

Perspectives on the Influence of Sunflower, Rapeseed, and Linseed Cakes on the Fatty Acid Profile of Cow's Milk

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Abstract

This article is a systematic review that explores the influence of different types of oilseed cakes used in cow feed on the fatty acid profile of milk, with a focus on the Omega-6/Omega-3 ratio. Sunflower, rapeseed, and linseed cakes are analyzed from the perspective of their lipid composition and their effects on milk quality. Studies show that linseed cakes significantly increase the Omega-3 content in milk, achieving a balanced Omega-6 to Omega-3 ratio, which is favorable for cardiovascular health and inflammation reduction. Conversely, rapeseed cakes provide a balanced fatty acid profile, with high oleic acid content. Sunflower cakes result in a high Omega-6 to Omega-3 ratio, which may promote inflammatory processes if not supplemented with Omega-3-rich sources. Predominantly using linseed cakes or combining them with rapeseed cakes can significantly improve the fatty acid profile of milk. Although sunflower cakes provide a high Omega-6 content, adjustments through supplementation with Omega-3 sources are necessary to ensure an adequate lipid profile. These findings are relevant for optimizing cow feed strategies to obtain a nutritionally superior milk product, characterized by an improved fatty acid composition that can benefit both human health and dairy industry standards. Tailoring feed strategies with appropriate oilseed cake combinations offers opportunities to produce higher-quality dairy products with superior lipid profiles, addressing consumer demand for healthier options.

Keywords: fatty acids of milk, linseed cakes, Omega-3, Omega-6, rapeseed cakes, sunflower cakes

1. Introduction

Since the early stages of livestock domestication, milk and its derived products have been an indispensable part of the human diet due to their supply of essential nutrients in a balanced ratio suitable for the body [1]. In this context, milk serves as a valuable source of fundamental nutrients, including fatty acids that play an important role in maintaining human health [2-4]. In the human diet, essential fatty acids provide numerous benefits to the body, contributing to overall well-being and proper physiological function [5]. Fatty acids are key components of cell

membranes, actively participating in various metabolic processes, providing energy, and serving as precursors for different bioactive substances [6]. The way these fatty acids are present in milk directly influences its nutritional quality and potential health benefits [7].

The types of fatty acids found in milk are largely influenced by several factors, with the cows' diet playing the most important role [8]. What cows eat directly impacts the balance of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA), including essential fats like Omega-3 and Omega-6 [9]. Modifying the type of feed supplement can be an effective method for altering the structure of fatty

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acids in milk [4, 10, 11]. Sunflower, rapeseed, and linseed cakes are commonly used as feed supplements, each with a specific fatty acid profile that influences the composition of the produced milk [12].

2. Materials and methods

This paper is a systematic review based on the analysis of relevant scientific literature. For this study, relevant scientific articles available in reputable databases such as MDPI, Sci-Hub, Google Scholar, and PubMed were analyzed.

The research focused on studies investigating the fatty acid profile of milk obtained from cows fed with sunflower cakes, rapeseed cakes, and flaxseed cakes. The selection criteria for articles included peer-reviewed publications from reputable journals, studies that directly measured the fatty acid content of milk from cows fed with the mentioned feed types, and those providing quantitative data on Omega-3, Omega-6, saturated, and mono-unsaturated fatty acids.

The collected data were extracted, compared, and synthesized to highlight similarities, differences, and trends in fatty acid composition.

3. Results and discussion

Sunflower cakes are known for their large amount of Omega-6 fatty acids, especially linoleic acid (LA), is commonly present. This fatty acid is essential for normal and healthy development; however, an excessive Omega-6 to Omega-3 ratio may promote inflammation [13]. Incorporating sunflower cakes into cow diets often results in milk with a high Omega-6 to Omega-3 ratio, which may be less beneficial for human health [4, 14].

On the other hand, rapeseed cakes are well-known for their rich content of monounsaturated fatty acids, particularly oleic acid [15]. Oleic acid provides significant cardiovascular benefits by lowering unhealthy LDL cholesterol and boosting healthy HDL cholesterol. Adding rapeseed cakes to cow diets can improve the nutritional profile of milk, especially by increasing the content of beneficial fats [10, 15- 17].

Linseed cakes are particularly notable for their high concentration of Omega-3 fatty acids, particularly alpha-linolenic acid (ALA), which acts as a

building block for longer-chain Omega-3 fatty acids like EPA and DHA, renowned for their beneficial impact on heart health, cognitive function, and inflammation reduction. Milk obtained from cows fed with linseed cakes generally contains higher Omega-3 levels, making it more suitable for a balanced and healthy diet [18-20].

Analyzing the Omega-6 to Omega-3 ratio is essential to understand how different feed types influence the nutritional value of milk. Research suggests that an optimal Omega-6 to Omega-3 ratio should be around 4:1 or lower. Exceeding this ratio has been associated with inflammatory processes that may increase the likelihood of developing chronic conditions such as cardiovascular diseases, arthritis, and diabetes [4, 11].

Previous studies have shown that milk from cows fed with different oilseed cakes presents varying Omega-6 to Omega-3 ratios. Sunflower cakes typically result in milk with a high Omega-6 to Omega-3 ratio, generally ranging between 12:1 and 15:1. This imbalance is due to the high linoleic acid content of sunflower cakes [4, 14, 20- 23].

Milk obtained from cows fed with rapeseed cakes exhibits a more balanced fatty acid profile, with Omega-6 to Omega-3 ratios ranging between 5:1 and 8:1 [4, 24, 25]. This moderate ratio is attributed to the high oleic acid content, a monounsaturated fatty acid with beneficial effects on cardiovascular health. Studies indicate that oleic acid it can lower LDL ("bad") cholesterol and raise HDL ("good") cholesterol, which helps decrease the risk of atherosclerosis and other heart-related conditions. Additionally, due to the lower amounts of polyunsaturated fatty acids in rapeseed cakes, the Omega-6 to Omega-3 ratio remains closer to recommended limits [10, 14, 25].

The most favorable ratios are observed in milk obtained from cows fed with linseed cakes, with Omega-6 to Omega-3 ratios ranging between 1:1 and 3:1. Milk produced under these conditions is highly beneficial for human health, providing protection against inflammation and supporting essential bodily functions [18-20, 26].

The observations from Table 1 suggest that the use of linseed cake as feed represents the best option for achieving an optimal Omega-6 to Omega-3 ratio in milk. However, rapeseed cakes provide a reasonable compromise, with a relatively balanced fatty acid profile and notable cardiovascular benefits [17, 27-29].

Table 1. Influence of oilseed cakes on the fatty acid profile of cow's milk

Type of Oilseed Cake	Fatty Acid Profile of Milk	Nutritional Benefits and Risks	Sources
Sunflower Cakes	High Omega-6 content, particularly linoleic acid. Omega-6/Omega-3 ratio: 12:1 - 15:1	May contribute to inflammatory processes due to excess Omega-6. Requires supplementation with Omega-3 sources for optimal balance.	4, 11
Rapeseed Cakes	Balanced profile, with an Omega-6/Omega-3 ratio between 5:1 and 8:1	Provides a balanced ratio of fatty acids and supports improving heart health by lowering LDL cholesterol and boosting HDL cholesterol.	10, 25
Linseed Cakes	High Omega-3 content, particularly alpha-linolenic acid (ALA). Omega-6/Omega-3 ratio: 1:1 - 3:1	The best balance between Omega-6 and Omega-3. Promotes heart health, enhances cognitive function, and helps reduce inflammation.	18, 19, 20

On the other hand, sunflower cakes require supplementation with Omega-3-rich sources to compensate for the imbalance caused by excess Omega-6. Choosing the appropriate feed can greatly influence the nutritional quality of milk and the benefits it offers to consumers [4, 10, 11]. The differences between the fatty acid profiles of sunflower, rapeseed, and linseed cakes are particularly relevant when analyzing their impact on health [18-20, 25, 30]. The fatty acid composition of milk varies considerably depending on the type of feed used and factors such as cow breed, lactation stage, and season which can influence the benefits or risks associated with its consumption [31].

The table below summarizes the results obtained from various studies, focusing on Omega-3, Omega-6, saturated fatty acids, and monounsaturated fatty acids. Understanding these values is crucial for recommending the most suitable feeds based on desired nutritional objectives.

According to the data presented in Table 2, there are significant differences in the fatty acid composition of milk produced by cows fed with different types of cakes: linseed, sunflower, and rapeseed. These differences directly influence the nutritional value of the milk and can offer varying health benefits to consumers.

Table 2. Fatty acid composition of milk depending on the type of cake

Parameter	Rapeseed Cakes	Sunflower Cakes	Flaxseed Cakes	Sources
Total Milk Fat	3.96% - 4.13%	4.01%	4.13%	11, 25
Saturated Fatty Acids (SFA ¹)	60%	55%	45%	2, 4, 32
Monounsaturated Fatty Acids (MUFA ²)	38.9% Oleic Acid (C18:1)	26.21% Oleic Acid (C18:1)	18.9% Oleic Acid (C18:1)	33
Polyunsaturated Fatty Acids (PUFA ³)	5.0%	6.5%	4.77% - 5.09%	19, 33, 34
Linoleic Acid (C18:2, PUFA ³)	10.3%	15.7%	12.6%	19, 20, 35
Alpha-Linolenic Acid (C18:3, PUFA ³)	1.3%	0.3%	4.5%	10, 20, 36
Conjugated Linoleic Acid (CLA ⁴)	0.905% - 0.801%	0.905%	0.801%	19, 34
PUFA ³ /SFA ⁵ Ratio	0.94	0.65	0.05% - 0.06%	37
n-6/n-3 Ratio	4.5	0.15	0.117% -0.208%	11
Omega-3 (Alpha-Linolenic Acid, ALA ⁶)	0.5%	0.2%	2.0%	2, 19, 20, 32, 36
Omega-6 (Linoleic Acid, LA ⁷)	1.5%	3.0%	1.0%	2, 19, 20, 32, 36

¹Saturated Fatty Acids; ²Monounsaturated Fatty Acids; ³Polyunsaturated Fatty Acids; ⁴Conjugated Linoleic Acid; ⁵Saturated Fatty Acids; ⁶Alpha-Linolenic Acid; ⁷Linoleic Acid

Milk produced from cows fed with linseed cakes is particularly distinguished by its high content of Omega-3, especially alpha-linolenic acid (ALA). According to the results presented, milk produced from this type of cake contains approximately 4.5%

ALA, a considerably higher value compared to the milk obtained from the other cakes [10, 20]. This characteristic makes linseed cakes an excellent source for producing milk enriched with Omega-3, known for its benefits related to cardiovascular

health, cognitive functions, and anti-inflammatory properties [2, 32]. Moreover, the n-6/n-3 ratio of milk produced from linseed cakes (0.117 - 0.208) is favorable, suggesting a balanced profile of fatty acids [11].

In contrast, sunflower cakes are characterized by their high Omega-6 content, particularly linoleic acid (LA), with a value of 15.7% [19, 20, 35]. This proportion is significantly higher compared to the milk obtained from the other types of cakes. However, a high content of Omega-6 can unbalance the ratio between Omega-3 and Omega-6, potentially promoting inflammatory processes if not properly balanced by supplementation with Omega-3-rich sources [2, 21-32]. Additionally, the n-6/n-3 ratio in milk produced from sunflower cakes is approximately 0.15, indicating a potential imbalance if not combined with an adequate Omega-3 source [12].

Regarding rapeseed cakes, these are distinguished by their high content of monounsaturated fatty acids (MUFA), particularly oleic acid (C18:1), with a value of 38.9% [33]. Monounsaturated fatty acids are recognized for their beneficial effects on cardiovascular health, including reducing LDL cholesterol and increasing HDL cholesterol levels. Therefore, using rapeseed cakes contributes to obtaining a healthier lipid profile in milk for consumers [2, 4, 32]. Additionally, the PUFA/SFA ratio for milk derived from rapeseed cakes (0.94) suggests a balanced and nutritionally adequate profile [37, 38].

The comparison between the different types of cakes highlights that linseed cakes are the most effective for increasing Omega-3 (ALA) content in milk, an essential fatty acid associated with multiple health benefits. Also, sunflower cakes provide a major source of Omega-6 (LA), but their use should be balanced by adding sources rich in Omega-3 to prevent an imbalanced n-6/n-3 ratio. Meanwhile, rapeseed cakes contribute to producing milk with a high content of monounsaturated fatty acids, particularly oleic acid, offering a lipid profile that promotes cardiovascular health [37, 39-41].

Regarding CLA (Conjugated Linoleic Acid), all types of cakes analyzed present similar values, ranging between 0.801% and 0.905%. Although these values are suitable for promoting a healthy lipid profile, the differences are not statistically significant. Additionally, CLA values can also be influenced by the methods used to process the feed, not only by its raw composition [19, 20, 34].

Furthermore, using a combined strategy that includes both linseed and rapeseed cakes could prove particularly effective. This approach could help enhance the Omega-3 (ALA) content, maintain an adequate MUFA profile, and create a favorable PUFA/SFA ratio. This strategy could better meet the needs of consumers seeking dairy products with improved lipid profiles.

4. Conclusions

The comparative analysis of milk obtained from cows fed with sunflower, rapeseed, and linseed cakes reveals significant differences in their fatty acid profiles, particularly in the ratios of Omega-3 and Omega-6. These differences directly impact the nutritional value of milk and its associated health benefits.

Linseed cakes are the most effective in enhancing Omega-3 content, particularly alpha-linolenic acid (ALA). This makes them a highly suitable option for producing milk enriched with Omega-3, which is essential for cardiovascular health, cognitive functions, and anti-inflammatory responses.

Additionally, the favorable n-6/n-3 ratio (ranging from 0.117 to 0.208) indicates a well-balanced fatty acid profile that aligns well with contemporary dietary recommendations. Such a profile is particularly advantageous for consumers seeking to increase their Omega-3 intake and improve their overall health.

Rapeseed cakes offer a balanced fatty acid profile, characterized by a high content of monounsaturated fatty acids (MUFA), especially oleic acid (C18:1). This composition supports cardiovascular health by reducing LDL cholesterol levels and enhancing HDL cholesterol. Furthermore, the moderate PUFA/SFA ratio (0.94) suggests that rapeseed cakes provide a lipid profile suitable for promoting healthy cholesterol levels without compromising other essential fatty acids.

By contrast, sunflower cakes provide a substantial amount of Omega-6 fatty acids, particularly linoleic acid (LA), resulting in a much higher n-6/n-3 ratio (up to 0.15). While Omega-6 is essential for proper physiological functions, an excess compared to Omega-3 can promote inflammatory processes.

Therefore, sunflower cakes should be used carefully, ideally in combination with feeds rich in

Omega-3, such as linseed cakes, to restore a balanced fatty acid profile.

An important observation is that no single type of cake provides a perfectly balanced fatty acid profile on its own. However, combining linseed cakes and rapeseed cakes could be a highly effective strategy. This approach would enhance the Omega-3 content while maintaining an adequate MUFA profile, ultimately resulting in a nutritionally superior milk product.

Considering the various findings, the use of linseed cakes should be prioritized for increasing Omega-3 levels, while rapeseed cakes are valuable for promoting beneficial monounsaturated fats.

Sunflower cakes, though providing important Omega-6 fatty acids, should be carefully balanced with Omega-3-rich feeds to achieve optimal ratios. Future research could explore optimal feeding strategies that combine these cakes to achieve the best possible fatty acid profiles. Such approaches could enhance the health benefits of dairy products, aligning them with consumer demands for higher-quality, nutritionally enriched milk.

Future perspectives

The results of this systematic review emphasize the importance of continuing research aimed at improving the nutritional quality of cow's milk through dietary strategies.

One promising direction would be to conduct local experimental studies to validate and extend the findings presented in the current literature.

It would also be valuable to investigate different combinations of sunflower, rapeseed, and linseed cakes in cow diets, with the goal of optimizing the balance of saturated and unsaturated fatty acids, especially the Omega-6/Omega-3 ratio.

Furthermore, long-term studies are needed to assess how these dietary interventions may affect the quality, shelf life, and nutritional profile of processed dairy products.

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