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Review

Dietary lipid sources for growing rabbits: A review on animal health and productivity

Fontes lipídicas na dieta de coelhos em crescimento: uma revisão sobre a saúde e a produtividade animal

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Abstract
Studies that explore the use of lipids and their effects on animal nutrition have become increasingly abundant, producing a mass of information. The review was carried out on a parity basis through a survey of articles in the bibliographic databases: *Web of Science* and *Periodicals Capes*, using search terms associated or not, in the plural or singular, in English and Portuguese, such as: “lipids” AND “rabbits" AND "nutrition". After analyzing the files in the two scientific databases, certain files were excluded because they did not fit the theme or because they did not meet the inclusion criteria and repeated articles. A relevance test was carried out for the use of the articles, where they should deal with the subject: articles that report the use of lipids in the nutrition of non-ruminant animals; articles made available in complete form; articles that had at least one of the keywords; articles where the main subject is related to lipids. The articles were selected and tabulated in an Excel® spreadsheet with relevant information for exploration in the review. The use of oils and fats is a favorable point in the nutrition of non-ruminant animals, presenting benefits in the enrichment of final products such as: providing higher levels of omega-3 and omega-6, and thus obtaining meat products with lower levels of saturated fat and higher unsaturated fat contents promoting benefits to human health through its consumption, reduction of food costs, improvement in palatability and appearance of foods. These are nutritional strategies used in hot seasons of the year due to the low calorific increment produced.
Keywords: alternative sources; enrichment; nutrition; production

Resumo
Estudos que exploram o uso de lipídios e seus efeitos na nutrição animal têm se tornado cada vez mais abundantes, produzindo uma grande quantidade de informações. A revisão foi realizada de forma paritária por meio de uma pesquisa de artigos nas bases bibliográficas: Web of Science e Periódicos Capes, utilizando termos de busca associados ou não, no plural ou no singular, em inglês e português, tais como: "lipídios" E "coelhos" E "nutrição". Após analisar os arquivos nas duas bases científicas, determinados arquivos foram excluídos porque não se adequavam ao tema ou não atendiam aos critérios de inclusão, além de artigos repetidos. Um teste de relevância foi realizado para a seleção dos artigos, nos quais eles deveriam tratar do assunto: artigos que relatam o uso de lipídios na nutrição de animais não-ruminantes; artigos disponibilizados na forma completa; artigos que possuíam pelo menos uma das palavras-chave; artigos nos quais o assunto principal está relacionado a lipídios. Os artigos foram selecionados e tabulados em uma planilha do Excel® com informações relevantes para exploração na revisão. O uso de óleos e gorduras é um ponto favorável na nutrição de animais não-ruminantes, apresentando benefícios no enriquecimento de produtos finais, tais como: fornecer níveis mais altos de ômega-3 e ômega-6, e assim obter produtos de carne com menores teores de gordura saturada e maiores teores de gordura insaturada, promovendo benefícios para a saúde humana por meio do consumo, redução dos custos alimentares, melhoria na palatabilidade e aparência dos alimentos. Essas são estratégias nutricionais usadas nas estações quentes do ano devido ao baixo incremento calórico produzido.
Palavras-chave: fontes alternativas; enriquecimento; nutrição; produção

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1. Introduction

Rabbit breeding is a growing branch within livestock due to the ease of handling and rearing in addition to the quality protein profile of this species. As reported by Falcone et al.[1], one of the great challenges we will face in the future will be to feed a population of around nine billion people, warranting a greater production of alternative foods. In this sense, rabbit farming is an activity that stands out in the food sector.

Protein is an essential food in the human diet. In this respect, rabbit meat can be a good option due to its low fat and high protein contents and high levels of omega-3 fatty acids, B vitamins, and minerals such as potassium, iron, phosphorus, and calcium[2]. Alternatives in the field of livestock nutrition have been sought to enrich the products and enhance the animals' diet[3].

According to Vossen et al.[4], an alternative to induce the consumption of high-fatty-acid foods by the population is to include them in popular foods. Several lipid sources such as linseed oil and fish, which contain fatty acids, mainly omega-3, can be added to the animals' diets and be incorporated into their carcasses. This strategy is already used in the case of ruminant animals[5,2]. Souza et al.[6] highlighted that Brazil is a privileged country for its production of legumes such as soy, sunflower, cotton, castor bean, canola, and palm oil, which enable the extraction of oil for the production of meals and cakes that are used in animal feed.

In addition to reducing costs, the use of lipids in feed enhances the aggregation of feed particles, consequently decreasing its powderiness; improves palatability; as well as enriches the final product. In this regard, alternative lipid sources with these characteristics have been researched in efforts to improve animal performance and increase appreciation by the consumer[7,8].

Lipids play a crucial role in the quality of rabbit meat and overall nutrition. They contribute to the flavor, juiciness, and texture of meat products, while also aiding in the absorption of fat-soluble vitamins. Additionally, lipids serve as sources of essential fatty acids, such as omega-3 and omega-6, which play important roles in human health, including cardiovascular function, nervous system health, and inflammatory response. Thus, the inclusion of appropriate lipids in the diet of rabbits and, in general nutrition, is essential to ensure nutritional and sensory quality of food and promote a healthy and balanced diet. Therefore, the objective of this systematic review is to describe the use of lipid sources and their relationship with the performance of growing rabbits.

2. Material and methods

The peer-reviewed study was conducted from a survey of articles in the *Web of Science* and *Periódicos Capes* bibliographic databases using associated or unassociated search terms, in the plural or singular, in English and Portuguese, such as: “lipids” AND “rabbits" AND "nutrition". After analyzing the files in the two scientific databases, some were excluded because they did not fit the theme or did not meet the inclusion criteria, or were repeated articles.

The following criteria were adopted:

a) Articles that report the use of lipids in the nutrition of non-ruminant animals;

b) Articles available in full;

c) Articles including at least one of the keywords (lipids, rabbits, nutrition); and

d) Articles whose main topic is related to lipids.

Accordingly, 47 files were selected—26 from *Web of Science* and 21 from *Periódicos Capes*, out of a total of 150 articles found. The selected articles were tabulated in an Excel® spreadsheet with the relevant information, for exploration in the review, as shown in Table 1.

3. Review

3.1 Lipids in animal nutrition

Lipids can be defined chemically as a heterogenous group among themselves, whose common characteristic is insolubility in water, tending to coalesce[9]. They are sources of essential fatty acids such as linoleic acid (omega-6) and linolenic acid (omega-3), which are not synthesized by the animal organism and need to be supplemented through the diet[10]. According to Weallens et al.[11], the use of lipid sources (oils and fats) in the nutrition of non-ruminant animals offers several advantages. Among these advantages, the provision of easily digestible energy (which is required by genetically improved strains), improved palatability and texture of the diet, reduced feed powderiness, improved pelleting process, and reduced feed wastage can be highlighted.

Fats and oils have been increasingly studied in animal nutrition not only because they are a source of energy, but because they are a source of fatty acids that are essential for the constitution of some cells, hormones, and physiological functions of the animal organism[12,13]. Although lipids have several advantages when used in animal diets, their composition contains unsaturated fatty acids, which are prone to oxidation[14]. Oxidation is a spontaneous factor that triggers the rancid process, reducing the shelf life and nutritional value of food products[10].

Table 1. Articles selected and included in the literature review

Author	Journal	Information
1. Andrade et al. (2018).	Food Science and Techology	“Effect of different lipid sources on the diet of rabbits”
2. Attia et al. (2018).	Pesquisa Agropecuária Brasileira	“Soy lectin dietary supplementation in rabbits”
3. Barron et al. (2020).	Cadernos de Ciência e Tecnologia	“Lipids in animal production”
4. Bombardelli et al. (2009).	Revista Brasileira de Zootecnia	“Effect of diets with different energy levels "
5. Briega et al. (2017).	Ciência Veterinária UNIFIL	“Sunflower oil”
6. Da Silva et al. (2009).	Acta Scientiarum. Animal Science	“Fatty acid profile”
7. De Arruda et al. (2003).	Revista Brasileira de Zootecnia	“Performance of rabbits”
8. De Lima et al. (2000).	Revista Nutrição	“Fatty acids and health”
9. Druzian et al. (2007).	Ciência Rural	“Fatty acid profile”
10. El-Hack et al. (2018).	Journal of Animal Physiology and Animal Nutrition	“Oil mix supplementation in the diet of rabbits”
11. Falcone et al. (2022).	Revista Cientifica Rural	“rabbit nutrition”
12. Faria et al. (2008).	Revista Brasileira de Zootecnia	“Digestibility of rabbits”
13. Faria et al. (2004).	Revista Brasileira de Zootecnia	“Performance of rabbits”
14. Ferreira et al. (2004).	Revista Caatinga	“Performance of rabbits”
15. Galan et al. (2013).	Scientia Agraria Paranaensis	“Lipids in the diet of rabbits”
16. Gasco et al. (2019).	Journal of Animal Science and Biotechnology	“Lipid profile of insect meal in the diet of rabbits”
17. Gidenne et al. (2017).	Animal Feed Science And Technology	“Feed efficiency of rabbits”
18. Godoi et al. (2009).	Revista Brasileira de Zootecnia	“Soybean oil profile”
19. Gomes et al. (1999).	Revista Brasileira de Zootecnia	“Cecotrophy and nutrition”
20 Hakatana et al. (2007)	Revista Brasileira de Farmácia	“Fatty acids”
21. Hulot et al. (1994).	Meat Science	“Performance of rabbits”
22. Klinger et al. (2017).	Archivos de Zootecnia	“Lipid sources in the diet of rabbits”
23. Martin et al. (2006)	Revista Nutrição	“Polyunsaturated fatty acids”
24. Melgarejo et al. (2014).	Revista Brasileira de Engenharia Agrícola e Ambiental	“Canola oil”
25. Min et al. (2013).	Food Science and Technology	“Lipid metabolism in rabbits”
26. Muramatsu et al. (2005).	Acta Scientiarum Animal Science	“Vegetable oil in animal diet”
27. Nars et al. (2022).	Saudi Journal of Biological Sciences	“Oils in the diet of rabbits”
28. Novello et al. (2008).	Revista Brasileira de Zootecnia	“Fatty acids in animal diet”
29. Palazzo et al. (2015).	Archives Animal Breeding	“Lipids in the diet of rabbits”
30. Perini et al. (2010).	Revista Nutrição	“Omega 3 and 6 fatty acids”
31. Rai et al. (2016).	Food Chemistry	“Composition of oils”
32. Ramalho et al. (2013).	Revista Virtual de Química	“chemistry of oils”
33. Reda et al. (2007).	Revista Analytica	“oil and fat”
34. Ribeiro et al. (2009).	Revista Brasileira de Zootecnia	“Lipid sources in the animal diet”
35. Santos-Zango et al. (2008).	Revista Nutrição	“Linoleic acid”
36. Schmidt et al. (2019).	Revista Científica de Produção Animal	“Corn oil”
37. Silva et al. (2021).	Revista Brasileira de Agrotecnologia	“Canola oil”
38. Silva et al. (2009).	Acta Scientiarum. Animal Sciences	“Fatty acid profile”
39. Souza (2022).	Revista Veterinária e Zootecnia	“Lipids in animal nutrition”
40. Toral et al. (2002).	Revista Brasileira de Zootecnia	“Digestibility of rabbits”
41. Trebusak et al. (2019).	Animals	“Addition of oils in the diet of rabbits”
42. Valinote et al. (2005).	Revista Brasileira de Zootecnia	“Source of lipids”
43. Vossen et al. (2012).	Journal of Food Biochemistry	“Fatty acids”
44. Weallens et al. (2021).	Journal of the Science of Food and Agriculture	“Lipids in animal nutrition”
45. Zeb et al. (2017).	Food Measure	“Oils in animal nutrition”
46. Zotte et al. (2022).	Meat Science	“Oils in the diet of rabbits”

According to Galan et al.[15], the use of lipid sources in rabbit nutrition is a strategy that provides the amount of energy necessary for their development and growth, in addition to being a strategy for the use of waste, such as the use of fat from the carcass of animals. a Silva et al.[16] highlighted soybean oil among the lipid sources used in animal nutrition as its composition includes around 85% unsaturated fatty acids and 15% saturated fatty acids, which are rich in linoleic (50 %), linolenic (7%), and oleic (24%) acids.

Godoi et al.[17] underscored that the inclusion of soybean oil in the animal diet is attractive due to its high digestibility provided by high levels of unsaturated fatty acids, and that its major disadvantage is competition with human food that results in its high price on the market. Corn oil is not widely used in animal diets, since the corn grains used in the composition of the feed already contain around 3.5% oil, which contributes to making energy available. In this sense, genetic improvement programs have acted strongly towards producing corn cultivars with a grain oil content of up to 6%[18].

According to Andrae et al.[19], corn is not considered an oilseed, being the main source of carbohydrates and proteins, and having a lipid content of around 3 to 5% concentrated in the embryo that must be quickly processed into oil or incorporated into the feed. The main fatty acids present in this embryo are linoleic (59.6%), oleic (25.4%), palmitic (10.9%), stearic (2%), and linolenic (1.2%). Sunflower is considered an oilseed whose seeds have a high percentage of oil (50%), which makes it an interesting product to be used as a lipid source in the feed of non-ruminant animals[20]. Rai et al.[21] described that sunflower seed has several benefits, and one of its main characteristics is the high presence of linoleic (59-67.5%) and oleic (14-18%) acids.

Another oilseed that has been investigated for inclusion in animal diets is canola. Derived from canola seeds, canola oil ranks as the third most extensively cultivated oilseed globally. Canola seeds are composed of approximately 38% oil, encompassing 7% saturated fatty acids and 61% monounsaturated fatty acids. These seeds exhibit characteristics that contribute to cholesterol reduction within low-density lipoprotein (LDL), as well as moderate levels of polyunsaturated fatty acids. Additionally, canola seeds possess a favorable equilibrium between omega-6 and omega-3 acids[22].

The fatty acid content of fat will vary according to the animal category it comes from, possibly requiring a chemical analysis to determine whether the ideal amounts are being supplied[22]. Reda et al.[23] described that the stability of fatty acids depends on their chemical structure, with saturated fatty acids being the more stable, which will make some sources more interesting for use, as shown in Table 2.

Table 2. Fatty acid composition of vegetable oils.

Oil	Saturated fatty acids (%)	Monounsaturated fatty acids (%)	Polyunsaturated fatty acids	
			Linoleic acid (%)	Linolenic acid (%)
Sunflower	11	2	69	0
Corn	13	25	61	1
Canola	6	58	26	10
Soy	15	24	54	7

Source: Reda et al. (2007); adapted.

In animal nutrition, lipids—particularly oils and fats—can be used as a means to make the feed more cost-effective by reducing the inclusion of other high-energy ingredients. This allows for diet modulation and enables the enrichment of meat by-products with sources of omega-3 and omega-6 fatty acids.

3.2 Fatty acids

Fatty acids are a class of compounds that contain a long hydrocarbon chain and a terminal carboxyl group[24]. They differ from each other in the number of carbons in the chain and the number of unsaturations. Different behaviors are observed between fatty acids[25]. Lipids have a variety of fatty acids in their composition, differing in the side chain, degree of unsaturation, position, and configuration of the double bonds, presence of special functional groups, and position of geometric isomers[26].

De Lima et al.[27] explained that the functions of fatty acids will depend on their bonds. Examples are palmitic acid (C16:0) and myristic acid (C14:0), which increase the levels of low-density lipoproteins; lauric acid (C12:0), which causes hypercholesterolemia; and oleic acid, which may be related to changes in cholesterol levels. Polyunsaturated fatty acids are considered beneficial to health, as they reduce the aggregation of platelets and triglycerides, reducing the risk of cardiovascular diseases. They are considered essential in human nutrition since the body is not able to produce them, requiring daily intake in the form of omega-6 and omega-3[28].

According to Perini et al.[29], omega-3 and omega-6 polyunsaturated fatty acids are essential and stand out for their health benefits, including their action on immune and inflammatory responses. Santos-Zago et al.[30] described that omega-3 and omega-6 fatty acids have several mechanisms of action; among them, the ability to change body composition involving metabolic changes, which potentiate the action of lipase, consequently decreasing lipogenesis.

Martin et al.[5] pointed out that fatty acids are present in the most diverse forms of life, citing linoleic acid, which plays essential roles in its maintenance, structural functions of cell membranes, and metabolic reactions. Silva et al.[31] described that unsaturated fatty acids are related to the maintenance of human health since they raise serum levels of high-density lipoproteins (HDL) and reduce levels of low-density lipoproteins (LDL), parameters that are associated with cardiovascular health. In this sense, rabbit meat is considered healthy, as it contains a low level of fat and high levels of fatty acids, around 47% lauric acid and 18% myristic acid[32].

3.3 Physiology of digestion in rabbits

The digestive system of rabbits, when compared to that of other non-ruminant animals, is characterized by a highly functional cecum, as it has a rich microbiota, which allows greater use of fibrous foods. This organ has the unique feature of harboring an abundant bacterial microbiota and can recycle nutrients through cecotrophy[33]. As stated by Faria et al. [34], the digestive physiology of rabbits is adapted to accommodate diets with a higher fiber content. This fiber-rich composition is fermented within the cecum and colon. Meeting the species' minimum fiber requirements is imperative, as any deficiency can lead to disruptions in their digestive tract. Such disruptions arise from changes in the fermentation process and a reduced passage rate, resulting in the onset of diarrhea.

Arruda et al.[35] highlighted that due to their herbivorous nature and functional cecum, rabbits have a pronounced need for dietary fiber. This fiber is essential for upholding and harmonizing the gastrointestinal tract by regulating the pace at which the diet moves through the system. This inherent requirement also restricts the feasibility of exploiting incomplete diets to meet their nutritional needs. Digestion in rabbits begins in the mouth, which has three functions: prehension, chewing, and salivation. Once prehended, the food undergoes grinding through mastication and the particles resulting from mastication are soaked in saliva containing enzymes, which allows small breakdowns of nutrients, forming the food bolus that is subsequently swallowed[33].

After the food bolus is swallowed, it is taken to the stomach, which is divided into three regions: fundus, cardiac, and pyloric[33]. The food bolus retains a low level of salivary esterase activity inside, with only a few breaks in the ester bonds of short-chain fatty acids. The peristaltic movements of the stomach wall contribute to the dispersion process of lipids in the food bolus, making it easily cleaved in the next stages of digestion by intestinal enzymes[36].

After the processes that occur in the stomach, the acidified food bolus is taken to the small intestine, which is divided into three parts, namely, duodenum, jejunum, and ileum[33]. The most important site in the process of fat digestion occurs in the small intestine[36]. Upon reaching the duodenum, the fatty fraction induces the secretion of the hormone cholecystokinin (CCK), which promotes the contraction of the gallbladder, which will secrete bile acids into the duodenum, emulsifying the lipids and preventing the small droplets from regrouping and forming large drops[35], thereby hindering the action of lipases. Enzymatic digestion and absorption of nutrients occur in the jejunum, whereas the ileum is responsible for the absorption of water and minerals and some nutrients that have not yet been absorbed[37].

According to Ferreira et al.[33], the large intestine is responsible for the fermentation processes, selective excretion of fiber (formation of cecotrophs), and its reingestion for better use. The large intestine is divided into three portions: the cecum, colon, and rectum, whose main functions are the absorption of water and minerals, production of B vitamins, and excretion of fecal matter[32].

According to Toral et al.[36], cecotrophs are rich in protein, cellulose, vitamins, volatile fatty acids, and mineral salts, constituting a form of nutrient utilization with impacts on animal performance. Gomes et al.[38], described coprophagy as an adaptation that small animals developed due to difficult eating conditions. By performing it, they manage to recycle undigested food, making better use for their growth and development.

3.4 Effect of including lipid sources in rabbit diets

The nutrition of non-ruminant animals has been widely studied in search of alternatives that have direct effects on the performance and carcass quality of the animals. Regarding the lipids added to the animal diet, Vossen et al.[4] explained that because of the search for healthier foods that complement the human diet, the addition and choice of sources of fatty acids in the animal diet become essential, in an attempt to enrich these products.

The findings from these studies highlight the potential advantages of incorporating lipids into animal diets, particularly in non-ruminant animals such as rabbits. By including specific lipid sources, it is possible to modify the composition of fatty acids in the animal's body, which can have far-reaching implications for various physiological functions. Moreover, the positive effects observed on animal weight and health further support the notion that lipids can be used as a strategic component in animal nutrition.

Therefore, considering the evidence from available research, the inclusion of lipids in the diet of non-ruminant animals, such as rabbits, appears to be a promising nutritional strategy. It not only influences the composition and functionality of cell membranes but also promotes animal growth and well-being. By carefully selecting appropriate lipid sources and incorporating them into the diet, producers can optimize the nutritional profile of meat products, offering consumers healthier options while enhancing animal performance and overall food quality.

Research studies have shed light on the effects of incorporating various lipid sources in animal diets, providing insights into the physiological changes that occur within the animal organism. Min et al.[39] emphasized that the inclusion of lipids induces alterations in the fatty acid composition of cell membranes, which in turn influences their functions. Additionally, it affects the secretion of proteins like low-density lipoproteins, phospholipids, free cholesterol, and apolipoprotein B, all of which play essential roles in various physiological processes.

Zeb et al.[40] investigated the effects of including sesame oil in the diet of growing rabbits. The researchers reported positive outcomes, demonstrating that the inclusion of sesame oil led to improvements in the weight of the animals without causing any adverse health effects. This suggests that lipids derived from sources like sesame oil can have beneficial effects on animal growth and development.

The aforementioned authors pointed out that sesame oil becomes a good source of lipids to be added to animal diets since it has significant amounts of polyphenolic compounds. Gasco et al.[41] evaluated the inclusion of insect fats on the performance, health, and digestive efficiency of growing rabbits and found that lipids from the black soldier fly (*Hermetia license* L.) and yellow mealworm (*Tenebrio molitor* L.) can be used as a partial or total substitute for soybean oil at up to 1.5% of rabbit diets, without affecting their performance, digestibility, serum chemical characteristics, or intestinal development.

Trebusaket al.[42] recommend an increase in the intake of polyunsaturated fatty acids in the human diet due to their beneficial effects on health, and one of the ways to ensure an increase in their consumption, or that they are consumed regularly, is by incorporating them in foods. A strategy is to include lipid sources in animal diets so that polyunsaturated fatty acids are incorporated into their meat.

As indicated by Gidenne et al.[43], the incorporation of lipid sources into rabbit diets emerges as a crucial factor, yielding multiple benefits. These advantages encompass enhancements in pellet quality, the adjustment of energy levels within the rations, and the facilitation of increased utilization of fiber sources. In addition, lipid sources cause the modulation of intramuscular fat and increase n-3 essential fatty acids[44].

El-Hack et al.[3] conducted a study evaluating the effects of black and red pepper oil as growth promoters in the diet of growing rabbits. Their findings added further influence to the potential benefits of incorporating lipids into animal diets. The inclusion of black and red pepper oil at a concentration of 1.5 g/kg resulted in improved performance in terms of growth.

Additionally, the study revealed that the inclusion of pepper oil led to favorable changes in carcass quality, immunity, and blood parameters. Specifically, the lipid and peroxidation profiles were reduced, indicating a potential improvement in lipid metabolism and oxidative stability. Furthermore, the antioxidant parameters and immunity of the animals were enhanced, suggesting a positive impact on their overall health and well-being.

These results reinforce the notion that lipids, such as black and red pepper oil, can serve as growth promoters and contribute to the improvement of various physiological parameters in animals. The study by El-Hack et al.[3] provides evidence of the potential beneficial effects of incorporating specific lipid sources into animal diets, supporting the idea that lipid enrichment can positively influence animal performance, health, and quality of meat products.

Considering the combined findings of Min et al.[39], Zeb et al.[40], and El-Hack et al.[3], it becomes evident that the inclusion of lipids in non-ruminant animal diets, including rabbits, offers multiple advantages. These advantages range from the modification of fatty acid composition and improved cell membrane functionality to enhanced growth, reduced lipid profiles, improved antioxidant parameters, and strengthened immunity.

As a result, the strategic use of lipids in animal nutrition holds great promise for optimizing animal production, meeting consumer demands for healthier food options, and improving overall animal well-being and product quality. It emphasizes the importance of considering lipid sources and their specific effects when formulating animal diets, with the aim of achieving optimal performance, health, and nutritional outcomes.

Narset al.[45] evaluated the effect of using chamomile and grape seed oil and their mixture as food additives and their effect on the performance parameters of growing rabbits. Their findings on experimentation is that the use and combination of oils promote an improvement in the performance (weight gain, feed conversion, and feed intake) of growing rabbits and the health of the animals when compared to the use of antibiotics.

The addition of lipids becomes essential in production animals, Attia et al.[46] described that the lectin obtained through the extraction of soybean oil can be used as a source of nutritional strategy since it improves the hematological, biochemical, and antioxidant status and increases milk production in rabbits during the suckling period. This resulted in the provision of energy to the offspring, allowing an improvement in their performance and growth after weaning.

4. Conclusion

The enrichment of diets with lipids offers several advantages in the nutrition of non-ruminant animals. The addition of fatty acids, particularly omega-3 (w3) and omega-6 (w6) fatty acids, to meat products enhances their nutritional appeal for consumers. Meat products with lower levels of saturated fat and higher levels of unsaturated fatty acids offer potential benefits for human health. Moreover, incorporating lipid sources into the diets of non-ruminant animals, such as rabbits, can be a beneficial nutritional strategy, especially during periods of excessive heat. Lipids have a low heat increment and are well accepted by animals, making them an ideal component in the diet. This approach can help to reduce feeding costs and improve feed palatability, ultimately enhancing animal performance and productivity. Overall, the enrichment of non-ruminant animal diets with lipids not only provides nutritional benefits but also offers economic advantages and contributes to the improvement of food quality. By optimizing the fatty acid composition of meat products, producers can meet consumer demands for healthier food choices while maintaining the desirable sensory attributes and appearance of the final products.

Declaration of conflict of interest

The authors declare that there are no conflicts of interest.

Author contributions

Conceptualization: A. A. Almeida, J. K. Valentim and L. S. Fonseca. *Data curation*: A. A. Almeida, J. K. Valentim and J. Zanella. *Investigation:* A. A. Almeida, J. K. Valentim, D. D. Moraleco and L. S. Fonseca. *Methodology*: A. A. Almeida, J. K. Valentim and L. S. Fonseca. *Project management*: L. S. Fonseca. *Visualization*: A. A. Almeida, J. K. Valentim and A. C. D. Silva. *Supervision*: L. S. Fonseca and J. K. Valentim. *Writing (original draft)*: A. A. Almeida, J. K. Valentim, A. C. D. Silva, D. D. Moraleco and J. Zanella. *Writing (review and editing):* L. S. Fonseca.

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