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USABILITY OF HEMP PLANT IN POULTRY NUTRITION

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Abstract: Hemp (*Cannabis sativa* L.) is an annual plant with 2n=20 chromosomes, one-year, C3 group, cultivated for its long and strong fibers and seeds. It is a plant that should be cultivated in a controlled manner due to the presence of THC (tetrahydrocannabinol) in its natural structure. Producers who avoid control and monitoring have turned to alternative products instead of hemp farming. Countries that cultivate cannabis in large areas; France, China, and Canada. Some countries are updating their cannabis-related laws and making efforts to increase hemp acreage. It is known that hemp farming has been practiced in Anatolia since 1500 BC. Various products such as hemp seeds, hemp pulp, hemp oil have been used in various studies in poultry feeding studies, while no negative results have been encountered, but various positive results have been suggested and their use is recommended. It is of great importance to investigate the effects of cannabidiols, which have strong antimicrobial, antioxidant and immunostimulant effects, as they are expected to support the immune system in poultry, especially broilers. Some of the studies in which hemp products are used in poultry nutrition are as follows; Addition of hemp meal to laying hen diets has been reported to make no significant difference in egg production, feed consumption, feed utilization, body weight gain or egg quality, but results in lower palmitic acid concentrations and higher Linoleic acid (LA) and alpha-linolenic acid (ALA) concentrations, which are healthier for human consumption. Hemp seeds and hemp oil used in chicken rations caused an increase in the omega-3 polyunsaturated fatty acid content and color intensity of egg yolks, but no adverse effects were observed on the sensory profiles of cooked eggs. Addition of cannabis meal to fast growing broiler diets did not affect performance or mortality, and no effect on the number of *Clostridium perfringens* in the cecum was reported. Hemp seeds have a remarkable effect on the growth of broiler chicks and can help reduce feed expenditures for broiler rearing. In this paper, the use and usability of the hemp plant, whose production areas are expanding rapidly, in poultry will be examined.

Keywords: Poultry nutrition, Hemp, Antioxidant, Immune system, Feeding performance

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1. Introduction

For the assessment and analysis of different feed sources to ensure the long-term viability and sustainability of the livestock and animal products sectors, it is crucial to conduct a thorough investigation into the presence and accessibility of lesser-known and underutilized feed sources (Salami et al., 2019).

Cultivated hemp, belonging to the annual plant species within the *Cannabinaceae* family, is characterized by its unique features. This plant, which has been the subject of foreign fertilization, possesses a chromosome count of 2n=20, showcasing its genetic makeup. As described by Small and Cronquist in 1976, hemp exhibits both dioic and monoic types, presenting a diverse reproductive system. In the dioic variety, male and female flowers are segregated on distinct plants, highlighting a clear distinction in their reproductive structures. Conversely, in monoic types, the male and female flowers coexist on the same plant, albeit in different sections of the inflorescence, demonstrating a fascinating botanical phenomenon. Renowned for its multifaceted utility, hemp serves as a pivotal industrial plant that caters to various sectors, utilizing almost all parts of its anatomy. Its significance within the industrial realm stems from its widespread applications across different industries, positioning it as a versatile botanical resource. Within the realm of industrial plants, hemp is classified into various types, including *Cannabis sativa, Cannabis indica,* and *Cannabis ruderalis*, each possessing distinct characteristics and properties (Schultes et al., 1975). Over the years, the fibers, seeds, leaves, and flowers derived from the stems of hemp have emerged as the most valuable and extensively utilized components, underscoring their economic importance. The chemical composition of hemp is subject to multiple factors such as varietal differences, processing techniques during pressing, and seed processing methods, as expounded by House et al. (2010), shedding light on the intricate chemical profile of this industrially significant plant.

The aim of this study is to evaluate the impact of hemp plant utilization in poultry farming on the nutrition, health, and production performance of chickens. Our hypothesis suggests that hemp-based feed may enhance the growth rate of chickens, increase egg production, and strengthen the immune system of poultry. Additionally, we anticipate that the utilization of hemp as poultry feed could offer environmental and economic sustainability advantages. This study aims to provide a comprehensive assessment to understand the potential role of hemp in the poultry industry.

2. Hemp Parts Used in Poultry Feeding

2.1. Hemp Seeds

Most varieties of hemp are cultivated with the primary goal of seed production, with the most valuable output being hemp oil (Callaway, 2004). The hemp seed typically contains 30-35% seed oil, which is extracted through the cold pressing method, ensuring the preservation of the oil's physical and chemical properties (Hazekamp et al., 2010). The remaining solid byproduct after oil extraction is known as hemp pulp. Depending on the processing technology used, a portion of the oil (0.4-10%) may still be retained in the hemp pulp (House et al., 2010). Hemp seeds are predominantly utilized in animal nutrition, primarily for ornamental birds that are not intended for food production, accounting for approximately 95% of their usage. The remaining 5% is allocated to the food sector. The chemical contents of hemp seeds are given in Table 1.

Table 1. Nutritional value of hemp seeds in terms of vitamins and minerals (Göre and Kurt, 2021)

Source	(mg/100g)
Vitamin E (total)	90.00
alpha-tocopherol	5.00
gamma-tocopherol	85.00
Thiamine (B1)	0.40
Riboflavin (B2)	0.10
Phosphorus (P)	1.16
Potassium (K)	859.0
Magnesium (Mg)	483.0
Calcium(Ca)	145.00
Iron (Fe)	14.00
Sodium (Na)	12.00
Manganese (Mn)	7.00
Zinc (Zn)	7.00
Copper (Cu)	2.0

Hemp seeds are known for their rich protein content and as a source of omega-3 fatty acids. Recent findings suggest that incorporating omega-3 and omega-6 fatty acids into poultry feed can have beneficial effects on immune responses, egg quality, meat nutrition, and growth. Performance within hemp seeds, essential fatty acids such as linoleic acid (omega-6) and α-linolenic acid (omega-3) can be found (Smith, 2000). The chemical contents of hemp fatty acids are given in Table 2.

Gakhar et al. (2012) demonstrated that adding 20% hemp seed to egg-chicken rations increased egg weight and omega-3 fatty acid content without impacting egg yield or specific gravity.

Khan et al. (2009) observed that including up to 20% dried and crushed hemp seeds in broiler diets led to increased breast and thigh weights. This positive outcome was attributed to the high-quality protein and lipid combination, along with the beneficial properties like the absence of trypsin inhibitors and the antioxidant activity of cannabidiol. Another study by Khan et al. (2010) showed that feeding broiler chickens with 20% hemp seed improved feed conversion rate, live weight gain, slaughter age, and mortality rate. Kalmendal (2008) explored the use of hemp seed cake in organic broilers and found that its nutritional value was comparable to rapeseed pulp. Mahmoudi et al. (2012) discovered that including hemp seed in broiler diets up to 7.5% did not negatively impact performance and even reduced serum cholesterol levels. Their subsequent study revealed that incorporating hemp seed meal in the diets of fast-growing organic broilers had no adverse effects on production performance or mortality rates. These studies collectively suggest that hemp seeds can be safely incorporated into poultry diets up to 30% without compromising their intended purpose.

2.2 Hemp Flowers and Cannabinoid Extract from Flower

Cannabis sativa L. has been extensively studied, leading to the identification and isolation of over 500 compounds, as reported in various studies (Pellati et al., 2018; Al Ubeed et al., 2022). Among these compounds, a total of 566 have been pinpointed and grouped into more than 18 categories of secondary metabolites, showcasing the remarkable chemical diversity present in this plant species.

Table 2. The chemical contents of hemp fatty acids (Siano et al., 2019)

Source	Component	Flour oil	Cold pressed oil	Seed oil
1	Palmitic, C16:0	7.35	7.15	7.03
2	Stearic, C18:0	2.62	2.73	2.78
3	Oleik, C18:l ω-9c	12.79	12.75	12.74
4	Linoleic, C18:2 ω-6c	56.42	56.08	56.16
5	Arachidic, C20:0	0.74	0.89	0.81
6	γ-Linolenik, C18:3ω-6	3.00	3.03	2.94
7	cis-II-Eicosinoic C20:l	0.45	0.26	0.37
8	α-Linolenik, c18:3 ω-3	14.55	14.89	15.02
9	cis-ll, 14-Eikosinoic C20:2	0.82	1.03	0.99
10	Behenik, C22:0	0.29	0.20	0.27

Notably, the flowers and leaves of *Cannabis sativa* L. are particularly rich in these bioactive compounds, as highlighted in recent research (Kopustinskiene et al., 2022). Specifically, the identified compounds include 125 cannabinoids, 198 non-cannabinoids, and 120 terpenes. Recent investigations in 2021 have further expanded this list to reveal the presence of 2 alkaloids, 34 flavonoids, 42 phenols, and 3 sterols within the plant matrix (Al Ubeed et al., 2022). This comprehensive characterization underscores the complexity and pharmacological potential of *Cannabis sativa* L., offering a wealth of chemical entities for further exploration and exploitation in various fields of science and medicine. Moreover, the distinct aromatic profile of Female Hemp plants can be attributed to terpenes such as pinene, limonene, terpineol, and borneol, which are synthesised within the plant tissues (McPartland and Russo, 2001). These terpenes not only contribute to the sensory experience associated with Hemp consumption but also play a crucial ecological role by repelling insects and inhibiting the growth of competing vegetation. A key defensive mechanism employed by *Cannabis sativa* L. involves the production of resin by glandular trichomes, which possess antibiotic and antifungal properties, serving as a natural shield against pests and pathogens. Within these trichomes, a myriad of secondary metabolites, including phytocannabinoids and terpenoids, interact synergistically to safeguard the plant from external threats while also imparting its distinctive odor profile (Andre et al., 2016).

2.2.1. Some cannabinoids and their mechanism of action

The most well-known and studied cannabinoids in the Hemp plant are THC (tetrahydrocannabinol) and CBD (cannabidiol)The therapeutic potential of CBD, a prominent cannabinoid in *Cannabis sativa* L., has garnered significant attention due to its reputed health benefits across diverse medical conditions. CBD has been linked to an array of therapeutic effects, including relaxation, anxiety relief, and pain management, with documented efficacy in alleviating symptoms associated with cancer chemotherapy-induced vomiting, glaucoma, anorexia, neuropathic pain, spasticity, and other ailments. Approved for medical use in numerous countries, particularly in North America, CBD-based products are widely available in various formulations such as oils, capsules, topicals, and dietary supplements, catering to different consumer preferences. While CBD shares a molecular weight with THC, the psychoactive component of Hemp, it stands out for its analgesic, antiepileptic, antibacterial, anti-inflammatory, and antidepressant properties, making it a valuable therapeutic agent for both acute and chronic pain management (Beşir et al., 2022).

The multifaceted immunomodulatory and antioxidant actions of CBD are underpinned by intricate molecular mechanisms that involve interactions with various immune cells and inflammatory pathways. CBD exerts modulatory effects on activated B cells and interferon-β/signal transducer and activator of transcription pathways, influencing cellular inflammation cascades such as the nuclear factor kappa-light chain enhancer pathway. By targeting adenosine receptor A2A and modulating adenosine reuptake, CBD can finely tune the activities of immune cells like neutrophils, macrophages, and T cells within the inflammatory milieu. Additionally, CBD impacts cytokines including interferon-c, interferon-γ (Lee ve Erdelyi, 2016), tumor necrosis factor α (Magen et al., 2009; Rajesh et al., 2010; Khaksar ve Bigdeli, 2017; Wang et al., 2017), interleukin (IL)-1β (IL-1β) (Pazos et al., 2013; Wang et al., 2017), IL-6 (Lee ve Erdelyi, 2016) as well as adhesion molecules like ICAM1 and VCAM1, thereby regulating inflammatory responses at multiple levels (Rajesh et al., 2010). Furthermore, CBD exhibits anti-apoptotic effects by reducing caspase 9 activation (Castillo et al., 2010) and inhibiting caspase 3 (Rajesh et al., 2010; Da Silva et al., 2014; Santos et al., 2015), key components involved in apoptotic pathways. Importantly, CBD boosts the production of the anti-inflammatory cytokine IL-10, further enhancing its immunomodulatory properties and underscoring its therapeutic potential in managing inflammatory disorders (Kozela et al., 2017).

The endocannabinoid system is a complex network within the human body that includes cannabinoid receptors, endocannabinoids, and enzymes responsible for the synthesis and breakdown of these compounds. It has been extensively studied in recent research as a potential target for treating various pathological conditions. This intricate system plays a crucial role in numerous physiological processes such as regulating energy balance, stimulating appetite, controlling blood pressure, providing analgesia, managing nausea and vomiting, facilitating memory and learning, and modulating immune system responses, as highlighted in studies by Balpınar and Aytaç (2021). Anandamide and 2-arachidonylglycerol are well-known endocannabinoids that act as signaling molecules within the brain, allowing for the adjustment of input signals from parent cells. Moreover, the endocannabinoid system has its own hemp molecules, which operate in a retrograde manner from dendrites to axon terminals, aiding in the fine-tuning of neuronal communication.

The endocannabinoid system has garnered significant attention due to its potential therapeutic implications in various health conditions. Notably, it interacts with a nuclear receptor called PPAR-γ, which is involved in regulating metabolic and inflammatory processes, as pointed out by O'Sullivan and Kendall (2010). Cannabinoids found in hemp, other than THC, interact with the endocannabinoid system receptors at a lower rate and with less affinity, as reported in studies by Pertwee (2008) and Elsohly et al. (2017). Among these compounds, cannabidiol (CBD) has emerged as a prominent phytocannabinoid with non-psychoactive properties, as emphasized by Aydoğan et al. (2020). CBD has been recognized for its anxiolytic and antipsychotic effects, as highlighted in research by Zuardi et al. (1995) and Crippa et al. (2009). Additionally, CBD is known to counteract the psychoactive effects induced by THC, showcasing its potential therapeutic value in mitigating adverse reactions associated with THC consumption, as mentioned by Mechoulam et al. (2006).

3. Hemp Products and Poultry

Hemp seeds are reported to be abundant in various vitamins, minerals, essential amino acids, and essential fatty acids, making them a popular choice in poultry nutrition, particularly as bird feed (Silversides and LeFrancois, 2005; Goldberg et al., 2012; Eriksson and Wall, 2012; Konca et al. 2014). The utilization of hemp-derived CBD in research is quite limited, with a focus on clinical rather than nutritional studies. Clinical trials involving CBD are predominantly conducted pre-human use, with rats being the primary subjects, alongside occasional use of dogs and monkeys. Poultry nutrition commonly incorporates products derived from hemp seeds and seed derivatives, although it is essential to note that hemp seeds do not inherently contain CBD. Konieczka et al. (2023) explored the impact of CBD and CBD+Se (selenium) additives in chicken diets, revealing a protective effect against DNA damage in the intestinal mucosa, leading to improved interaction and enhanced fattening performance. Langer and Scilcher (1999) conducted a study on muscle pain in rats, administering 100mg/kg of 99% pure CBD intramuscularly after a series of intense workouts, noting a mild effect on muscle. However, CBD displayed anti-inflammatory properties on skeletal muscle, suggesting its potential use as an analgesic and anti-inflammatory agent. Moreover, the removal of cannabidiol (CBD) from the prohibited substances list allows athletes access to this non-psychoactive hemp component, aligning with the World Anti-Doping Rules International Standard Prohibited List 2023.

Gustafsson and Jacobsson (2019) explored CBD's impact on embryo development by administering in-ovo CBD injections to chicken chicks on days 1, 4, and 7, leading to a 20% decrease in chick incubation efficiency due to developmental interference. Recent years have seen intensified research on in-ovo injection in poultry feed, focusing on amino acid development, growth performance, immune response, and digestive organ enhancement (Bhanja and Mandal, 2005). Studies have suggested that in-ovo feeding can bolster the population of bacteria resistant to enteric pathogens (Ferket 2006, Smirnov et al. 2006) and enhance intestinal resistance to *Salmonella enterica* in young chickens through in-ovo CpG-ODN administration. Furthermore, the in-ovo injection of oligosaccharides has been shown to impact digestive and storage capacities, with reports indicating that chick weight and growth are accelerated with the injection of amino acids, trace elements, fatty acids, and vitamins (Bakyaraj et al., 2012).

4. Conclusion

In conclusion, various hemp products like seeds, pulp, and oil have been studied in poultry feeding, yielding positive outcomes without encountering adverse effects, thereby recommending their utilization. The antimicrobial, antioxidant, and immunostimulant properties of Cannabidiols are anticipated to benefit the immune system of poultry, particularly broiler chickens, underscoring the importance of further investigations into their effects. Despite extensive research on hemp seeds and their derivatives in poultry nutrition, studies on the impact of CBD and other cannabinoids remain scarce. Only a single study on CBD nutrition and embryonic development was identified in our literature review. While one study facilitated embryo development (Gustafsson and Jacobsson, 2019), another utilized hemp extract (Konieczka et al., 2023).

The cost of 99.56% pure CBD was recorded at $6000 per kilogram in the year 2016, but has since plummeted to the range of $450 to $375 per kilogram by 2024. This substantial reduction in price, amounting to approximately 15 times less in less than a decade, can be attributed to various factors such as the issuance of permits for hemp cultivation dedicated to CBD production within our nation, the steady expansion of hemp production areas, and the continuous advancements in technology related to CBD extraction processes. These developments have collectively contributed to the potential consideration of CBD as a viable additive for enhancing animal nutrition. The ongoing expansion of CBD production sites coupled with the continuous technological enhancements in extraction methods are driving the rapid decline in CBD prices, making it increasingly feasible for utilization across various industries provided it demonstrates positive outcomes.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	H.A.Ş.	R.V.Ş.
C	50	50
D	50	50
S	100	
L	50	50
W	90	10
CR	50	50
SR	50	50

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declared that there is no conflict of interest.

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