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Nutritional, productive and physiological effects of sesame products in poultry diets: A review article

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Abstract

This review aims to evaluate published studies on the productive and physiological effects of sesame products in broiler chicken diets. Various sesame-derived products, including sesame meal, sesame oil, sesame hulls, and sesame leaves, have been used in poultry diets, with particular emphasis on their effects on productive performance and physiological responses. The increasing global price of soybean meal has led to growing interest in identifying alternative plant protein sources for poultry nutrition. Sesame (*Sesamum indicum* L.) and its by-products are considered promising feed ingredients due to their relatively high protein content and the presence of stable, high-quality polyunsaturated fatty acids. In addition, sesame contains several bioactive compounds such as sesamin and sesamol, which possess strong antioxidant properties. Previous studies indicate that the inclusion of sesame meal at moderate levels (5-10%) in poultry diets can maintain productive performance. The nutritional value of sesame meal can be further improved through supplementation with essential amino acids, particularly lysine, as well as the addition of phytase enzyme. However, high inclusion levels may negatively affect growth performance and nutrient utilization due to the presence of anti-nutritional factors such as phytates and oxalates. Furthermore, the antioxidant compounds present in sesame contribute to improving physiological responses and meat quality in poultry. Therefore, sesame products may be considered a suitable partial alternative to soybean meal when used at appropriate dietary inclusion levels.

Keywords: Antioxidants, sesame meal, broiler chickens, productive performance, alternative protein sources

Introduction

Nutrition is one of the most important components of animal production systems, which contributes approximately 60 to 70 percent of the total production cost of livestock and poultry production (Ali & Al-Dalawi, 2025; Mottet & Tempio, 2017) ^[9, 57]. Modern broiler production systems need to be improved for better growth performance and feed conversion efficiency, and the use of targeted plant-based feed additives has been considered one of the effective strategies to meet these requirements (Ahmed & Aziz, 2023; Hassan *et al.*, 2010) ^[6, 34].

Broiler production has been considered one of the most important components of animal production, which makes significant contributions to food security, particularly in those countries facing problems in providing affordable animal protein (Ali & Al-Dalawi, 2025) ^[9]. Poultry meat has been considered one of the best sources of animal protein, which has high nutritional value and low-fat content compared to meat obtained from other animals (FAO, 2012) ^[24]. Animal proteins contain essential amino acids, which are required for protein synthesis and play an important role in the metabolism of the human body (Wu *et al.*, 2014) ^[89]. These amino acids are found in higher concentrations in meat, fish, and dairy products (Wyness, 2016) ^[90].

The increase in broiler production helps to increase the availability of affordable protein sources in the local market, which helps to meet the demand for food and supports food security (AgriEconomist, 2020) ^[5]. However, the continuous increase in the price of soybean meal, which is the main protein source of broilers, has prompted researchers to explore the use of alternative plant protein sources, which can be used instead of soybean meal without affecting productivity (Aziz-Aliabadi, 2024) ^[13].

Sesame (*Sesamum indicum* L.), of the Pedaliaceae family, is an essential nutritional crop Cultivated across the world. Sesame seeds are identified by their high oil and protein content, along with other bioactive compounds such as sesamin, sesaminol, and sesamol, which are found to have antioxidant, anti-inflammatory, and anticancer activities (Pathak *et al.*, 2019) [67]. Sesame seeds are rich in essential minerals like iron, calcium, copper, magnesium, silicic acid, and phosphoric acid, and vitamins A, B, and E (Prasanthi & Rajini, 2005) [68].

Sesame seeds contain other bioactive compounds such as phytate (IP6), lignans, tocopherols, lecithin, pinorelinol, myristic acid, and linoleate, which are responsible for the oxidative stability of sesame seeds and oil. Several products and by-products of sesame, such as sesame oil, sesame leaves, sesame hulls, and sesame meal, have been examined for their use in animal nutrition (Malasi, 2013) [54].

The objective of this review article is to evaluate the literature available regarding the productive and physiological effect of sesame products in broiler chicken feed, focusing on their use

As alternative protein sources for broiler chickens, particularly in view of the rising global price of soybean meal.

Materials and Methods

2. Nutritional composition of sesame products

2.1 Sesame seeds

Sesame a plant of the Pedaliaceae family, is considered to be one of the most important oil crops known to human beings since ancient times. Sesame is cultivated on a large scale and is considered to be of significant value due to its oil content, which varies from 50 to 60%, and also due to its 25% protein content (Weiss, 1983) [88]. Sesame seeds are known to be rich in lipids, protein, minerals, vitamins, and dietary fiber. Studies indicate that sesame seeds are composed of 21.9% protein and 61.7% fat, and are rich in iron, calcium, and other vital minerals (Rout *et al.*, 2018) [75].

Sesame seeds are known to be a complete nutritional reservoir due to their high nutritional value (Haixia *et al.*, 2015) [93]. Table (1) presents the nutritional composition of sesame seeds.

Table 1: Nutritional composition of sesame seeds

Component	Unit	Sesame Seeds	Sesame Flour	Sesame Meal
Water	g/100 g	1.60	6.61	5.00
Energy	kcal/100 g	586	382	567
Protein	g/100 g	18.08	40.32	16.96
Total lipids (Fat)	g/100 g	50.87	11.89	48.00
Carbohydrates	g/100 g	24.05	35.14	26.04
Ash	g/100 g	5.40	6.05	4.00
Total dietary fiber	g/100 g	5.50	N/A	N/A
Total sugars	g/100 g	N/A	N/A	N/A
Calcium	mg/100 g	960	150	153
Iron	mg/100 g	19.20	14.30	14.55
Magnesium	mg/100 g	362	362	346
Phosphorus	mg/100 g	659	810	774
Potassium	mg/100 g	582	425	406
Sodium	mg/100 g	12	41	39
Zinc	mg/100 g	7.29	10.70	10.23
Copper	mg/100 g	4.214	1.432	1.457
Manganese	mg/100 g	2.540	1.403	1.427
Selenium	µg/100 g	35.5	N/A	N/A
Vitamin B1 (Thiamine)	mg/100 g	0.240	2.53	2.573
Vitamin B2 (Riboflavin)	mg/100 g	0.200	0.27	0.275
Vitamin B3 (Niacin)	mg/100 g	6.70	12.60	12.816
Vitamin B5 (Pantothenic acid)	mg/100 g	0.052	2.76	2.807
Vitamin B6	mg/100 g	0.816	0.152	0.146
Folate	µg/100 g	100	29	30
Food folate	µg/100 g	100	29	30
Dietary folate equivalents	µg/100 g	100	29	30
Vitamin A	µg/100 g	3	69	66
Vitamin A	IU/100 g	50	3	3
Vitamin E	µg/100 g	N/A	N/A	N/A
Vitamin K	µg/100 g	N/A	N/A	N/A
Saturated fatty acids	g/100 g	1.252	1.634	6.722
Monounsaturated fatty acids	g/100 g	3.377	4.405	18.127
Polyunsaturated fatty acids	g/100 g	3.919	5.113	21.039

Source: (El-Tinay *et al.*, 1976) [21]

2.2 Sesame seed meal as a protein source in poultry diets

Feed costs are considered to be a major problem in the poultry industry, which amounts to 75% of total costs of production. Soybean meal is considered to be a primary protein source in poultry diets due to their high nutritional value. Most Asian countries, such as Iraq, are forced to import this protein source. As a result, cottonseed meal, sunflower meal, and sesame seed meal are considered to be alternative protein sources in poultry diets (Baghban-Kanani, 2018) [14].

Sesame seed meal (SSM), which is obtained as a by-product of oil extraction from sesame seeds, has been considered to be a good source of crude protein (40-60%), with relatively high levels of methionine (6.97%). Sesame seed meal has been widely used in poultry feed because of its relatively lower cost compared to soybean meal (Al-Harhi & El-Deek, 2009; Lee *et al.*, 2021; Shen *et al.*, 2021) [94, 46, 77].

In addition, the amino acid composition of sesame seed meal has been considered to be comparable to soybean meal,

except for the relatively lower levels of lysine and the relatively higher levels of methionine in sesame seed meal, whereas soybean meal has been considered to be relatively deficient in methionine and has adequate levels of lysine (Mamputu & Buhr, 1995) [56].

Sesame seed meal has been considered to be rich in minerals, although the bioavailability of these minerals has been considered to be relatively low because of the high levels of oxalates and phytates (Ravindran & Blair, 1992) [73]. Sesame seed meal has been found to contain significant levels of phytate, which has been reported to affect the availability of minerals and proteins, such as calcium, in the diet (Farran, 2000) [26].

The supplementation of the phytase enzyme has been considered to be effective in reducing the need for inorganic phosphorus, as the phytase enzyme has been reported to hydrolyze the phytate complex and release amino acids, minerals, phosphorus, and starch (Ravindran *et al.*, 1999; Zwart, 2006) [74, 95].

A combination of soybean meal and sesame seed meal at an appropriate ratio is known to produce a nutritionally balanced diet with regard to lysine and methionine content (Olomu, 1995) [64]. Sesame seed meal is known to have anti-nutritional compounds such as oxalates, trypsin inhibitors, phytic acid, and tannins (Ogunbode, 2016) [63]. It is thus important to find out what level of inclusion is best when it comes to sesame seed meal.

The use of sesame seed meal as a locally available feed ingredient in broiler diets can partly replace imported SBM. Due to low levels of lysine and high levels of methionine in sesame seed meal, it is recommended to mix it with SBM in a proportion of 1:2 to avoid deficiencies of essential nutrients, especially amino acids (Attia *et al.*, 2003) [12].

Table 2: Chemical composition of sesame seed meal

Nutrient Component	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fiber (%)
Value	8.06	53.5	7.0	6.0	8.0

Source: (Younis & Al-Sofek, 2021) [92]

2.3 Sesame oil and its bioactive compounds

Sesame seeds are considered one of the most disseminated oil-bearing seeds in the world because of their richness in various bioactive compounds, nutrients, and health-promoting compounds (Gharbia *et al.*, 2000) [29]. Sesame seeds are considered a traditional food ingredient because of their high content of edible oil, which can reach up to 40%, and the oil content is rich in high-quality and stable polyunsaturated fatty acids (Sirato-Yasumoto *et al.*; Gagan, 2014) [82, 96].

Sesame oil has high oxidative stability and is resistant to oxidative rancidity due to the presence of natural antioxidants, sesamol, sesamin, and sesamol, which play an important role in extending the storage stability of vegetable oils and fats (Obiajunwa *et al.*, 2005) [62]. Sesamin has also shown antibacterial effects (Home Cooking, 1998) [36].

Several studies have also indicated that sesame seeds and oil can help in reducing cholesterol levels in the human body due to their high content of antioxidants. Moreover, sesame seeds and oil are rich in a high amount of polyunsaturated fatty acids, especially omega-6 fatty acids, especially linoleic acid, which is considered to play a significant role in reducing cholesterol levels in the human serum and also in reducing cardiovascular and atherosclerosis-related problems (Rama *et al.*, 2008) [71].

Sesame oil is also known for its high content of essential fatty acids, especially linoleic acid (46.9%) and oleic acid (37.4%), in addition to vitamin E, especially γ -tocopherol, which makes up 90.5% of total vitamin E content, as well as phytosterols (Hama, 2017; Gharby *et al.*, 2017) [33, 30]. Sesame oil is also known to contain a similar amount of unsaturated fatty acids compared to olive oil (Ma & Fang, 2019) [50].

Sesame oil is also known to have a number of biological activities, such as anti-inflammatory activity, moisturizing activity, and healing activity (Afroz *et al.*, 2019) [4].

Table 3: Nutritional value of sesame oil

Component	Unit	Value
Water	g/100 g	0
Energy	kcal/100 g	884
Total Lipid (Fat)	g/100 g	100
Manganese	mg/100 g	N/A
Vitamin E	μ g/100 g	1.4
Vitamin K	μ g/100 g	13.6
Saturated Fatty Acids	g/100 g	14.2
Monounsaturated Fatty Acids	g/100 g	39.7
Polyunsaturated Fatty Acids	g/100 g	41.7

Source: (El-Tinay *et al.*, 1976) [21]

2.4 Sesame hulls and leaves as feed ingredients

In recent decades, there has been a significant increase in the prices of livestock feeds, in addition to occasional problems in their availability in certain circumstances (Stillman *et al.*, 2009; Lawrence *et al.*, 2010) [83, 44]. Such problems are usually experienced in feed ingredients that are rich in crude protein or essential amino acids, such as those in soybean meal (Indexmundi, 2013b) [40]. In this regard, there is a growing interest in exploring alternative feed sources that can help reduce the costs of livestock feeds without compromising productivity, animal health, and product quality (Indexmundi, 2013a) [40].

Sesame seed hulls are considered a by-product of oil extraction and production of tahini. Sesame seed hulls account for about 12% of the weight of the sesame seeds. Sesame seed hulls also include small sesame seeds that are not removed during the dehulling process, thus increasing their crude fat content. Sesame seed hulls vary in composition depending on the oil extraction plants and extraction methods. Sesame seed hulls and sesame meal are mostly used in ruminants, while limited information is available on their usage in broiler diets (Obeidat & Al-Oally, 2010; Herano *et al.*, 2003; Obeidat & Gharaybeh, 2011) [60, 35, 61].

Sesame leaves contain lysine and methionine, which are naturally occurring amino acids as compared to synthetic lysine and methionine (Dogan & Zeybek, 2009) [20]. The sesame plant is an herbaceous plant that grows up to 1.5 m in height with purple, white, and pink flowers, and capsule fruits containing multiple seeds measuring 2-5 mm in length. The seeds contain protein with high levels of methionine, leucine, lysine, and arginine (Aduku, 2005) [3].

Sesame leaves contain high levels of crude protein content, between 18-25%, and also contain crude fiber, lipids, and ash content. The leaves also contain various active compounds, including tannins, flavonoids, and saponins, which have antioxidant effects and can improve the productive performance of poultry birds (Akinmutimi, 2006) [7].

Table 4: Chemical composition of sesame seed hulls

Component	Unit	Value
Dry matter	g/kg	970.0
Crude protein	g/kg	108.3
Crude fat	g/kg	134.2
Crude fiber	g/kg	171.0
Ash	g/kg	165.0
Neutral Detergent Fiber (NDF)	g/kg	165.6
Acid Detergent Fiber (ADF)	g/kg	123.2
Total carbohydrates	g/kg	126.0
Calcium (Ca)	g/kg	97.2
Metabolizable Energy	MJ/kg	10.9

Source: (Bonos *et al.*, 2014) ^[15]

3. Results and Discussion

3.1 Effect of sesame products on the productive performance of poultry

Previous studies indicated that sesame seed hulls in broiler diets may adversely affect feed intake, body weight gain, and feed conversion ratio (Kras *et al.*, 2013; Kalmendal *et al.*, 2011). Other previous studies indicated that sesame seed hulls in broiler diets may improve body weight gain without any adverse effects on feed intake and feed conversion ratio (Bonos *et al.*, 2014) ^[15]. Bonos *et al.* (2014) ^[15] indicated that sesame seed hulls in broiler diets at a level of 10% increased final body weight of broiler birds compared to other dietary treatments, although it did not significantly affect growth rate and feed conversion ratio. Moreover, sesame seed meal is known to contain relatively higher amounts of phytates (3.6 to 5.18%) and oxalate (13%), which may adversely affect protein digestibility and utilization (Hossain & Jauncey, 1989) ^[37]. Sesame seed meal is also known to affect calcium availability and utilization (Ward *et al.*; Farkyam *et al.*, 1989) ^[87, 25].

Adedeji *et al.* (2019) ^[2] found that the inclusion of sesame leaves at 10 g/kg in broiler diets gave comparable final live body weight to the control treatment, while there were improvements in the values of weekly weight gain, feed efficiency, and carcass characteristics compared to the control treatment. However, increasing the inclusion level of sesame leaves from 10 to 40 g/kg decreased final body weight, weight gain, and average feed intake. This may be attributed to the presence of phytic and oxalic acid in sesame leaves (Mamputu & Buhr, 1991) ^[55]. Moreover, the bitter taste of sesame and its high oil content may also contribute to decreased feed consumption (Liener, 1980) ^[49]. This may be attributed to the presence of anti-nutritional compounds in sesame seeds, as found by Lease & William (1967) ^[45].

The inclusion of sesame seed meal in broiler diets, according to Ukpanah *et al.* (2024) ^[86], did not show significant differences between treatments regarding feed intake and feed conversion ratio, but high inclusion levels of sesame seed meal decreased productive performance. This is in agreement with the findings of Tuned-Akintunde *et al.* (2012) ^[85], Ali *et al.* (2019) ^[10], and Owosibo *et al.* (2017) ^[65] that increasing the inclusion level of sesame seed meal in broiler diets may lead to decreased growth rate.

The increase of inclusion levels of sesame seed meal from 5% to 15%, which increases the level of dietary fat, considering that fat constitutes the major component of sesame seeds, does not negatively affect nutrient digestibility, and may even reduce endogenous nutrient loss (Gbadamosi *et al.*, 2017) ^[28]. This may be attributed to the effect of fatty acids, which may enhance nutrient digestion (Gbadamosi *et al.*, 2017; Yasothai,

2014) ^[28, 91], thereby reducing metabolic disorders resulting from excessive consumption of lipids.

Hussein (1991) ^[38] worked with the productive performance of broiler chickens fed with diets where soybean meal was replaced with sesame seed meal and lysine and methionine supplements. The study showed that there was a significant increase in the average body weight gain of the birds compared with other treatments in the experiment. There were no significant differences in the average weight gain of birds fed with diets containing sesame seeds in other treatments where it was used in broiler diets at the growth and sexual maturity stages (Hussein, 1998) ^[39].

The increase in body weight may be attributed to the digestion and metabolic activity of the birds. Sesame seeds contain oleic acid, which is an unsaturated fatty acid that may reduce cholesterol absorption in the intestines and its subsequent excretion through bile juice secretion (Chen *et al.*, 2005) ^[97].

Sesame seeds have high zinc and B vitamin contents that play crucial roles in metabolic activities (Dawson *et al.*, 1992) ^[18], vitamin C (Glenville, 2008) ^[31], which is essential in stimulating pancreatic insulin secretion (Shittu & Addesite, 2008) ^[79]. Sesame seeds also have vitamin E that works with vitamin C in combating free radicals in the body and plays an essential role in productive performance in broiler chickens (Shittu *et al.*, 2009) ^[80]. Vitamin E and vitamin C work together as powerful antioxidants in combating free radicals in the body (Shittu *et al.*, 2009) ^[80].

According to Passi *et al.* (2019) ^[66], the inclusion of raw sesame seeds in the broiler diet did not negatively impact the performance of the broilers and resulted in an increase in feed intake and body weight. This could be attributed to the methionine content in the sesame seeds, which would enhance the performance and efficient use of the feed. This agrees with the findings of Ngele *et al.* (2011) ^[59] on the performance of broilers fed diets with up to 10% raw sesame seed meal, which did not negatively impact the performance of the broilers.

On the other hand, Mahmoud *et al.* (2015) ^[52] found that the inclusion of roasted sesame hulls in broiler diets resulted in significant increases in the live body weight of the broilers. Similarly, Rahimian *et al.* (2016) ^[70] found improved performance in the live body weight and weight gain of broilers fed diets with sesame seed meal. However, some studies found that the replacement of soybean meal with sesame seed meal resulted in significant reductions in the body weight and weight gain of broilers (Al-Harthi & El-Deek, 2009) ^[94].

3.2 Effect of sesame products on the physiological performance of poultry

Qattan *et al.* (2008) ^[69] indicated that the bioactive compounds in sesame seeds, such as sesamol, sesamol, and alpha tocopherol, are of great importance in reducing Low-Density Lipoproteins (LDLs) and preventing lipid oxidation. The vitamins present in sesame seeds, namely Vitamin C, Vitamin A, Vitamin B, and Vitamin E, act synergistically to combat oxidative stress and free radicals, which are capable of causing damage to cells and tissues. This would improve the health of poultry, which in turn would improve feed intake, meet the metabolic demand, and ultimately improve body weight gain in addition to attaining efficient feed conversion ratio (Shittu *et al.*, 2007) ^[78].

Sesamin has been shown by Ruankham *et al.* (2021) ^[76] to reduce Reactive Oxygen Species (ROS) in human neuroblastoma cells exposed to hydrogen peroxide (H₂O₂).

Moreover, sesamin stimulated antioxidant enzymes such as Catalase (CAT) and Superoxide Dismutase (SOD). Sesamin reversed H₂O₂-induced apoptosis by reducing Bax gene expression and increasing BCL-2 gene expression.

Sesamin has been shown by Fan *et al.* (2017) [23] to modulate SIRT3 and SOD expression levels in mice with aortic constriction and to reduce cardiac remodeling induced by oxidative stress.

Sesamin is known to have a hypolipidemic effect by regulating lipid metabolism pathways and cholesterol transport. Sesamin has been shown by Liang *et al.* (2015) [48] to reduce the gene expression of several critical genes in cholesterol absorption, namely, MTP and ACAT2. Sesamin also inhibited HMG-CoA Reductase (HMGCR) gene activity, which is responsible for cholesterol synthesis. Sesamin increased CYP7A1 gene activity, which is responsible for bile acid synthesis. This would reduce cholesterol synthesis and increase cholesterol excretion in faeces.

In addition, sesamin plays a positive role in Reverse Cholesterol Transport (RCT) through the enhancement of sterol transporters like ABCA1 and ABCG1 by modulating various signal transduction pathways like PPAR γ , MAPK, and LXRA (Majdalawieh *et al.*, 2020) [53]. Therefore, it is likely that sesamin may help in reducing VLDL, LDL, and triglycerides and in increasing HDL levels, thus offering protection against atherosclerosis.

Sesamin has shown protective activity against liver and kidney diseases. Sesamin was shown to reduce elevated levels of liver enzymes like ALT and AST and total bilirubin in animal models of liver fibrosis and to increase antioxidant enzyme activities like SOD and GSH-Px (Chen *et al.*, 2015) [16].

Sesamol was shown to possess antibacterial activity (Home Cooking, 1998) [36]. In addition, sesamin contains vitamin E, which is easily absorbed in the body and thus increases its activity (Cooney *et al.*, 2001) [17].

It was noted by Ali and Muhammed (2013) [98] that linoleic acid is one of the most important unsaturated fatty acids in animal feed and plays a vital role in preventing cardiovascular diseases. Khosravi-Boroujeni *et al.* (2017) [42] noted that blood pressure levels were reduced in animals fed with sesame seeds; however, more investigation is required in this area.

Li *et al.* (2013) [47] showed that sesamin supplementation in hypertensive rats significantly reduced heart weight, left ventricular weight, cardiomyocyte size, and cardiac hypertrophy index. Furthermore, sesamin maintained cardiac tissue integrity, inhibited mitochondrial damage, and lowered blood pressure, as well as oxidative stress and fibrosis marker levels, including MDA, nitrotyrosine, and TGF- β 1.

Moreover, Thuy *et al.* (2017) [84] showed that sesamin supplementation significantly improved cardiovascular parameters, heart rate, blood pressure, and QT interval in diabetic rats induced by streptozotocin. All these findings confirm the cardioprotective effects of sesamin.

Sesame oil and sesamin have shown promising effects in reducing blood glucose levels. Abe-Kanoh *et al.* (2019) [1] showed that dietary intake containing 12% white sesame oil significantly reduced fasting blood glucose levels from 248.4 mg/dL to 202.1 mg/dL in diabetic mice within 60 days.

Devarajan *et al.* (2016) [19] showed that sesame oil supplementation significantly reduced fasting and postprandial blood glucose levels, HbA1c, and lipid profile parameters, as well as increased levels of HDL, in patients with type 2 diabetes during an 8-week clinical trial.

Sesame seeds contain essential minerals, including calcium, copper, and magnesium, which play significant roles in pancreatic β -cell function and insulin secretion, resulting in lower levels of serum glucose (Rao *et al.*, 2002) [72]. This effect is essential in regulating physiological processes necessary for muscle and skeletal development in poultry fed sesame seed meal.

According to Gbadamosi *et al.* (2017) [28], unsaturated fatty acids, which constitute 80-82% of the total lipid content of sesame seeds, significantly reduce serum LDL cholesterol levels, which is considered one of the major risk factors in cardiovascular diseases.

4. Conclusion

Sesame seed by-products, such as sesame seed meal, sesame oil, sesame seed hulls, and sesame leaves, are found to be viable alternatives to soybean meal in poultry nutrition, especially at optimal inclusion rates. They are distinguished by their high-quality protein content, polyunsaturated fatty acids, and other bioactive compounds, which are rich in antioxidants. Moderate inclusion rates of sesame seed meal and sesame oil may improve productive performance and physiological responses in poultry. However, it is important to exercise caution in the use of high inclusion rates to avoid the adverse effects of anti-nutritional factors, which may affect productive performance and physiological responses in poultry.

Although many researchers have worked on the use of sesame products in poultry nutrition, there are still many gaps to be filled, such as:

- 1- Investigating the long-term effect of sesame products on poultry physiological health.
- 2- Determining the optimal inclusion rates of each sesame product in poultry nutrition to maximize its nutritional benefits while minimizing the adverse effects of anti-nutritional factors.
- 3- Comparing the productive and physiological responses of different sesame products, such as sesame seed meal, sesame oil, sesame seed hulls, and sesame leaves.

Future research should focus on exploring the effect of sesame products, such as their antioxidant compounds, on poultry diets, especially at the level of vital organs and cells. Further research is needed to investigate the combined effect of sesame products, such as sesame seed meal, sesame oil, sesame seed hulls, and sesame leaves, to find the most effective combination to provide an optimal level of protein and essential amino acids. Finally, economic research is recommended to evaluate the possibility of using sesame products in local poultry diets and compare their economic benefits to using imported soybean meal.

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