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Review Article

Effects of dietary supplementation of Black Cumin (*Nigella sativa*) in small ruminants: A review

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Abstract

Nigella sativa **(seeds and oil) has been used in food dishes and traditional medicinal preparations since long back due to its flavouring, medicinal values and other beneficial attributes. However, since the last decade, a growing interest has been seen in the scientific community to utilize its beneficial effects in the diets of small ruminants. *Nigella sativa* (NS) contains around 30% crude protein, 35-40% oil and many beneficial plant secondary metabolites in which the principal component is thymoquinone which shows antioxidant activities including other beneficial attributes. Studies showed that it might beneficially improve nutrient intake, nutrient digestibility, growth and milk production, and reproductive performances along with improving immunity status and gut health of small ruminants when supplemented in diet individually or in combinations with other herbs. Additionally, it may also be used as an alternative to protein sources such as soybean meal, cotton seed meal, etc. However, fewer studies have been done to study the effect of *Nigella sativa* on the reproduction and gut health of small ruminants. Nonetheless, *Nigella sativa* can be safely and favourably useful to enhance the production, reproduction, immunity status, and blood biochemical and haematological profile of small ruminants. This article enlightens the aspects of dietary supplementation of *Nigella sativa* in small ruminants for its effect on production, reproduction and health performances in small ruminants.**

Keywords: Growth performance, Immunity status, *Nigella sativa*, Small ruminants

Highlights

- This manuscript contains crisp information from various scientific platforms regarding *Nigella sativa* in small ruminants.
- *Nigella sativa* has positive effects on animal production when supplemented in proper amounts.
- More study needs to be done to investigate the effect of supplementing *Nigella sativa* on the reproductive and gut health of small ruminants.
- Also, this article suggests for economical analysis of supplementing *Nigella sativa* in small ruminants.

INTRODUCTION

The whole world is encountering a huge shortage of fodders for farm animals (Lalhriatpuii and Singh, 2021; Yadav *et al*., 2021; Kisku and Singh, 2022). Scientists are searching for better and alternative options of feeds which may enhance nutrients availability for animals along with other beneficial effects on growth performances (Singh, 2018a; Singh, 2018b). The last decade witnessed a rapid interest in the utilization of medicinal or herbal feed supplements as an effective alternative to use of antibiotics (Sadarman *et al*., 2021). Increased awareness regarding residual effects and compromised food safety became the first cause of dependence of consumers on herbs as an

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alternative to antibiotics (Longato *et al*., 2015). Secondly, more likeness towards the food obtained from the herbs fed animals is more and considered safe by them (Zhong *et al*., 2019). Ethno-veterinary use of medicinal herbs has been practised since long back by farmers, and it was suggested that they might easily adopt herbal-based feeding approach (Mirzaei, 2012; Mirzaei *et al*., 2012). However, scientific documentation for the utilization of herbs as potential growth promoter feed supplements needs to be done through scientific researches (Alagawany *et al*., 2020; Mohammad and Chatterjee, 2020; Sauvan *et al*., 2020).

Nigella sativa seeds (NSS), also known as black seed or black cumin seeds (Dubey *et al*., 2016), and its derived oil has gained much attention in recent studies as feed supplements (Ahmad *et al*., 2021, Sadarman *et al*., 2021). It contains a wide range of phytochemicals that may benefit animals (Cherif *et al*., 2018a; Kanter, 2009). As per different researches, it posses beneficial properties including antioxidant, antimicrobial, immuno-modulating, anthelmintic, anti-coccidial among several others (Bamosa *et al*., 2002; Bamosa *et al*., 2010; Alenzi *et al*., 2013; Abdalla *et al*., 2015; Cherif *et al*., 2018b; Ahmad *et al*., 2021). It is aromatic and has flavouring property (Randhawa, 2008). NSS may be considered as a good protein source for animals as it contains about 30% crude protein and has a low degradability rate in the rumen (El-Ayek, 1999) which may be utilized in animal feeding (Shewita and Tha, 2011; Mahmoud and Bendary, 2014; Longato *et al*., 2015). Recent studies (Habeeb and El-Tarabany, 2012; Cherif *et al*., 2018a; Odhaib *et al*., 2018a, 2018b; Obeidat, 2020; Sadarman *et al*., 2021) showed that NSS might improve growth, production, immune status and rumen characteristics in farm animals. Cherif *et al*. (2018b) reported enhanced meat keeping quality of NS fed lambs. Moreover, Ibrahim *et al*. (2003) remarked that NSS could be used safely and economically as an animal feed supplement and replace antibiotics (Erener *et al*., 2010; Islam *et al*., 2011).

Extensive studies have been carried out on the pharmacological and therapeutic properties of NSS (Ahmad *et al*., 2013; Longato *et al*., 2015). However, specific reviews regarding the beneficial effects of NSS as growth-promoting feed supplements in small ruminants are scanty. Hence, we aimed to review a critical and comprehensive manuscript to gain better understanding of the effect of NSS on the growth performance of small ruminants.

Methodology of review

Major literature finding was done through online literature platforms such as Google Scholar, Research Gate, PubMed, EBSCO, etc. We did not aim to present a complete literature review rather we focused to discuss important findings on the supplementation of NS in small ruminants. Important studies during 2005-2021 were given special emphasis in this manuscript; however, earlier studies deemed suitable with small ruminants were also readily referred. Studies which were not scripted in the English language were excluded from this manuscript.

Nigella sativa: A brief introduction

Nigella sativa (NS) may be considered as an elite herbaceous herb cultivated widely in parts of Europe, Africa, Mediterranean countries, Saudi Arabia and Indian sub-continent (Longato *et al*., 2015; Singh and Solanki, 2015; Dubey *et al*., 2016). Mozaffari *et al*. (2000) remarked that NS originates from Turkey, Pakistan and Iran. NS is used in the preparation of wide variety of products, such as culinary dishes, cosmetics, pharmacological products, etc. due to its beneficial effects. However, these days a great interest has been noted in animal scientists to utilize it in animal feeding to achieve improved growth and other performances. NS may be chiefly utilized in two forms viz. seeds and its derived oil. Paarakh (2010) remarked that NSS contains high amount of oil in it (35-42%). Fig. 1 represents the beneficial biological effects of NS. As per the latest estimation (Zanouny *et al*., 2013b; Sadarman *et al*., 2021), the proximate

composition of NSS (on dry matter basis) includes dry matter 91.6% (range: 88.6-92.6%), Ash 3.84% (range: 2-8.43%), organic matter 96.2% (range: 91.6-98.0%), crude protein 23.3% (range: 7.5-33.1%), ether extract 9.67% (range: 4.7-12.7%), crude fiber 9.84 (range: 6.6-19.9%), nitrogen free extract 52.0% (range: 34.8-67.9%), neutral detergent fiber 42.7% (range: 22.8-55.1%), acid detergent fiber 23.7% (range: 11.4-29.3%), hemicellulose 19.0% (range: 11.4-25.8%).

Mode of action of *Nigella sativa* in small ruminant body

NS shows many beneficial activities, which makes it a potentially strong candidate to be used as a feed supplement for enhancing the performances of small ruminants. The antioxidant activity of NS is mainly due to high phenolic compounds in it (Omar *et al*., 1999; Chaieb *et al*., 2011; Bourgou *et al*., 2012; Longato *et al*., 2015; Kooti *et al*., 2016). Bourgou *et al*. (2008) investigated 14 phenolic and flavonoids compounds in NSS, amongst which vanillin acid was the predominant compound amounting about 120 mg per 100 g of composite NS (roots and shots) dry weight. Furthermore, Mariod *et al*. (2009) found that hydro-benzoic, syrnigic, and p-cumaric acids were principle phenolic components showing antioxidant activities through a planned *in vitro* experimentation. In addition to that, Nickavar *et al*. (2003) showed 32 compounds exhibiting antioxidant properties in NSS. However, Singh *et al*. (2005) investigated 38 different compounds showing antioxidant activity in which p-cymene (36.2%) was major fraction followed by thymoquinone in essential oils derived from NS. Recent studies considered that major pharmacological properties of NS were due to thymoquinone (Longato *et al*., 2015; Sahak *et al*., 2016). Thymoquinone has immuno-modulatory properties; it increases working of neutrophils as a part of natural body defense mechanism against invading infections (Salem, 2005).

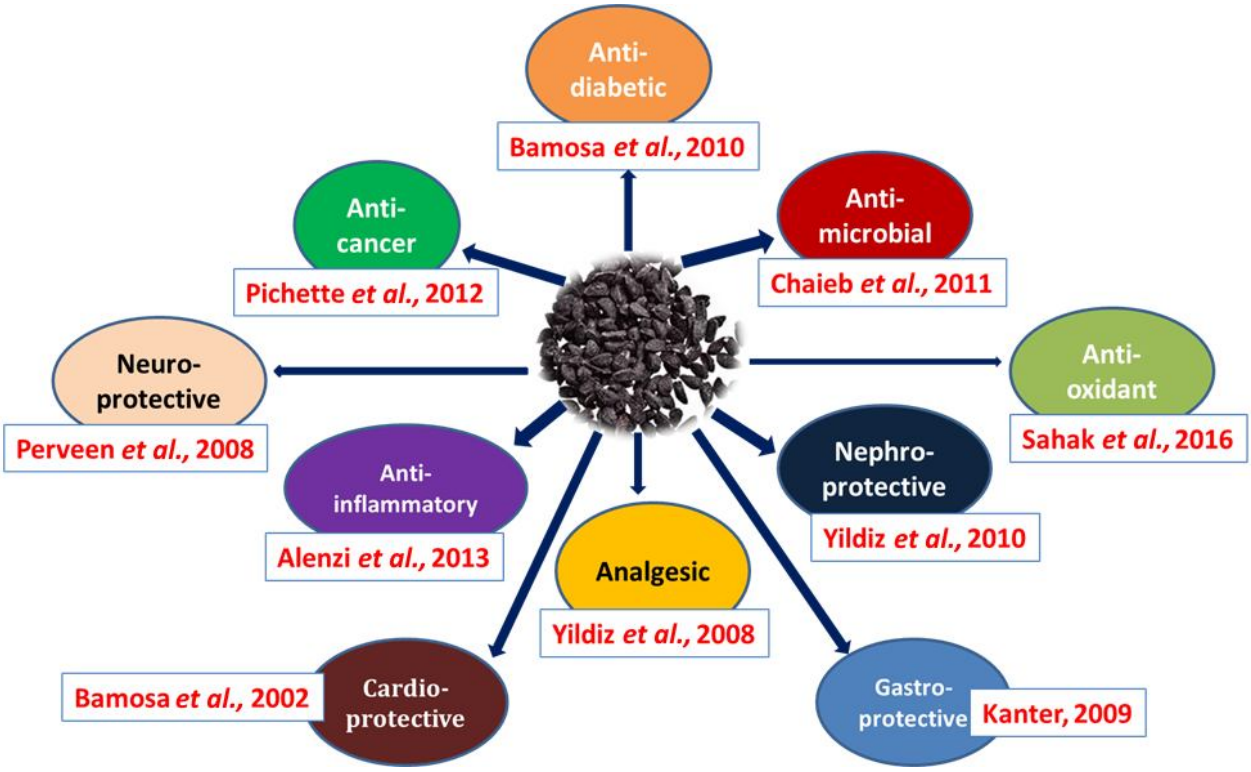

Fig. 1. Major biological properties of *Nigella sativa*

Majorly antimicrobial and antioxidants activities relieve the host animals from defense mechanism against invading pathogens through its secondary metabolites (Kumar *et al*., 2014; Sriranga *et al*., 2021). Moreover, more nutrient digestibility has been seen through NS supplementation (Ahmad *et al*., 2021; Sadarman *et al*., 2021). NS has been shown to increase the activity of thyroid hormones which stimulates more feed intake in small ruminants, hence, more available nutrients (Vander Tuig *et al*., 1979; Yildiz *et al*., 2008; Yildiz *et al*., 2010; Zanouny, 2011; Abd-ElMoty *et al*., 2015). Additionally, NS supplementation enhances lactogenic hormones which improve milk performance in small ruminants (Abo El-Makarim *et al*., 1999; Abd-ElMoty *et al*., 2015; Ahmad *et al*., 2021; Sadarman *et al*., 2021).

Effect of NS on nutrient intake and production performance of small ruminants

NS supplementation has positive role in growth and production performance of sheep and goats. Hassan and Hassan (2009) conducted experiment on supplementation of *Rosmarius officinalis* (RO), NS, probiotics or non-supplemented Karadi male lambs @ 7.5 g kg^{-1} DM of diet. Results of experiments revealed non-significant difference in nutrient intake. Supplemented groups gained body weight much faster than non-supplemented group. However, DMI was highest in probiotic supplemented group than other groups. Best FCR was evaluated in NS group followed by RO and Probiotic group than non-supplemented group. In connection with that Hassan *et al*. (2010) reported that NS supplemented groups showed improved live weight gains in Karadi lambs. However, carcass characteristics did not change in NS or rumen degradable nitrogen (RDN) supplemented groups. Notwithstanding that, NS and RDN supplemented lambs showed heavier slaughter yield and tail fat weight. El-Ghousein (2010) found that addition of either NSS or chamomile flower @ 10 g $animal^{-1}$ day^{-1} may suitably enhance milk production. In addition to that, weaning body weight, ADG of lambs from supplemented Awassi ewes were higher. However, Hassan *et al*. (2011) found a non-significant effect of NSS supplemented @ 7 g kg^{-1} DM or rumen un-degradable nitrogen (UDN) on live body gain of lambs. In addition to that, UDN and NSS supplementation did not adversely affect the carcass characteristics. Zanouny *et al*. (2013) investigated for 2 levels of NSS in different comparable groups of Ossimi male lambs. Supplemented groups received either no NSS or 100 mg kg^{-1} body weight of animal day^{-1} or 200 mg kg^{-1} body weight of animal day^{-1}. Outcomes of the study revealed that 100 mg kg^{-1} body weight of animal day^{-1} NSS supplementation may be incorporated in the diet. Habeeb and El-Tarabany (2012) found that supplementation of NS 2 g kg^{-1} DM enhanced body weight and ADG during hot climatic conditions.

Cherif *et al*. (2018a) conducted a study to evaluate the effect of supplementation of NSS on growth performance of Barbarine lambs fed on high (300 g kg^{-1} barley hay and 700 g kg^{-1} concentrate) or low (700 g kg^{-1} barley hay and 300 g kg^{-1} concentrate) levels of concentrates. NSS was supplemented @ 12 g kg^{-1} dry matter of feed. Results of the study showed significant improvement in dry matter intake (DMI), crude protein intake (CPI), NH_3N and average daily gain (ADG) in supplemented lambs. However, protozoal population and plasma triglycerides were reduced significantly. They concluded that 12 g kg^{-1} DM NSS supplementation may enhance growth performance in lambs without affecting normal physiology and their carcass characteristics. Obeidat (2020) showed that supplementation of NS meal may improve growth performance of Awassi lambs economically and may replace soybean and barley as protein and energy supplements considerably. He supplemented lambs with 15% NS meal on DM of diet basis for 80 days and observed significantly improved DMI, CPI, neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE) and metabolizable energy (ME) in supplemented

group. Final body weight, average daily gain (ADG) and feed efficiency was better in NS meal group. Additionally, the cost kg^{-1} body weight gain was also lower in supplemented than control group lambs. Odhaib *et al*. (2018a) randomly distributed 24 Dorper lambs into 4 comparable groups containing 6 animals in each group viz. control as T1 group; T2 supplemented with 1% RO; T3 supplemented with 1% NSS and T4 supplemented with 1% RO and 1% NSS. Results suggested significantly higher final body weight, DMI, ADG in T2 groups than other groups. FCR was non-significantly different among all groups. They remarked reduced nutrient digestibility may be encountered when supplementation is done beyond 1% NSS and RO levels. In other set of experiment, Odhaib *et al*. (2018b) showed that 1% NSS or RO levels may have beneficial effects on properties of mutton of Dorper lambs.

Abdullah and Farghaly (2019) tried to replace cotton seed meal with NS meal in their experiments on lambs at 33.3% and 66.7% replacement levels. Highest body weight and ADG was achieved in 66.7% replacement group followed by 33.3% levels than control group. Replacement groups showed increased DMI and CPI, however, feed conversion ratio (FCR) did not change across the groups. Additionally, increased NH_3N and total volatile fatty acids and nutrient digestibility was observed in replacement groups. They concluded that NS meal may safely replace cotton seed meal without adversely affecting growth performance of lambs in their growing stage. Retnani *et al*. (2019) conducted a randomized block design experiment for three levels of NS meal supplementation to lambs viz. 10% and 20% levels of diet DM for 8 weeks. Results revealed significantly higher ADG and blood urea nitrogen levels in supplemented groups than non-supplemented group. Higher nutrient digestibility was observed with increased levels of NS meal in the diet. They concluded that 20% NS meal inclusion in diet of lambs may enhance growth performance and nutrient digestibility with no adverse effect on blood biochemical and haematological profile of lambs. Alragubi (2017) took 21 Al-Bakri ewes of similar age and body weight and randomly distributed them into 3 groups with equal number of ewes and supplemented them with 5% and 10% levels of NSS than no supplementation in control group. Study showed that NSS supplementation may increase body weights of ewes followed by higher milk production. Study by Alragubi (2017) showed that NSS supplementation may increase fertility and % of weaned lambs through those ewes. Abd-ElMoty *et al*. (2015) showed that supplementation of 100 mg $head^{-1}$ day^{-1} significantly increased milk yield, fat, protein and energy contents than non-supplemented Ossimi ewes. Early studies by Mostafa (1998) recorded an increase of 46% milk yield in goats fed with NSS in his experiment. El-Saadany *et al*. (2008) also observed increased milk yield in Zairabi goats supplemented with 100 mg kg^{-1} NSS body weight. El-Basiony *et al*. (2015) experimented on 20 Damascus goats separated randomly and fed only basal diet or 4 g $head^{-1}$ day^{-1} *Echinacea pupurea* or 8 g kg^{-1} DM *Echinacea pupurea* or 7.5 g $head^{-1}$ day^{-1} NS or 10 g $head^{-1}$ day^{-1} *Cichorium intybus* for 98 days. Results of the study showed that supplemented group reflected improved nutrient digestibility, milk quality and quantity in lactating Damascus goats. Furthermore, Abdalla *et al*. (2015) concluded from their research that supplementation of NS meal @ 13.5 and 25% as a source of protein significantly improved productive performances in ewes. Higher lamb birth weight, average weaning weight and ADG to weaning were observed in supplemented groups. Milk fat, protein and total solids increased at 13.5% levels of NS meal. However, at 25% level of NS meal, highest solid not fat content was observed. However, Mahmoud and Bendary (2014) tried to substitute cotton seed cake and soybean meal through NS meal and sesame meal in diet of Bakri lambs with 12.5% of diet. They reported non-significant effect on production performances in all groups.

Effect of NS on blood metabolites and immunity status of small ruminants

Favorable effects of NS supplementation have been studied for blood metabolites and immunity status in small ruminants in different research findings. Elmowalid *et al*. (2013) showed that NS has immuno-modulatory properties in sheep through *in vitro* trial. Significantly higher levels of growth hormone, blood sugar, blood urea nitrogen and serum uric acid were observed in supplemented groups by Hassan and Hassan (2009). Nonetheless, supplemented group showed improved immunity status with normal haematological and bio-chemical parameters (Odhaib *et al*., 2018b). Non-significant changes in blood metabolite levels were marked in the study in supplemented and non-supplemented groups (Cherif *et al*., 2018a). Lower cholesterol, protozoan and liver enzyme levels were reported in supplemented groups (Abdullah and Farghaly, 2019). El-Hawy *et al*. (2018) studied NS meal supplementation as an alternative protein source in estrous synchronized pregnant Bakri ewes. NS meal supplementation was done at 13% and 25%. Non-significant difference was found across all groups for total protein, albumin, globulins, lipids and low-density lipid levels. But, NS meal group had better immune functions at increasing levels of NS meal. They concluded no adverse effects on haematological and biochemical parameters with improved immunity (IgA and IgG levels).

In connection to that, Aqil *et al*. (2017) took experimentally infected goats with peste des petis (PPR) virus to study the therapeutic and immunologic activities of NSS in them. Study revealed that NSS may enhance immunity and can play a vital role in reducing the pathogenecity of PPR virus in goat under field conditions. El-Far *et al*. (2014) attempted to estimate antioxidant and anti-nematodal activities of NS and *Zingiber officinale* (ZO) in ewes. Ewes were supplemented 3 g animal^{-1} day^{-1} with either NS or ZO. The results showed enhanced antioxidant activities, reduced oxidative stress, and reduced malondialdehyde levels. Gut health was also improved through supplementation of NS or ZO as shown by reduced per gram fecal eggs counts in ewes. Nanda *et al*. (2013) conducted a randomized field level study on non-descript goats supplemented with polyherbal mixture containing NS. Outcomes of study showed increased haematological indices and haemoagglutinition for enhanced humoral immunity status in supplemented goats. However, Zanouny *et al*. (2013) encountered no significant changes in blood metabolite and reproductive traits of male lambs. Habeeb and El-Tarabany (2012) found that supplementation of NS 2 g kg^{-1} DM enhanced reduced stress and immunity status and had no significant effects on blood haematology, liver and kidney functions in Zairabi kids during hot climatic conditions. Jain and Sahni (2010) found that significantly enhanced blood metabolite concentrations along with reduced per gram fecal egg counts were noticed when goats were supplemented with NSS in crude powder or aqueous extract form @ 500 mg kg^{-1} body weight animal^{-1} day^{-1} for 7 days. However, El-Hawy *et al*. (2018) suggested for conducting studies on the effect of NS meal on the gut health of ewes. El-Ghousein (2010) found that addition of either NSS or chamomile flower @ 10 g animal^{-1} day^{-1} may increase haematological and immunity indices observed in supplemented ewes with their corresponding followers.

Scope for further research

Before recommending dose level of NS (seed or oil cake) for any specific breed under a climatic condition should be followed by a scientific study in those conditions for favorable effects on different performances of small ruminants. Supplementation of NS used in different reviewed studies had large variations in dose levels from 0.02-25% of DM basis of diet. Hence, more uniform and highly effective least dose level should be worked out for economic and beneficial effects on small ruminants. Fewer studies have been done to investigate the effects of dietary

supplementation of NS to study reproductive performance and gut health of small ruminants. Hence, more studies are needed to study the reproductive performance and gut health of lambs, ewes, kids, goats in details. In addition to the stated points, economic analysis of supplementations of NS should be carried out for a holistic approach in recommending a particular dose level of NS in small ruminants.

Conclusion

Nigella sativa possess considerable nutritional qualities and may be used as phyto-additive to promote the performance of small ruminants. *Nigella sativa* contains beneficial plant secondary metabolites in which principle component is thymoquinone which shows antioxidant activities including other beneficial attributes. It may be remarked that dietary supplementation of *Nigella sativa* may have favorable effects on nutrient intake, nutrient digestibility, growth and milk performance, and reproductive performances along with improving immunity status and gut health of small ruminants when supplemented in their diets individually or in combination with other herbs. Additionally, it may also be used as alternative to protein sources such as soybean meal, cotton seed meal, etc. More studies are required to investigate the effect of *Nigella sativa* on reproduction, gut health and economics of supplementation of *Nigella sativa* in small ruminants.

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Author's contributions: AKS: Conceived the idea, drafted and edited; PS, UK, AK, SK: Assisted in pictorial representations, referencing and drafting of this manuscript.

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