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Beneficial health effects of cumin (*Cuminum cyminum*) seeds upon incorporation as a potential feed additive in livestock and poultry: A mini-review

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ABSTRACT

Cumin (*Cuminum cyminum* Linn) is an annual plant of the family Umbelliferae, with its use dating back to ancient times when it was cultivated for its medicinal and culinary potential. Cumin seeds could contain a wide variety of phytochemicals, including alkaloids, coumarins, anthraquinones, flavonoids, glycosides, proteins, resins, saponins, tannins, and steroids. In particular, linoleic acid, one of the unsaturated fatty acids found in abundance in cumin oleoresin, is credited with promoting good health. Many of cumin's purported biological actions in livestock and poultry have been attributed to flavonoids such as apigenin, luteolin, and glycosides. Cumin has several healthful qualities, such as antibacterial, insecticidal, anti-inflammatory, analgesic, antioxidant, anticancer, anti-diabetic, anti-platelet aggregation, hypotensive, bronchodilatory, immunological, anti-amyloidogenic, and anti-osteoporotic properties. Cumin supplementation may improve milk production and reproductive function in dairy cows by altering the feeding pattern of bacteria in the rumen, encouraging the growth of beneficial microbes, or

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Medicinal herbs

stimulating the secretion of certain digestive enzymes. Because of the low price of cumin seed, it could be concluded that its inclusion in the diet might be beneficial to the commercial poultry industry and reduce the overall cost of egg and meat production. In recent years a rise in cumin's popularity has been seen as a result of the herbal movement spearheaded by naturopaths, yoga gurus, advocates of alternative medicine, and manufacturers of feed additives. Animal nutritionists are exploring the use of cumin for its potential to boost growth, improve nutrient usage efficiency, and reduce greenhouse gas emissions. This mini-review discusses how cumin could be used as a feed ingredient to boost productivity and ensure healthy animal reproduction.

1 Introduction

The ability of animals to treat themselves in the wild demonstrates the degree to which livestock and agricultural production have always been self-sufficient (Chandran et al. 2019; Patange et al. 2022a). Nonetheless, the shift in emphasis from agricultural production to livestock health rather than animal feeding is an intriguing new trend. This connection is based on the phytochemicals or bioactive components in plants and medicinal herbs that are good for animal and poultry health if employed in enough amounts (Dhama et al. 2015; Chandran and Arabi 2019; Deepak et al. 2020a; Abdelli et al. 2021; Hartady et al. 2021; Buttar et al. 2022; Seidavi et al. 2022). Plants' bioactive compounds have long served as a lifeline for both livestock and humans, providing them with vital nutrition, acting as potent immunomodulatory agents and healing remedies, and also suggested for adjunctive usage as an alternative to antibiotics in the era of emerging drug resistance as well as countering emerging pathogens (Dhama et al. 2014; Yadav et al. 2016; Dhama et al. 2018; Tiwari et al. 2018; Chandran and Radhakarishnan 2019; Chandran 2021a; Uddin et al. 2021; Kumar et al. 2022a; Kumari et al. 2022; Patange et al. 2022b). Wild animals and other scavenging species frequently self-medicate by eating plants known to have therapeutic effects. Farmers began utilizing antibiotics and vaccinations to combat disease-causing organisms as a result of intensification, which increased morbidity and mortality in animals (Chandran 2021a). However, antibiotic resistance emerged due to incorrect dosing, skipping the withdrawal phase, and prolonged antibiotic use. As a result of this trend, the World Health Organization has advocated for a complete prohibition on the use of all medically important/high priority antibiotics in livestock production below the therapeutic threshold (Chandran 2021b; Chandran et al. 2022; Prakash et al. 2021b). Alternative feeding practices are essential in contemporary animal nutrition, and especially so for young animals, who are particularly vulnerable to health problems. We may need to look at how animals thrive in the wild, without the aid of synthetic antibiotics, if we are to find a workable answer to this problem. Through the discovery and development of several phytomedicines, scientists have demonstrated that medicinal plants like cumin contains bioactive chemicals that are capable of improving health via its antibacterial, anti-parasitic, hematological, and other key health aspects (Chandran and Athulya 2021; Chandran 2021a; Kumari et al. 2022).

Therapeutic uses have long been associated with cumin (*C. cyminum*), an annual herb of the Umbelliferae family. It was thought to have been cultivated primarily in the Mediterranean region. India is both a major producer and consumer of cumin. India also exports many cumin seed value-added goods, such as cumin oil and cumin oleoresins (Chandran 2021a; Kumari et al. 2022). Cumin seeds are a common Ayurvedic remedy for a wide variety of mild to moderate conditions, including diarrhea, dyspepsia, flatulence, colic, abdominal distension, edema, bronchopulmonary disorders, puerperal disorders, analgesic, and cough. The effects of cumin are multifaceted, and it can improve eyesight, muscular endurance, and lactation (Prakash et al. 2021a). In traditional medicine, cumin seeds have been used to cure a variety of conditions, including toothache, dyspepsia, epilepsy, and jaundice. Pharmacological actions include anti-diabetic, immunologic, anti-tumor, and antibacterial functions. Essential oils extracted from cumin have been used successfully to treat a variety of medicinal issues, including epilepsy, indigestion, wounds, jaundice, and several respiratory and gastrointestinal disorders. It has been studied and found to have therapeutic uses, including antibacterial, antioxidant, anticancer, immunologic, and anti-diabetic properties. Therefore, it is evident that the aforementioned qualities of cumin make it an effective feed additive (Kumar et al. 2017; Prakash et al. 2021b). Toxic chemical residues, especially from antibiotics, have been related to their consumption of animal products and their use in animal farming. In recent years, the use of organic feed additives in animal nutrition has received a lot of attention due to concerns about food safety and human health (Kumar et al. 2022b). Cumin can improve the quantity and quality of milk produced by cattle. Cumin also helps greatly with the fermentation process in the rumen. Despite the availability of chemical additives, cumin seed is rising in popularity as a feed supplement for animals. This could be seen as a corrective action to mitigate the negative effects of chemical residue accumulation (Alizadeh et al. 2019). This review concentrates on the possibilities of using cumin seeds for boosting the comprehensive well-being of livestock.

2 Biochemical compositions of cumin seed

The nutritional composition of cumin seeds comprises carbohydrate (33 percent), fat (15 percent), protein (12 percent), starch (11 percent), fibre (11 percent), total ash (10 percent), moisture (7 percent), volatile oil (3-4 percent) and minerals (5.4-10.5 percent) (Gamal et al. 2021). Cumin seeds contain a plethora of essential oils, including saturated and unsaturated fatty acids such as petroselinic acid, oleic acids, and other fatty acids. Cumin's distinctive taste originates in its essential oils. Neutral lipids, glycolipids, and phospholipids make up 84.8 percent, 10.2 percent, and 5.1 percent of the dry weight of cumin seeds, respectively. Cuminaldehyde, p-cymene, cuminol, β-pinene, and terpenoids are the primary volatile components of cumin. Cumin has a distinctive strong flavour. It's warm aroma is due to its essential oil content. It's main constituents of aroma compounds are cuminaldehyde and cuminic alcohol. Other important aroma compounds of roasted cumin are the substituted pyrazines, 2-ethoxy-3-isopropylpyrazine, 2- methoxy-3-sec-butylpyrazine, and 2-methoxy-3- ethylpyrazine. Other components include γ-terpinene, safranal, p-cymene, and β-pinene. The oil content, quality, and nutritional composition have all been shown to vary, according to the research undertaken, depending on the country of origin and the growing conditions (Kumar et al. 2017). Figure 1 shows the biochemical makeup of cumin seeds.

3 Beneficial effects of incorporating cumin seeds in livestock feed

The beneficial effects of cumin seeds upon incorporation into livestock feed are depicted in Figure 2.

3.1 Influence of cumin seed on milk production and milk quality

For dairy farming to be sustainable, novel methods are needed to increase milk output while decreasing costs (Deepak et al. 2020b; Lejaniya et al. 2021a; Saleena et al. 2022a; Saleena et al. 2022b). Feedstuff prices, in particular, have been rising steadily in emerging countries like India, highlighting the urgent need for more efficient production processes. The demand for animal products is expanding because human beings depend prominently on these products to fulfilling their nutritional requirements (Chandran et al. 2021b; Lejaniya et al. 2021b; Sharun et al. 2021). The galactagogue herb *Payapro* has cumin as one of its main ingredients. Goat milk production was increased by 13 percent when cumin seed extract (1.27 percent of dry matter) was added compared to the control group (Chandran et al. 2021a). Miri et al. (2013) also experimented on lactating goats and found that cumin seed incorporation in the diet increased milk production by 13% in less-supplemented groups. The significant increase in monounsaturated and polyunsaturated fatty acids (PUFA) can also

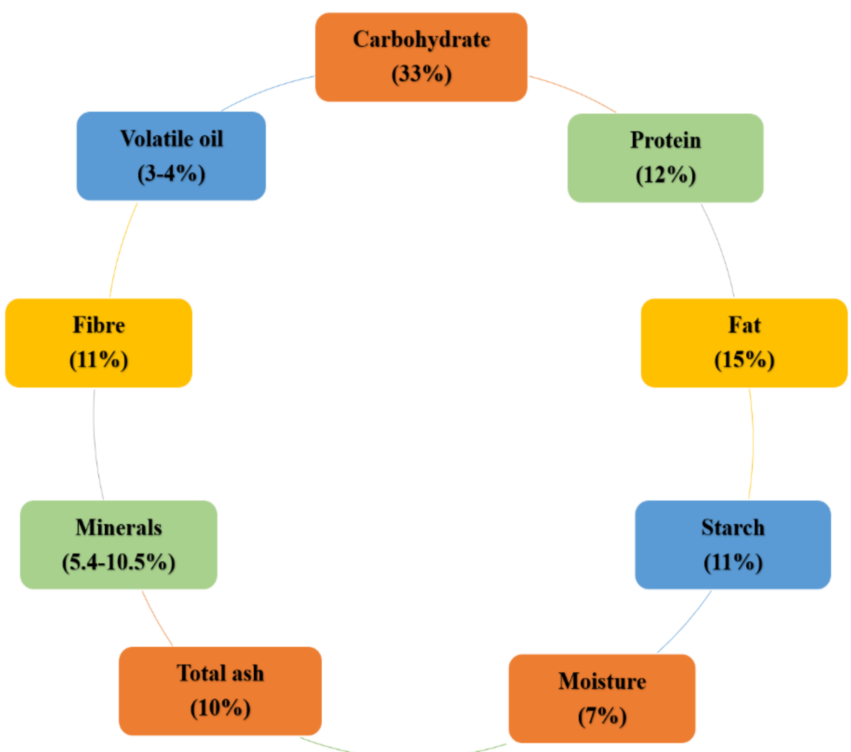

Figure 1 Biochemical composition of cumin seed

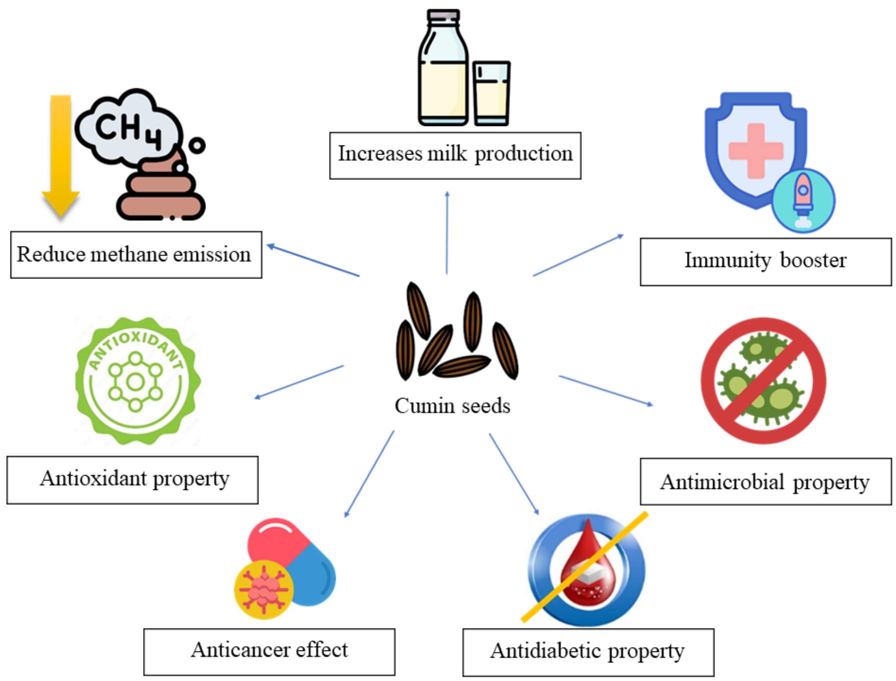

Figure 2 Beneficial health effects of cumin seed

be attributed to cumin seed supplementation in the diet. The ratio of PUFA to saturated fatty acid content in milk was well augmented, in addition to the higher concentration of conjugated linoleic acid (increased by 20 percent) and significant increase in δ-9 fatty acid desaturase (the enzyme responsible for the production of monounsaturated fatty acid) levels were significantly raised. This study demonstrates that the conjugated linoleic acid and PUFA content in livestock milk can be improved by the supplementation of cumin seed in their feed. Goats given 1g/L cumin seed extract had more linoleic acid and linolenic acid recovered in their milk. Tannins and other polyphenols can influence fatty acid metabolism at several points in the rumen's biohydrogenation process. Petroselinic acid (C18:1n-12), found in cumin, has been demonstrated to prevent the conversion of linoleic acid to arachidonic acid and may explain in part the rise in linoleic acid concentration in goat milk given cumin seed extract, as documented by (Bettaieb et al. 2011).

3.2 Role in enhancing nutrient utilization

Extensive studies show that feeding animals a diet that include cumin seeds increases their efficiency in digesting and using those nutrients (Kumar et al. 2017). Cumin seeds had no unfavorable effect on the palatability of the diet, as evidenced by no change in dry matter intake and milk composition (Heidarian et al. 2013). Broilers fed a meal supplemented with cumin oil gained considerably more weight than control animals. It has been also reported that including 2 percent cumin in the diet of heat-stressed broilers helped mitigate the detrimental effects of heat stress and improved growth performance. Increases in body weight gain, feed intake and feed conversion ratio were observed in broilers fed diets containing 0.75 and 1 percent cumin and turmeric mixture, respectively (Al-Kassi 2009). These results may be attributable to cumin's stimulant, carminative, digestive, antimicrobial, and gastric toxicity-preventative properties.

3.3 Effect on methane abatement

Fermentation in the hindgut of livestock produces methane, an essential component of greenhouse gases, and is one of the primary sources of greenhouse gases (Sorg 2022). When it comes to the greenhouse gases released into the atmosphere, agriculture and other land use practices account for about 24 percent of the total amount (Adegbeye et al. 2019). Cattle are responsible for 65% of total greenhouse gas emissions from the livestock sector, making it the largest contributor to global warming. Methane is predominantly created as a result of rumen fermentation in cattle; hence it is vital to lessen the methane production from animals, with feed additives playing a major role. Supplementing a goat's diet with cumin seed extract has been shown to reduce methane emissions by 11.8 percent *in vitro*, and by as much as 22 percent in buffered rumen fluid. Cumin seed extract may have an inhibiting effect on ruminal microbial biomass, which may explain this phenomenon. If the proliferation of gram-positive H_2-producing bacteria in the rumen is inhibited, less hydrogen is available for biohydrogenation and methanogenesis. It stands to reason that if protozoa are eradicated, the host animal will benefit from increased conjugated linoleic acid availability and methane emissions will decrease. Herbal components including essential oils, saponins, and tannins have been found to act as rumen modifiers and reduce harmful emissions (Kuralkar and Kuralkar 2021). The rumen's gram-positive bacteria produce the hydrogen used in the process of methanogenesis. Therefore, cumin's inclusion in the diet has a deleterious effect on these species.

3.4 Antimicrobial action

The essential components of cumin seed essential oil include cumin aldehyde, ρ-mentdien-1,3-al-7, ρ-mentadien-1,4-al-7, ρ-cymene, β-pinene, and γ -terpinene (monoterpene carbohydrates), sabine hydrate, 1,8-cineole, caryophyllene, α-terpineol, and many other elements. The antibacterial properties of cumin essential oil are due to the presence of phenolic components such as cymene, limonene, and linalool (Teneva et al. 2016). It has been shown that essential oils can inhibit the growth of gram-positive and gram-negative bacteria and fungi. However, the effect can vary due to differences in essential oil strength and the types of bacteria that are being targeted (Alizadeh et al. 2019). Antimicrobial and antifungal properties were exhibited by cuminaldehyde against *Aspergillus flavus*, *A. niger*, *Penicillium chrysogenum*, *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus epidermidis*, and yeasts (*Saccharomyces cerevisiae* and *Candida albicans*). Its effect on the curb of certain diseases due to *P. aeruginosa* infections has been reported by Kumar et al. (2017). The larvicidal and antibacterial properties of cumin oil and cumin aldehyde were found to be quite potent. Cumin seeds were observed to reduce acid production and development of *Lactobacillus plantarum* in an *in vitro* investigation conducted by Singh et al. (2017). Extensive research shows that cumin oil is effective against a wide variety of food, soil, animal, and human infections (Kumar et al. 2017; Prakash et al. 2021b).

3.5 Antioxidant property

Unpaired electrons in the outermost shell of atoms make free radicals highly reactive species. An increase in the body's free radical production can result in oxidative stress, which can damage vital biomolecules and set off a cascade of adverse events that can lead to a variety of degenerative conditions. Antioxidant enzymes provide a natural defense against free radicals, or animals can supplement their diet with antioxidant vitamins and minerals. Research done in India has shown that the flavonoids in cumin seeds, especially apigenin and luteolin, provide the oil with a high level of antioxidant activity, which as a bonus, enables cumin seeds to function as an antioxidant. Essential oils derived from cumin seed include potent anti-oxidant properties. Cumin cultivars' phenolic contents in methanolic extracts varied from 4.1 to 53.6 mg/g dry weight. Cumin seed has a phenolic concentration of 9 mg/g (dry weight). Additionally, it was predicted that the methanolic extract of cumin seed had a higher antioxidant property than the aqueous extract (Nadeem and Riaz 2012). The phenolic components and antioxidant activity of 26 spice extracts, including cumin, were analyzed in a separate investigation conducted by Fatima et al. (2018). The trolox equivalent antioxidant capacity (TEAC; mmol trolox/100 g dry weight) was used to quantify the antioxidant activity. The total phenolic content of cumin was 0.23g of gallic acid equivalent per 100g of dry weight, and its trolox concentration was 6.61 mmol/100g. The antioxidant properties of cumin were assessed using several different techniques, including the DPPH (1-1 diphenyl-2-picrylhydrazyl) radical scavenging method, the soybean lipoxygenase-dependent lipid peroxidation methods, and the Fe^{2+} ascorbate induced rat liver microsomal lipid peroxidation assays. Cumin seed methanol extract inhibits rat liver microsomal lipid peroxidation with an IC 50 of 0.16±0.30. The IC 50 values for the DPPH radical scavenging method and the

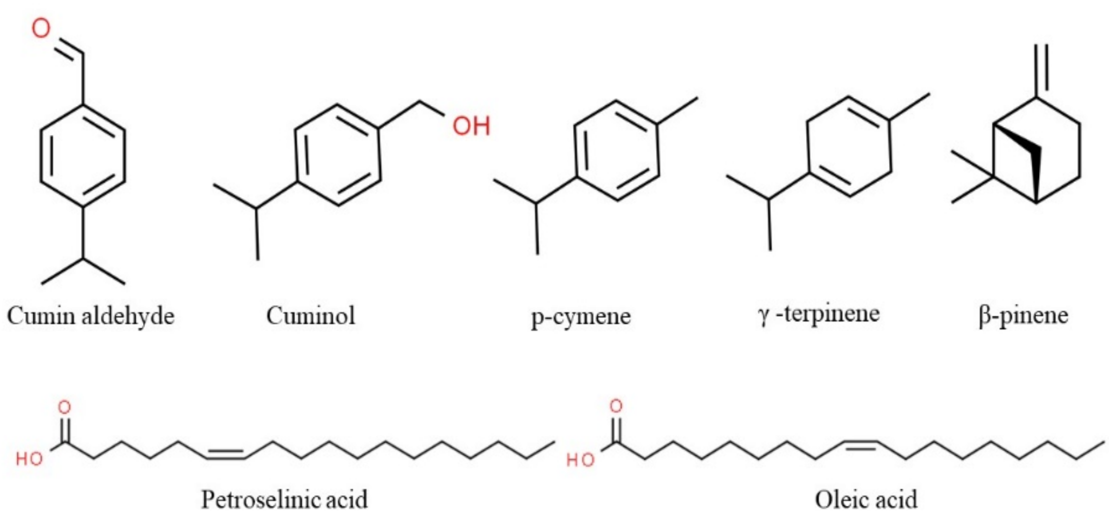

Figure 3 Chemical composition of cumin seed essential oil

lipoxygenase-dependent lipid peroxidation systems were 0.52±0.01 and 0.72±0.02 respectively (Wei et al. 2015). Cumin's ability as an antioxidant and its overall phenolic concentration are intertwined. This spice can be used as a natural antioxidant besides used as a flavoring agent (Nadeem and Riaz 2012). Superoxide dismutase, catalase, and reduced glutathione were all reported to be increased in mice fed cumin seed supplements; however, glutathione peroxidase and glutathione reductase activities were unaffected. It has also been shown that cuminaldehyde can scavenge the superoxide anion. The antioxidant activity of cumin seed extracts was validated by Juhainmi and Ghafoor (2013), who found that supplemented mice had higher DPPH radical scavenging activities than non-supplemented animals throughout a range of concentrations from 8.25 to 11.24 mg/mL. Cumin's phenolic component level was linked to its antioxidative capability, they said. A lower risk of cancer and cardiovascular and cerebrovascular problems may result from consuming foods high in bioactive substances with strong free radical scavenging properties.

3.6 Antidiabetic activity

A glucose tolerance test conducted in rabbits showed area expansion under the glucose tolerance curve and hyperglycaemic peak (Kumar et al. 2017). The inclusion of cumin seeds (at 1.25 percent) in the ration of streptozotocin-induced diabetic rats was found to be beneficial, as evidenced by lower levels of hyperglycemia and glucosuria, followed by an increase in body weight of diabetic animals. Diabetic mice also exhibited other metabolic alterations, including decreased blood urea levels and urea and creatinine excretions. Body weight, tissue and plasma cholesterol, free fatty acids, phospholipids, triglycerides, alkaline phosphate, γ-glutamyl transferase, and aspartate transaminase were all decreased in alloxan diabetic rats after oral administration of cumin seeds, possibly due to inhibition of aldose reductase and α-glucosidase (Singh et al. 2017).

3.7 Role in immunity development

Cumin plays a chief part in developing anti-inflammatory responses in livestock (Figure 4). Inflammation is a defense mechanism animals use to fight off infections and heal damaged tissues (Broom and Kogut 2018). Chauhan et al. (2010) evaluated the immunomodulatory properties of cumin seeds using flow cytometry and ELISA in immunosuppressed and normal animals. Cyclosporine-A was induced in Swiss albino mice and they were dosed orally with cumin seeds (25, 50, 100, and 200 mg/kg) on successive days. As a result, there was a dramatic rise in the population of T (CD4 and CD8) cells. These data support the hypothesis that cumin seeds help in the maturation of immunological responses in animals by modulating the expression of T cells. Cumin seeds decreased adrenal gland growth and reduced elevated corticosterone levels in immune-suppressed animals (Gamal et al. 2021). These findings provide credence to the idea of using cumin seed as an immunomodulator for those with compromised immune systems.

3.8 Role in mitigation of animal osteoporosis

Due to the presence of phytoestrogens, cumin seeds have estrogenic and anti-osteoporotic properties. Animals fed a diet supplemented with cumin seed extract had significantly lower urine calcium excretion, greater bone strength, and more calcium content. Improvements in bone ash density and microarchitecture were also documented, with no adverse effects such as weight gain or uterine atrophy (Chauhan et al. 2010).

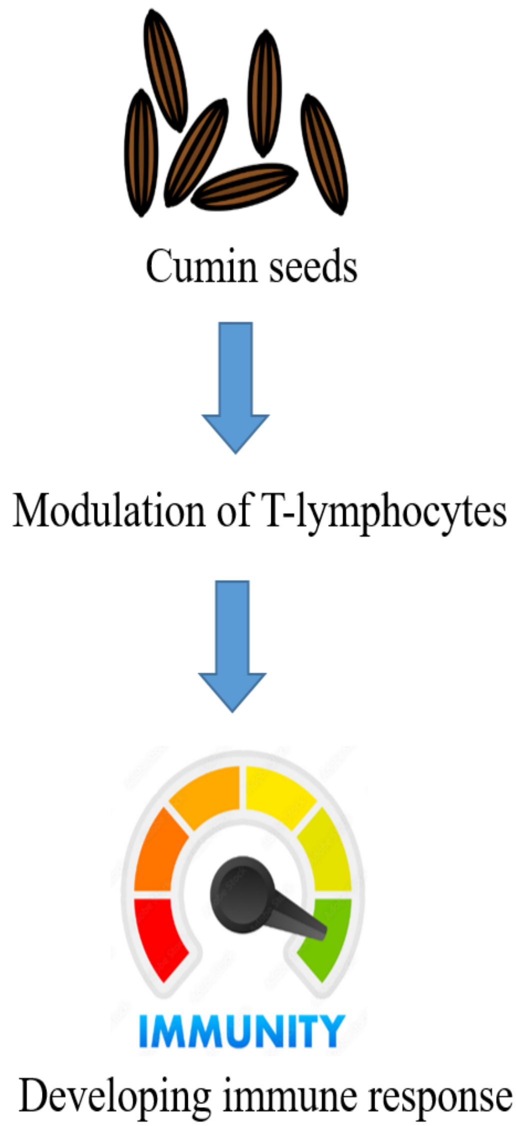

Figure 4 Immunogenic effect of cumin seeds

3.9 Anti-carcinogenic effect

Considered a necessary immune response to both ensnare invading pathogens and repair injured tissues; inflammation is at the forefront of modern immunology. On the other hand, inflammation is thought to be harmful because it causes nutrients to be redirected away from their productive uses. As a result, natural substances can be used as feed additives to better control tumor growth (Broom and Kogut 2018). Cumin is a blend of numerous herbs, several of which have been shown to have anticancer effects. Rats were fed cumin seeds in experiments designed to determine whether or not they affected preventing cancer. They exhibited resistance to colon cancer after being experimentally infected with the disease. Beta-glucuronidases activity and mucilage activity both decreased. It was found that uterine tumorigenesis which was induced by 3-methylcolanthrene, forestomach cancer tempted by benzopyrene, and hepatomas encouraged by dimethylaminoazobenzene in mice were prevented by the cumin provided in their diet. Metabolizing phase I enzyme and phase II enzyme present in cumin seeds are attributed to the modulation of cancerous mechanisms in mice (Kumar et al. 2017; Gamal et al. 2021).

3.10 Digestive stimulant action

Cumin seeds have been used in folk medicine and alternative medicine for centuries on the belief that they stimulate digestive enzymes; recent animal research by Fatima et al. (2018) confirmed this assertion. It has been studied extensively how both chronic feeding and single oral administration of cumin seeds affect the production of digestive enzymes in the pancreas and intestinal mucosa of rats. Lipase activity in the pancreas was inhibited by dietary cumin (1.25 percent), but trypsin, chymotrypsin, and amylase activity were all significantly increased. Cumin's ability to inhibit pancreatic lipase, amylase, trypsin, and chymotrypsin activity was demonstrated after a single oral dose was administered. Maltase activity in the small intestine was dramatically increased in rats fed cumin, while lactase and sucrose activity was unaltered (Abd El-Hack et al. 2016).

Although a single oral dose of cumin did not influence the rate of bile secretion, it did have a strong stimulatory effect on bile flow rate, increasing bile volume by 25 percent, as evidenced in the investigation of Shan et al (2005). Cumin had a significant impact on bile acid secretion (how much is secreted in a given amount of time), leading to a 70 percent increase compared to the control group. Cumin, when given orally, also significantly increased bile acid output after a single dose (Kumar et al. 2017). It stands to reason that cumin, which has a digestive stimulant action, might do so by stimulating the biliary secretion of bile acids, given that bile juice makes a significant contribution to the overall process of digestion and absorption, primarily by supplying bile acids required for micelle formation. The effect of the digestive stimulant spice cumin on the time it takes for food to leave the intestines of experimental rats has been investigated in a separate investigation. The use of cumin greatly reduced the time it took for the food to be delivered, by around a quarter of an hour. Cumin's positive effects on digestive enzymes and bile secretion roughly correlate with the shorter transit time it produces in the digestive tract (Fatima et al. 2018; Chandran 2021a).

3.11 Pulmonary-protective activity and anti-asthmatic effects

Research on the potential protective effects of cumin seed on experimental lung injury in rats following pulmonary aspiration revealed that cumin seed therapy suppresses inflammatory pulmonary responses. Additionally, it led to a notable decrease in iNOS activity and an increase in surfactant protein D in the lung tissue of various pulmonary aspiration models (Abdelli et al. 2021). The treatment with cumin seeds may help treat lung damage, which justifies prospective therapeutic application. Additionally, it has been found that cumin seed essential oil can help rats with hyperoxia-induced lung damage (Fatima et al. 2018).

Conclusion

One of the most widely used seed spices, cumin can be found in a wide variety of spice blends that are a regular part of the diet of animals and human beings. The chemical makeup of cumin included alkaloids, coumarins, anthraquinones, flavonoids, glycosides, proteins, resins, saponins, tannins, and steroids. Cumin oleoresin and its fatty acid composition are particularly high in linoleic acid, an unsaturated fatty acid with numerous positive health effects. Many of cumin's biological actions are attributed to flavonoids such as apigenin, luteolin, and glycosides. Cumin's nutritional profile revealed that it was rich in nutrients including thiamine, riboflavin, and niacin, in addition to the more commonly known carbohydrate, protein, and fat. It also contained iron and minerals in high concentrations, including iron and zinc, that are helpful for energy production, boosting the immune system, and treating skin diseases. The pharmaceutical and general applications of cumin are very extensive. Cumin is a popular and nutrient-rich spice, but it has recently been linked to several adverse effects, which suggests it should be used with caution in conjunction with therapeutic medications. Cumin seeds have been shown to have antimicrobial, insecticidal, inflammatory, analgesic, antioxidant, anticancer, anti-diabetic, anti-platelet aggregation, hypotensive, bronchodilatory, immunological, anti-amyloidogenic, and anti-osteoporotic effects. Based on the findings of this analysis, it can be concluded that using cumin as a feed additive in low doses has no negative effects on animal welfare and increases both nutrient consumption and production efficiency.

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Author's Contribution

All the authors contributed significantly.

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Disclosure statement

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