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USE OF SOME INDUSTRIAL PLANTS IN POULTRY

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Abstract: The rapid increase in the human population has also increased the demand for raw materials in many fields. The increasing population has brought along the problem of opening agricultural areas to settlement. For this reason, versatile plants that bring high efficiency from the unit area without harming the existing natural resources and can contribute in many fields such as food, textile, biofuel and animal nutrition arouse excitement among scientists. Industrial plants also provide the diversification of agriculture, enable the simultaneous development of plant and animal production, and make significant contributions to local economies, especially in developing countries. Industrial crops play a crucial role in various aspects of human society, economy, and sustainability. Their importance extends beyond food production and consumption, as they contribute to a wide range of industries and offer several benefits. One of these sectors which affected by industrial plants is poultry nutrition. Industrial crops are utilized to meet the energy, protein, vitamin, fibre, Omega-3, antioxidant, phytochemicals, phosphorous and mineral requirements of poultries. Such as soybeans, sunflower, maize, cottonseed and flax are widely used in the feeding of poultries. They serve as high-energy and protein sources, promoting healthy growth and productivity. These crops are specifically cultivated to provide essential nutrients and meet the dietary needs of poultries. As a conclusion, industrial crops serve as essential ingredients of poultry feeding methods, providing the crucial nutrients, energy, and protein required for the appropriate growth, development, and productivity of poultries. Their inclusion in diets ensures the optimal health and well-being of poultries in various agricultural settings. This review article has examined some important industrial plants as poultry feed.

Keywords: Industrial crops, Poultry nutrition, Poultry

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1. Introduction

Industrial crops play a significant role in the provision of nourishment for poultry, serving as both nutritious and cost-effective sources of feed for livestock. These plants are regularly assessed as potential feed content due to their nutritional importance and widespread availability. As a result of the studies, it was stated that white meat consumption will increase by 73% by 2050 (Percival, 2022). It is predicted that increasing world population and production costs will negatively affect the poultry industry (FAO, 2014; Cerisuelo and Calvet, 2020). Poultry production is sustainable with proper nutrition. The more efficiently feeding is done, the more resource demand will decrease and accordingly, costs will decrease (Greenhalgh et al., 2020). The suitability of a plant for poultry consumption is determined by a set of criteria that include the presence of various nutrient substances in different parts of the plant, as well as their digestibility, palatability, metabolizable, and the absence of harmful substances in different plant components (McDonald et al., 1998) and the agronomic properties, concerning cultivation, harvesting difficulties and financial issues. Regarding nutrient substances the essential nutrients in animal feeding items are (McDonald et al., 1998) proteinic nitrogenous compounds, with special reference to their major amino acid ingredients, nonproteinic nitrogenous compounds, carbohydrates, mainly starch, fats as oils, and cellulosic compounds as fibres, vitamins, and minerals.

Current developments show that the search for alternative feed sources is inevitable in the poultry industry. This paper offers an overview of several crucial industrial plants and their impact on poultry nutrition.

2. Poultry Industry

The World Food and Agriculture Organization, alongside various scholarly investigations, concurs that the human population is projected to reach approximately 9.2 billion individuals by the year 2050, thereby necessitating an augmented global food demand ranging from 35% to 56%. In light of these projections, the task of meeting this heightened demand while maintaining the nutritional adequacy of the food supply becomes increasingly complex and arduous (FAO, 2014; van Dijk et al., 2021). The shorter growth biology of poultry compared to other farm animals, the short period between two generations, and the fact that most of them have an omnivorous diet make them preferable to other animal species. In recent decades, the demand for poultry meat and, accordingly, per capita consumption rates have increased (OECD, 2022). Compared to other animal foods, the poultry industry has become preferable in terms of the high-quality animal protein, amino acids, energy and microelements it contains (Bohrer, 2017). As a consequence of the escalating need for sustenance brought about by the burgeoning human populace, the endeavour of supplying nutrient-dense food with constrained resources poses a formidable challenge for the field of animal husbandry. Developed countries such as the USA, China and Brazil rank first in world chicken meat production (FAO, 2021). Although the amount of chicken meat consumed per capita in the world is 14.7 kg, this rate reaches 64 kg in Israel and 50.1 kg in America (FAO, 2021).

In the past few decades, there have been notable advancements in the field of boiler production, which have undoubtedly revolutionized the industry. These remarkable developments have brought about significant improvements in various aspects of broiler manufacturing, resulting in enhanced efficiency and performance. For instance, between the years 1985 and 2010, there has been a substantial increase in the live weight and feed conversion rates of 35-day-old chickens. Specifically, the live weight has surged from 1.4 kg to an impressive 2.4 kg, while the feed conversion rates have also witnessed a commendable rise from 1.5 to 2.3. These findings highlight the tremendous progress made in optimizing the growth and productivity of poultry, thereby contributing to the overall advancement of the agricultural sector (Siegel, 2014). These increases have been associated with improvements in breeding, nutrition, vaccination, biosecurity guidance, disease prevention and control, and poultry environmental management. Considering these risks, it is important that protein production continues in a sustainable manner.

The objective of this overview is to describe the importance of nutrition in the poultry industry. The topics include the relationship between different industrial crops and poultry diets.

2.1. Sunflower

Sunflower seeds, which are characterized by their distinctively large and flat shape, belong taxonomically to the genus *Helianthus annuus*, which is a member of the family *Asteraceae*, commonly known as the aster, daisy, or sunflower family (Soliman et al., 1996; Canibe et al., 1999; San Juan and Villamide, 2001). The sunflower plant, which has been extensively recorded and studied, holds a prominent position in the hierarchy of essential resources in the realm of nutrition and agriculture. It stands as the second most significant reservoir of feed and protein, offering a valuable source of sustenance for both humans and animals alike. Sunflower seeds contain 20% of protein, whereas protein contents of the oil press cakes and extraction residues range from 30 to 50% (Dorrell and Vick, 1997). Sunflower seeds are considered rich with their energy content of 3,691 to 5,004 kcal (Daghir et al., 1980; Cheva-Isarakul and Tangtaweewipat, 1990). Furthermore, it also serves as the third most crucial source of oil, a highly sought-after commodity utilized extensively by both humans and animals for various purposes. In addition to its contributions in the realm of nutrition and oil production, the sunflower plant also holds the distinction of being the fourth largest supplier of oilseeds, further solidifying its position as a vital component of the global agricultural industry (Lusas, 1985; Aboul Ela et al., 2000; Garcés et al., 2009).

In a research endeavour that took place in 1997, an investigation was carried out, wherein it was ascertained and subsequently documented that the inclusion of sunflower meal within the poultry diets could serve as a feasible alternative to the utilization of soybean meal as a feed ingredient (Soliman, 1997). Research findings have indicated that the inclusion of sunflower in the diets of chickens at a level as high as 200g/kg does not appear to have any detrimental impacts on their growth performance and feed conversion (Valdivie et al., 1982; El-Sherif et al., 1995). In a separate and distinct academic inquiry, it has been conclusively ascertained that the existence and inclusion of substantial quantities of sunflower within the dietary compositions of poultry have been empirically proven to not yield any deleterious repercussions on key factors, such as the efficacy of productivity performance as well as the overall quality criteria pertaining to eggs (Tsuzuki et al., 2003; Casartelli, et al., 2006; Rezaei and Hafezian, 2007). On the other hand, in another study, the inclusion of sunflowers up to 20% (El-Sherif et al., 1997; Tavernari et al., 2008) or at even higher ratios (Rama Rao et al., 2006; Mushtaq et al., 2009) did not have any adverse effects on live body weight or body weight gain. In another study, sunflower was replaced with soybean meal up to 30% in chicken rations and the results were observed. According to the results of the study, it was ascertained that the consumption of feed by the animals and the subsequent increase in their live weight exhibited a significant enhancement of 13.17% and 12.04%, respectively, thereby indicating a marked improvement in their overall growth performance, all of which occurred in the absence of any adverse consequences (Furlan et al., 2001). According to the findings of scientific researchers, it has been determined that the inclusion of sunflower in chicken diet can reach a significant threshold of up to 15% without encountering any detrimental consequences. Additional investigations conducted by these very same scientists further elucidated that not only did the yolk index and Haugh unit score remain unaffected, but they also failed to exhibit any adverse effects. However, it is worth noting that the thickness of the shell exhibited an increase of 15% as a result of the incorporation of sunflower (Mirza and Sial 1992).

2.2. Soybean

Soybean (*Glycine max* L.), which is one of the basic nutrients with its high nutritional values, belongs to the *Leguminosae* family and has a high nutritional content.

Soybean, a grain rich in yellow vegetable protein, has its origins in China and has since become a widely distributed and cost-effective source of vegetable protein, comprising approximately 48 to 50% of its composition, while also boasting low-fat content (Garcia et al., 1997). Feed cost is seen as the main challenge in poultry production (Ravindran, 2013). Due to the prohibition of animal proteins from inclusion in feed in some regions (Van Harn and Veldkamp, 2011), vegetable protein is becoming an essential nutrition of feed for poultry (Ravindran, 2013), and SBM (soybean meal) remains the most crucial and preferred source of high-quality protein for animal feed manufacturing (FAO, 2014). Soy-based feeds, regarded as a means of obtaining animal protein, are experiencing a surge in popularity owing to their superior quality (Banaszkiewicz, 2011).

In their seminal work published in 1995, Fan et al. assert with utmost confidence that soybean meal is an unparalleled and supreme reservoir of protein, thereby solidifying its status as an unrivalled source of this essential macronutrient. Furthermore, they astutely emphasize that soybean meal bestows upon its consumers a staggering quantity of approximately 480 grams per kilogram of dry matter protein that is of unparalleled and exceptional caliber, thus solidifying its position as the epitome of protein quality (Yamka et al., 2003). Soybean has been reported to have the highest lysine digestibility and lowest crude fibre content among all other oilseed meals (Willis, 2003). Soybeans purportedly account for a significant proportion, specifically two-thirds, of the protein content found in animal feed on a global scale. Furthermore, soybeans contribute to over a quarter of the fats and oils utilized in the same context. Notably, three-quarters of the overall international trade in high-protein meals is attributed to soybeans (Peisker, 2001). It has been stated that the level of addition of SBM to diets varies from 25% in chick diets to 30-40% in the diets of old broiler chickens and laying hens (McDonald et al., 2002; Willis, 2003). One research study conducted an observation that soybeans possess a high level of digestibility suitable for avian species, regardless of their breed or age (Newkirk, 2010). Soybean meal has been reported to provide high energy density and feed conversion efficiency in broiler and turkey diets (Erdaw et al., 2016).

2.3. Maize

Alongside the tangible proof of sustenance discovered amidst selected archaeological excavations conducted within the geographical confines of Mexico, a scholarly consensus has emerged, positing that the crop of maize (scientifically classified as *Zea mays* L.) assumed a pivotal role in the early agrarian practices of ancient farmers, commencing some 7,000 to 10,000 years ago (Smith, 2001). Maize which is especially preferred for feeding poultry, is the most important feed grain grown worldwide. (Stamen, 2010). Since maize has consistently possessed the utmost level of dietary energy value when compared to other grains over an extensive span of time, it has undeniably emerged as the grain of choice in the realm of nutrition for domestic avian creatures in developing nations, including but not limited to Latin America, Africa, and Asia (Larbier and Leclercq, 1994). The primary consequence that arises from the process is commonly denoted as "draff" or "distillers dried grains" (DDG), and it possesses a significant protein content. In addition to DDG, it is also possible to incorporate another resulting substance known as "soluble," which encompasses the minutest remaining particles of both maize and yeast. Due to its elevated protein concentration, presence of trace elements and vitamins, and enhanced accessibility of phosphorus, DDGs have gained substantial popularity as feed ingredients for the purpose of poultry cultivation (Larbier and Leclercq, 1994). Corn grain contains nutrients in various amounts. They are approximately 4% fat, 9% protein, 73% starch, and 14% other components (mostly fibre). Oil is stored mainly in the seed, while starch and protein are mainly found in the endosperm, which makes up the majority of the seed (Tan and Morrison 1979). The digestible energy content of corn grain was indicated to be between 3.75–4.17 kcal/g in a particular study (Fetuga et al., 1979). The metabolized energy value of corn was stated as 3.6 kcal/g according to a study conducted on poultry (Nelson et al., 1974; Fetuga et al., 1979). Moreover, the recorded value for the digestibility of gross energy in chickens amounted to 86% (Fetuga et al., 1979).

2.4. Flaxseed

Flaxseed (*Linum usitatissimum* L.), a prominent oilseed plant, holds immense significance for its applications in industrial, food, and feed sectors. The appellation "flaxseed" derives from its Latin name, *Linum usitatissimum* L., which aptly translates to "very useful." With an extensive history spanning over five millennia, this plant has been widely consumed as a dietary staple since ancient times. Studies have reported that flaxseed contains approximately 40% lipid, 30% dietary fibre and 20% protein (Daun et al., 2003; Oohma, 2003). The primary objective of incorporating flax in poultry diets is to alter the composition of fatty acids in animal tissue, with the specific aim of generating eggs that are abundant in omega-3 fatty acids, thereby rendering them suitable for consumption by humans. A study on feeding 10%, 20% and 30% flaxseed for 28-day periods was reported for laying hens in 1990. According to this study, omega-3 fatty acids in eggs were reported to increase significantly at each level of flaxseed supplementation (Caston and Leeson, 1990). Feeding poultry with diets that are enriched with omega-3 has been observed to result in an augmentation of the omega-3 levels found in both eggs and meat. Enriched poultry products, as a result of their nutritional composition, possess the capability to function as a feasible and practical alternative for individuals who are seeking to augment their daily intake of omega-3 fatty acids, thereby presenting consumers with an advantageous opportunity to fortify their regular diet with this essential nutrient

(Leskanich and Noble, 1997). During the course of the study, the researchers introduced two different concentrations of linseed oil, namely 3% and 6%, into the diet of laying hens for a duration of 25 weeks. Throughout this period, the researchers meticulously observed and analysed the outcomes of this dietary manipulation. Notably, the findings from this investigation revealed that the addition of flaxseed oil had a remarkable and notable impact on the nutritional composition of the eggs, particularly with regards to the enrichment of α-linolenic acid and the overall content of omega-3-polyunsaturated fatty acids. Therefore, the results of this research strongly indicate the significant role of linseed oil in enhancing the nutritional quality of eggs, thereby highlighting its potential benefits in promoting human health. Furthermore, it was observed by the researchers that the level of cholesterol present in the yolk underwent a decline of approximately 5% in comparison to the control group. Additionally, when the hens were provided with the enriched diets, no significant alterations were identified in the quality parameters of the eggs, such as their texture, colour, or flavour. Moreover, the laying efficiency of the hens and the consumption of feed per egg remained consistent and unaffected by the dietary enrichment (Kozlowska et al., 2008).

2.5. Cottonseed

Cottonseed meal, used in certain amounts in poultry feeding, is a by-product obtained from the cotton plant. Cottonseed meal (CSM), which is derived from the process of extracting oil from cotton seeds, serves as a by-product of the oil industry. With protein levels ranging from 30% to 50%, CSM emerges as a notably abundant reservoir of this essential macronutrient. Furthermore, CSM is also found to be replete with a diverse array of amino acids, further enhancing its nutritional value and potential applications (He et al., 2015). One research investigation conducted an observation in which they found that chickens that are 7–21 days old have the capability to consume a diet that contains up to 20% cottonseed meal, provided that the formulation is supplemented with either 1.5% or 3% Lysine (Azman and Yılmaz, 2005). Mishra et al., 2015 have shown that low gossypol cottonseed meal (0.001% of free gossypol) can be safely incorporated at 5% (1-14 days of age) and 10% (15-35 days) as a partial replacement of soybean meal in diets containing the same level of crude protein and essential amino acids as control diet, without any adverse effect on performance (Mishra et al., 2015). The present study investigated the impact of different levels of cottonseed meal inclusion (0%, 4%, 8%, and 12%) in the diets of 1 and 42-day-old chickens, with regards to their digestibility, performance, and microflora composition. The results of this study demonstrated that the inclusion of 4% and 8% cottonseed meal in the feeds positively influenced the aforementioned parameters. The findings indicated that these particular levels of cottonseed meal inclusion were beneficial in terms of enhancing the digestibility and performance of the chickens, while also influencing the composition of the microflora in a favourable manner (Sun et al., 2013).

2.6. Hempseed

The Hemp plant, scientifically classified as *Cannabis sativa* L., which is a member of the *Cannabinaceae* family, has been widely recognized and acknowledged for its significant contributions throughout history in the realms of food production, medicinal applications, and the provision of various types of fibre (Russo and Reggiani, 2015). Hemp, a widely distributed and extensively cultivated plant, carries substantial industrial importance owing to its diverse applications as a source of whole seeds, dehulled seeds, seed flour, oil, and fibre (Callaway, 2004). In countries such as Iran, Pakistan and Türkiye, roasted salted hemp seeds are still sold as snacks in herbalists and are also used as bird feed (e.g., canary, pigeons) during mating period to increase stamina of male birds (Karimi and Hayatghaibi, 2006). Hemp seeds, which serve as an excellent protein source for poultry, have been documented to possess a noteworthy abundance of edestin and albumin, two types of storage proteins that exhibit exceptional quality and are characterized by their effortless digestibility and possession of indispensable amino acids (Callaway, 2004). Hemp seeds contain 20-25% high quality protein, 30-36% fat, 30-40% fiber and 6-7% moisture. In addition, while the energy content in the seed is 2200 kJ/100 g, the energy content in the seed meal is reported as 1700 kJ/100 g (Callaway, 2004). Khan et al. (2010) fed 160 day-olds broiler chicks with basal diet and basal diet+hemp seed (5, 10 and 20%). The findings of the study demonstrated that the inclusion of hemp seeds at a concentration of 20% in the diets of broiler chickens resulted in a significant improvement in body weight gain. In addition to this, the presence of hemp seeds in the diet led to a reduction in feed intake, indicating that the birds were able to achieve higher body weights with lower feed consumption. Moreover, the study also found a positive correlation between feed conversion and the inclusion of hemp seeds, suggesting that the birds were able to convert the feed more efficiently when hemp seeds were included in their diets. This is particularly noteworthy as hemp seeds are known to possess a rich nutritional profile, making them a potential alternative source of protein in organic poultry feeds. By incorporating hemp seeds into the diets of broiler chickens, it is possible to enhance their growth and performance while also reducing the reliance on traditional protein sources. Therefore, the inclusion of hemp seeds in organic poultry feeds holds promising potential in improving the overall sustainability and efficiency of broiler production systems. Thus, Eriksson and Wall (2012), added hemp seed cake in organic broiler diets (10% in starter and 20% in grower diets). It has been observed in many studies that it has a beneficial impact on egg weight (Gakhar et al., 2012; Halle and

Schöne, 2013; Skrivan et al., 2019) and eggshell thickness (Konca et al., 2019) in laying hens. Including hemp seeds in the diet instead of rapeseed oil has been suggested as a potential means of enhancing bone health in laying hens and cockerels, as per previous assertions (Skrivan et al., 2019; Skrivan et al., 2020).

3. Conclusion

Industrial plants are one of the major sectors that affect and are linked with many different sectors like food, textile, biofuel, and animal nutrition. They contain nutrients that are important for the poultry industry, which has an important place in world food production, in terms of the development of birds with high protein, vitamins, minerals, amino acids, and omega-3 content and the production of the products expected from them, and they constitute a source of raw materials for the poultry industry. The nutritional content, taste and digestibility of meat and eggs obtained from poultry are directly related to the environment in which the animals live and their diet, and has been addressed by scientists for many years as a subject that arouses interest and is worth researching. For years, the effects of many different plants on poultry nutrition have been investigated for this purpose. Although the plants discussed in this article have been studied for many years and are mostly used in the poultry nutrition industry, scientific studies on the subject are continuing and the effects of different industrial plant varieties on poultry nutrition can be evaluated.

Author Contributions

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

	R.V.Ş.	H.A.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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