism selection. *Aspergillus oryzae*, *Candida utilis*, *Lactobacillus*, and *Bacillus subtilis* are common fermentation microorganisms[10]. *Aspergillus Niger* may improve cassava leaf dry matter and organic matter digestibility[11]. This approach also reduces hydrogen cyanide levels. Fermenting animal feed improves performance and intestinal health, according to[12]. Their study implies this method might enhance calories, calcium, and dry matter availability. Flaxseed oil %2 did not affect rumen pH or NH3-N concentration[13].

3. Effect of flaxseed on volatile fatty acid (VFA)

Total volatile fatty acids come from ruminant fermentative microorganisms. They are the major energy source, according to[14]. Ruminant stomach bacteria produced volatile fatty acids[15]. Flaxseed quantities had the same effect on intestinal microbial composition and volatile fatty acid percentage[16]. Rumen fermentation creates volatile fatty acids, important metabolites that may supply up to 70% of the easy digestible energy, adding flaxseed to dairy cows' diets may boost ω-3 polyunsaturated fatty acid synthesis in raw milk[16]. Short-chain volatile fatty acids (VFA) from intestinal carbohydrate digestion lower colon pH and fuel intestinal cells[17].

4. Effect of flaxseed on digestibility

Flaxseed can provide a supplementary fat and protein source for dairy cows[18]. Lipids can decrease the digestibility of fiber, although the extent of this effect varies depending on the specific kind and characteristics of the lipid[19]. The decrease in dry matter intake (DMI) is linked to alterations in ruminal fermentation, gastrointestinal motility, palatability, secretion of gut hormones, and hepatic fat oxidation[20]. Adding flaxseed to the diet at 12.6% of dry matter enhanced digestibility across the entire digestive system, without any negative impact on rumen function[21]. The only positive benefit of feeding Karadi male lamb's diets with varying amounts of flaxseed (3, 6, and 9% by weight) is an increase in the digestibility of ether extract[22].

5. Effect of flaxseed on milk yield

(a) Milk: as a source of protein and energy, flaxseed (*Linum usitatissimum*) provides an appealing concentrate that may be added to the diets of breastfeeding dairy cows[18,23]. Alterations in microbial activity and PUFA bio hydrogenation, which resulted in the buildup of trans-10 C18:1, were linked to a drop in milk fat content after adding flaxseed oil[24]. The latter reduces milk fat by inhibiting the udder's epithelial cells' short- and medium-chain F.A. production[25]. In addition, oilseeds have a high concentration of long-chain unsaturated fatty acids (F.A.), which can reduce the fat content of milk by impairing the digestion of fiber and consequently decreasing the concentration of ruminal acetate[18].

(b) Fatty Acid Profile: flaxseed is added to the diet of dairy cows[26, 27]. Dairy cows whose diets include this oilseed may have higher amounts of omega-3 fatty acids, less fat in their milk, and more milk output[27].

(c) Milk composition: in a study conducted by Do Prado et al.[28], it was discovered that incorporating flaxseed or linoleic into the diet at a rate of 4.8% of the dry matter had beneficial impacts on both dry matter intake (DMI) and energy balance in dairy cows. Nevertheless, dairy cows who received treatment with Megalc at a dosage of 1.1% of the dry matter had an increased milk production. The claim opposes the findings of Petit[29] study, which found no changes in milk output while cows consumed whole

flaxseed as 13.9% of their dry matter intake. Nevertheless, cows which were given a diet containing 10.7% extrusion flaxseed showed a higher milk output in comparison to the control group[30]. The increase in α-linoleic acid seen in the milk of ewes that were given diets containing flaxseed is in line with previous studies that used whole or ground flaxseed[31], extruded flaxseed[27], and crushed flaxseed[32]. The increased impacts could be attributable for the immediate ingestion of these fatty acids from the meal into the gland that produces milk. Ejection may modify the amino acid framework around the fat droplets, which helps protect the fatty acids from ruminal biological the process of hydrogenation[27].

6. Effect of flaxseed on ovarian and reproductive state

Misoprostol increases uterine contractions after delivery, promotes first ovarian follicle and corpus luteum development, and shortens sexual cycles[33]. Flaxseed reduces cystic follicles but does not affect pregnancy rates, alpha-linoleic acid in flaxseed reduced in cattle[34]. These experiments show that flaxseed boosts female cow fertility. The studies undertaken by Petit et al.[35], and Hutchinson et al.[36] yielded no evidence suggesting that flaxseed had any impact on the maturation of ovarian follicles in cattle. Only two papers were recorded on the impact of flaxseed on female reproductive organs, excluding the ovaries. The histological alterations in the uteri of rats administered with flaxseed when combined with low dose estrogen[37]. These alterations display similarities with the impacts on the hormone estrogen, indicating an enhancement of uterine stimulation and development.

7. Effect of flaxseed on folliculogenesis and IVF performance

Animals are incapable of synthesising n-3 fatty acids de novo, thus they must acquire them through their diet[38]. Elongation and desaturation processes can convert short-chain n-3 fatty acids into long chain n-3 fatty acids[39]. Administering microencapsulated flaxseed, a dietary supplement rich in alfa linolenic acid (ALA), resulted in an increase in the quantity of small follicles and follicles collected through Ovum Pick-Up (OPU)[40]. However, multiple studies have shown that in ruminants, F.O. decreases the amount of food consumed[41- 43]. Therefore, in the context of ruminant nutrition, plant-based n-3 sources, specifically ALA obtained from flaxseed, may offer greater benefits compared to animal sources.

8. Effect of flaxseed on reproductive hormones

Investigations have shown that flaxseed affects the production, breakdown of steroid hormones in ovary the cells, as demonstrated in both *in vivo* and *in vitro* experiments[44]. An elevation in progesterone low levels in the blood plasma of cows when they were given flaxseed[33,45]. Conversely, cows fed with flaxseed (rich in 18:3 n-3 fatty acid; Flax) in their diets had reduced estrogen concentrations[36]. Nevertheless, a research done by Zachut et al.[46] revealed that the ingestion of flaxseed at 3.8% of dietary DM increases the estrogen levels in ovarian follicles. Thorough research on the regulatory impacts of steroid hormones, gonadotropins, insulin, anti Mullerian hormone, oxytocin, prostaglandins, and leptin on procedures related to female reproduction[47].

9. Effect of flaxseed on embryo production

Lipids carry saturated fats and are essential for various physiological activities, including reproductive function[48]. The cholesterol benefits may be linked to the ovarian stage after delivery, egg-producing follicle growth, or higher progesterone levels during the luteal phase[34]. Unsaturated fatty acids have a vital function in the production of prostaglandins[49]. High progesterone levels are believed to improve oocyte and embryo integrity and development in the womb[50], which improves pregnancy outcomes. A previous research conducted by Correddu et al.[51] has shown that flaxseed has significant quantities of α-linolenic acid, comprising 45-65% of its total fatty acid content.

10. Effect of flaxseed on plasma and glucose

Plasma urea levels are affected by farm animal diets and indicate protein intake or utilization[52]. The reduction in blood urea levels in female sheep treated with ground flaxseed, as opposed to those given whole flaxseeds or no flaxseed, can be attributed to the efficacy of oil seeds in regulating the population of ruminal protozoans and enhancing their capacity of protein from food the absorption[53]. According to Johnson et al.[54], adding oil seeds to cow meals increased blood urea levels owing to better digestive tract uptake.

Adding extruded flaxseed and a 40% rumen ungradable protein to the diets of sheep resulted in increased glucose levels in their bloodstream before and while giving birth. The quick rise may be attributed to improved nutritional elimination, ruminal fermentation, and propionate generation, as shown by Morsy et al.[24] and Kholif et al.[55]. Furthermore, there seems to be a correlation between blood glucose levels and fluctuations in DMI (dry matter intake), and the influence of compressed flaxseed as a source of polyunsaturated fatty acids on glucose metabolism is particularly noteworthy. Furthermore, higher rumen ungradable protein (RUP) resulted in elevated blood sugar levels. The anomaly occurred as a result of glucose generation, a process of metabolism in which extra amino acids were converted into glucose rather than used for protein synthesis in the mammary glands. Therefore, the increase in blood sugar levels resulting from a 40% increase in RUP levels in treatments including extrusion flaxseed may be attributed to this event.

11. Conclusion

The physiologically active compounds included in flaxseed exert their effects via a variety of signal transduction pathways. Consequently, flaxseed has many physiological, preventive, and medicinal uses. Flaxseed and its components have been shown in previous research to have positive effects on the reproductive system of females. The effects include the regulation of ovarian cell growth and programmed cell death, the influence on puberty and reproductive cycles, the development of eggs and embryos, as well as the modulation of hormonal regulators associated with reproductive processes and disorders.. Dairy cows' rumen fermentation, fatty acid content, and microbiome may be affected by adding extruded flaxseeds to their diet. When several types of flaxseed were supplemented, the rumen's microbiome and molar ratio of volatile fatty acids (VFA) always followed a predictable pattern. Enhanced nitrogen absorption in the rumen and decreased plasma urea levels also affect flaxseed. Some key facts about flaxseed's impact on reproductive and other functions in females need additional clarification. The effects of flaxseed on several female reproductive systems have been the subject of contradictory research in various animal models. Animal studies and in vitro studies using malfunctioning models (such as cancer or polycystic ovarian disease) make up the bulk of the literature on flaxseed's health benefits. Therefore the use of flaxseed in whole seed or ground form can be recommended as a dietary supplement.

Declarations

Competing interest

The authors declare that there are no competing interests.

Authors' contribution

This review was prepared done by team members with specific contributions of each author. Zhina Abbas Mohammed prepared the proposal and collected some subjects about revision. Sarood Samal Shawkat wrote the review. Both Zhina Mohammed and Sarood Shawkat All authors have read and approved the final manuscript.

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Availability of data and materials

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Ethical considerations

This study was conducted in accordance with the ethical standards of the relevant national and institutional guidelines for research and publication. All procedures performed were in compliance with ethical principles, and the authors confirm that they have followed the guidelines for ethical publication as outlined by the journal.

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