REVIEW

Use of Herbal Feed Additives to Enhance Meat and Yolk Color in Poultry: A Review of Studies Conducted in India

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Abstract

This work shows the use of herbal feed additives to improve meat and yolk color in poultry, with an emphasis on studies conducted in India. The growing desire for natural and safe chicken products has prompted researchers to look at alternative feed additives, particularly herbal ones, which are abundant in India due to its rich biodiversity and herbal medical traditions. It combines findings from several Indian studies, focusing on essential herbal additives such as turmeric, paprika, marigold, etc. The article explores how these chemicals affect color, the underlying mechanisms, the potential benefits and limitations, future research possibilities in India. Indian research provides unique insights into the benefits of herbal feed additives, which contribute to the global trend of natural and sustainable poultry production. This article underlines the potential for herbal additions to improve poultry product quality and match customer demands for natural, health-promoting foods.

Keywords: herbal feed additives, poultry, India

Introduction

India is the most popular country for production of poultry meat having sixth position in poultry meat production in the world (FAOSTAT, 2021). According to Basic Animal Husbandry Statistics (BAHS, 2023), the total meat production from poultry is 4.99 million tonnes, contributing about 51.14% of total meat production in the country. Out of the poultry meat, broiler chicken meat has become more and more popular in the country including Assam. India ranks 4th in broiler production in the world (Sapcota et al., 2018). The broiler meat market has been essential in supplying the country's growing need for foods high in protein. Poultry meat is healthy with low fat and high protein content, has good sensory qualities, low price and fast production which mean a short generative time (Shane, 2004). At present broiler farming has become a profitable and most popular income generating sector for the educated unemployed youth of Assam (Choudhury, 2017). Poultry farmers are interested in broiler production because of its quick returns, smaller marketing age, less space requirement and higher weight gains. However, consumers are now-a-days more conscious about

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their health and quality meat they consume. On the other hand, producers are interested in improving the efficiency of feed utilisation and minimising the cost of feed per kilogram live weight gain.

The trend in broiler chicken production using certain feed additives and herbal feed supplements to obtain maximum feed efficiency and healthy meat is increasing. The use of chemical feed additives and antibiotic growth promoter has been criticised by the consumers and it has been already banned in European Union since January 2006 (Nouzarian et al., 2011) due to biosecurity threats for human and animal health associated with the escalating resistance of pathogens to antibiotics and the accumulation of their residues in avian tissue and poultry products (Falcao-e-Cunha et al., 2007). Many studies have since been carried out in an effort to improve the growth performance of chickens by using alternative feed additives.

Recently, several studies (Choudhury, 2017; Deori, 2022) were conducted in Assam using phytobiotics as natural growth promoting feed additives and supplement in broiler chicken production. These are the substances obtained from various herbs and spices that have a wide range of medicinal properties and are best alternatives to antibiotic growth promoters (Rahman et al., 2014). Natural herbal ingredients decrease gut bacteria content, increase color, and oxidise lipids (Cross et al., 2007). Beneficial effects of these substances in poultry nutrition are due to their high content of pharmacologically active compounds stimulating appetite and feed intake, improving endogenous digestive secretion and activating immune responses (Nouzarian et al., 2011). Now-a-days herbs, spices and their oil extracts are commonly used in poultry diets as safe growth promoters (Tollba et al., 2010). The phytogenic plants and seeds are used as preservation approaches to enhance the sensory attributes and prolong the shelf life of animal products. The results showed that meat quality parameter such as meat color, which is an important visual criterion, is correlated with myoglobin and haemoglobin concentrations and their status. (Al-Sagan et al., 2020).

The visual appeal of chicken products is an important aspect in determining customer purchasing decisions. Traditionally, synthetic color additives were used to improve the coloration of meat and eggs. However, as people become more aware of the possible health dangers of synthetic additives, the desire for natural alternatives has increased. The country's rich legacy of herbal treatment has fueled a growing interest in employing natural herbal feed additives to improve these attributes in India. This study seeks to synthesise existing research on the use of herbal additions to improve eggshell and meat color in poultry in India.

Whereas chicken egg is a popular food item and commonly eaten egg for all societies of the world. They supply all essential amino acids for human and provide several vitamins and minerals, including retinol (vitamin A), riboflavin (vitamin B2), folic acid (vitamin B9), vitamin B6, vitamin B12, choline, iron, calcium, phosphorus and potassium. The color of the yolk is a reflection of its pigment content. In addition, the type of pigment in the egg and its concentration are directly influenced by the dietary concentration of any particular pigment. Most of the carotenoids in egg yolk are hydroxy compounds called xanthophylls. Lutein and zeaxanthin are two of the most common xanthophylls found in egg yolk. Consumer preferences vary greatly on yolk color. Color is described based on the Roche (RCF) or BASF Color Fan. Yolk colors from 6 to 15 can be achieved by using only natural pigments obtained from natural raw materials (Esfahani-Mashhour et al., 2009). Natural sources can be from plants such as marigold, chili, or corn. The high protein blue-green algae known as Spirulina has also been shown to be a very efficient pigment source for poultry skin and egg yolk. Pigment enriched eggs may be beneficial in preventing macular degeneration, a major cause of blindness in the elderly. The egg processing industry has routinely produced highly pigmented yolks for use in bakery products, pasta and mayonnaise. The dark yolk color has better acceptance by Indian consumers (Aygun, A., 2014). With a growing problem of macular degeneration in the elder people, there is a great market potential for these eggs.

Meat Color

The color of chicken meat is an important quality indicator that determines customer acceptance and marketability. Herbal additives that improve the color of poultry meat, to make them more acceptable to consumers in India, are the following herbal preparations.

Turmeric (*Curcuma longa*)

The study looked at the effects of turmeric (Picture 1.) supplementation (1.5% dietary inclusion) on chicken skin and meat color over a 6-week feeding period. The results showed a considerable improvement in skin and meat pigmentation, which was ascribed to the deposition of curcumin and other turmeric-derived pigments. Turmeric also increased antioxidant capacity, which helped to improve the quality of meat (Kumar et al., 2017).

Picture 1. Turmeric (*Curcuma longa*)
Source: IndiaMart (https://dir.indiamart.com/search.mp?ss=turmeric&mcatid=113922&catid=392&prdsrc=1&stype=attr=1&qr_nm=gd&res=RC5&com-cf=nl&ptrs=rs&ktp=N0&mtp=S&qry_typ=P&lang=en&wc=1

Spirulina (*Arthrospira platensis*)

The study investigated the impact of spirulina (Picture 2) supplementation (2% dietary inclusion) on chicken meat quality indicators, including color. The results revealed increased redness and yellowness in meat color, indicating improved pigmentation from spirulina-derived carotenoids. Spirulina supplementation also increased antioxidant levels, which improved beef oxidative stability and shelf life (Reddy et al., 2018).

Picture 2. Spirulina (*Arthrospira platensis*)
Source:IndiaMart (https://dir.indiamart.com/search.mp?ss=Spirulina+%28Arthrospira+platensis%29&mcatid=44828&catid=392&prdsrc=1&stype=attr=1&qr_nm=gd&res=RC3&com-cf=nl&ptrs=rs&ktp=N0&qu-comp=to&mtp=S&qry_typ=P&lang=en&wc=3)

Turmeric and spirulina improve the color of chicken skin and meat by increasing the absorption, deposition, and interaction of bioactive chemicals including curcumin and carotenoids. These substances enter the digestive tract and spread throughout the body, altering skin and meat pigmentation.

Annatto (*Bixa orellana*)

A study from Punjab Agricultural University reported that annatto (Picture 3), a natural coloring agent, significantly improved the yellow-orange pigmentation of chicken meat. Over a four-week feeding trial, this study looked at how annatto powder supplementation (0.5% dietary inclusion) affected the color of chicken flesh. The results showed a considerable improvement in the yellow-orange coloring of chicken meat compared to the control groups. The color enhancement was caused by the deposition of bixin and norbixin from annatto in muscle tissue. Additionally, annatto supplementation increased antioxidant activity in chicken flesh, improving oxidative stability and shelf life (Reddy et al., 2018).

Annatto improves chicken meat color by absorption and deposition of bixin and norbixin in muscle tissue. These carotenoid pigments are absorbed after digestion and transferred to muscle cells, where they provide a yellow-orange coloring.

Picture 3. Annatto (*Bixa orellana*)
Source: IndiaMart (https://dir.indiamart.com/search.mp?ss=annatto+powder&mcatid=161385&catid=565&prdsrc=1&stype=attr=1&qr_nm=gd&res=RC2&com-cf=nl&ptrs=rs&ktp=N0&mtp=S&qry_typ=P&lang=en&wc=2)

Fennel (*Foeniculum vulgare)*

Fennel seed (Picture 4) contain high levels of nitrites and nitrates (65-376.7 mg/100g) (Swaminathan et al., 2012). Nitrite present in fennel seeds react with myoglobin to produce nitrosomyoglobin which is red in color (Froning et al., 1969) for which FSP can impart redness of breast meat of broiler chicken (Al-Sagan et al., 2020).

Picture 4. Fennel (*Foeniculum vulgare*)
Source: IndiaMart (https://dir.indiamart.com/search.mp?ss=fennel%20&prdsrc=1&qr_nm=gd&res=RC4&com-cf=nl&ptrs=rs&ktp=N0&mtp=S&qry_typ=P&lang=en&wc=1&stype=attr=)

Egg Yolk Color

Yolk color is an important quality feature that influences consumer preferences. A vivid, orange-yellow yolk is frequently associated with superior flavour and nutritional content.

Marigold Extract (*Tagetes erecta*)

According to studies conducted at Tamil Nadu Veterinary and Animal Sciences University, marigold extract (Picture 5), which contains lutein and zeaxanthin, greatly improves yolk coloring. This study looked at the effects of various doses of marigold extract in layer diets. The Roche Yolk Color Fan (RYCF) revealed that adding 1.5% marigold extract greatly increased yolk color. The extract's high lutein content was responsible for the increased pigmentation (Murugesan et al., 2017). Another set of researchers investigated the effectiveness of marigold petal meal, a byproduct of marigold flower processing, as a natural pigment source. The results showed that including 3% marigold petal meal in the diet improved yolk color intensity significantly, comparable to synthetic pigments (Chitra and Rajasekaran., 2018). Marigold extract increases yolk color by promoting the absorption, metabolism, and deposition of carotenoids like lutein and zeaxanthin. These pigments are absorbed in the colon and carried through the bloodstream to the ovaries, where they are deposited in the yolk, boosting its color.

Picture 5. Marigold Extract (*Tagetes erecta*)
Source: IndiaMart (https://www.indiamart.com/proddetail/dried-marigold-powder-20886988473.html)

Turmeric (*Curcuma longa*)

According to research conducted by the Central Avian Research Institute, turmeric supplementation increases yolk color by boosting curcumin deposition. Turmeric is widely utilised in India due to its color-enhancing characteristics. This study looked at the impact of turmeric supplementation on yolk color over a 10-week period. The inclusion of 1.5% turmeric powder in the diet considerably increased yolk pigmentation, as evaluated by the Roche Yolk Color Fan (RYCF). The study also found improvements in overall egg quality (Panda et al., 2013). Another study looked at the effects of varying quantities of turmeric in individual diets. It was discovered that adding 2% turmeric to the yolk substantially increased its color. The study also emphasised turmeric's antioxidant effects, which help to improve egg quality and hen health (Rajput et al.,2013). A different study looked at the impact of turmeric powder at different inclusion levels on yolk color and egg quality measures. A 1% dietary inclusion of turmeric dramatically increased yolk color intensity while having no negative effect on egg production or quality (Sreekumar et al., 2015). Another study investigated the effect of curcumin, the main component in turmeric, on yolk color. The study discovered that a 1.75% dietary intake of turmeric improved yolk color significantly. Additionally, curcumin increased the antioxidant content of the eggs, extending their shelf life (Sharma et al., 2016). Turmeric improves yolk color by absorption and deposition of curcumin and other carotenoids. These molecules are absorbed in the colon and carried through the bloodstream to the ovaries, where they are deposited in the yolk, boosting its color.

Mulberry leaves (*Morus indica*)

Compound feed supplemented with dry mulberry leaves (Picture 6) to Mychix, a White Leghorn strain, layers from 36-44 weeks of age that were divided into 5 groups and fed different combinations of mulberry leaves at 0, 1.5, 3 and 6%. The egg-yolk color differed significantly ($P < 0.01$) among the groups receiving greens. 3% supplementation appeared most satisfactory in producing the desired yolk color for dried and frozen egg products. Incorporation of shade-dried mulberry leaves in layer's mash to the extent of 6% increased egg production with desirable yolk color without any adverse effect on body weight and egg quality.

Picture 6. Mulberry leaves (*Morus indica*)
Source: Indiamart. (https://5.imimg.com/data5/SELLER/Default/2023/2/QI/BE/FB/7025096/mulberry-leaves-500x500.jpeg)

Table 1. Herbal Feed Additives to Enhance Meat and Yolk Color in Poultry

No.	Feed Additive	Year	Author	Final recommendation/Conclusion
Meat Colour				
1.	Turmeric (*Curcuma longa*)	2017	Kumar, S., R. Rao	1.5% inclusion of Turmeric showed a considerable improvement in skin and meat pigmentation.
2.	Spirulina (*Arthrospira platensis*)	2018	Reddy, A., A. Tharwat, F. Alshammari	2% inclusion of Spirulina increased redness and yellowness in meat color, indicating improved pigmentation.
3.	Annatto (*Bixa orellana*)	2018	Reddy, D. M., G. V. B. Reddy, P. K. Mandal	as part of the Colorifico mixture in the amount of 0.4 g/100g in poultry meat, it improves the color and prevents oxidation during storage.
4.	Fennel (*Foeniculum vulgare*)	2020	Al-Sagan, A.A., Khalil, S., Hussein, E.O., Y.A. Attia	Nitrite present in fennel seeds react with myoglobin to produce nitrosomyoglobin which is red in color for which FSP can impart redness of breast meat of broiler chicken
Egg Yolk Colour				
1.	Marigold Extract (*Tagetes erecta*)	2017	Murugesan, G. R., R Sathishkumar	1.5% marigold extract greatly increased yolk colour. The extract's high lutein content was responsible for the increased pigmentation.
		2018	Chitra, R., D. Rajasekaran	3% marigold petal meal in the diet improved yolk colour intensity significantly, comparable to synthetic pigments.
2.	Turmeric (*Curcuma longa*)	2013	Panda, A.K., S.K. Singh, B. Majhi, M.C. Sahu	1.5% turmeric powder in the diet considerably increased yolk pigmentation, as evaluated by the Roche Yolk Colour Fan (RYCF). The study also found improvements in overall egg quality.
		2013	Rajput, N., R. Naik	2% turmeric to the yolk substantially increased its colour. The study also emphasized turmeric's antioxidant effects, which help to improve egg quality and hen health.
		2015	Sreekumar, T. S., R. Vijayakumar	1% dietary inclusion of turmeric dramatically increased yolk colour intensity while having no negative effect on egg production or quality.
		2016	Sharma, J. M., S. Dey	1.75% dietary intake of turmeric improved yolk colour significantly. Additionally, curcumin increased the antioxidant content of the eggs, extending their shelf life.
3.	Mulberry leaves (*Morus indica*)	1977	Narayana, H., S.V.S Setty	A 3% replacement with mulberry leaves appeared most satisfactory in producing the desired yolk color for dried and frozen egg products.

Benefits of Herbal Feed Additives

Natural additives are becoming more popular among consumers due to purported health benefits and safety concerns. Herbal additions address this desire by improving the visual appearance of poultry products. Brightly colored egg yolks and meat can boost the market value of chicken goods since they are frequently linked with higher quality and freshness. Brightly colored egg yolks and meat are frequently associated with superior quality and freshness. Eggs and chicken meat with improved natural pigmentation can be marketed as premium items and may command higher market prices. Spirulina and other herbs contain critical elements such as vitamins, minerals, and amino acids. These minerals can improve the nutritional profile of eggs and meat, adding value for customers.

Challenges with Herbal Feed Additives

Herbal additives may cost more to produce and process than synthetic additives, thereby raising the overall cost of chicken feed. The cost of herbal feed additives can change depending on availability, seasonality, and market demand, affecting the economic sustainability of poultry growers. Determining the best dosage and formulation of herbal additives to produce the desired effects on egg yolk and meat color can be difficult and may necessitate lengthy research and testing. The efficiency of herbal additions is determined by the bioavailability of their active ingredients. The technique of inclusion into feed, as well as the digestive physiology of chicken, can influence absorption and utilisation of these chemicals (Karunajeewa at al. 1984).

Conclusion

The use of herbal feed additives to improve egg yolk and meat color in chicken production has gained substantial traction in India, owing to rising consumer demand for natural and health-enhancing products. This trend is driven by a desire for more sustainable and health-conscious food options, which is consistent with the benefits provided by herbal additions. Studies conducted in India shows that various herbs such as turmeric (*Curcuma longa*), paprika (*Capsicum annuum*), marigold (*Tagetes erecta*), spirulina (*Arthrospira platensis*), and annatto (*Bixa orellana*) improve the pigmentation and overall quality of poultry products.

The use of herbal feed additives in poultry production in India offers a viable method to improving the color and quality of egg yolks and meat. Producers can address consumer desire for natural, safe, and nutritious poultry products by utilising herbs' natural pigmentation and health advantages. The incorporation of herbal supplements into chicken nutrition not only promotes sustainable and environmentally friendly practices, but also increases the marketability and economic feasibility of poultry products. With further study and innovation, herbal feed additives have the potential to play an important part in India's poultry production future.

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Upotreba biljnih dodataka za poboljšanje boje mesa i žumanjka peradi: Pregled studija provedenih u Indiji

Sažetak

U ovom radu prikazana je upotreba biljnih dodataka krmnim smjesama za poboljšanje boje mesa i žumanjka kod peradi, s naglaskom na studije provedene u Indiji. Rastuća želja za prirodnim i sigurnim proizvodima od peradi potaknula je istraživače da potraže alternativne dodatke stočnoj hrani, osobito one biljne, kojih u Indiji ima u izobilju, zbog njezine bogate bioraznolikosti i tradicijskog korištenja ljekovitog bilja. Kroz pregled nekoliko studija, usredotočujući se na esencijalne biljne dodatke kao što su kurkuma, komorač, neven itd., opisano je kako te biokemijske tvari iz biljnih preparata utječu na boju, temeljne mehanizme i potencijalne koristi i ograničenja, kao i buduće mogućnosti istraživanja u Indiji. Indijska istraživanja pružaju jedinstveni uvid u prednosti biljnih dodataka stočnoj hrani, koji doprinose globalnom trendu prirodne i održive proizvodnje peradi. Ovaj pregled naglašava potencijal biljnih dodataka za poboljšanje kvalitete proizvoda od peradi i zadovoljavanje zahtjeva kupaca za prirodnom hranom koja promiče zdravlje.

Keywords: biljni dodaci, perad, Indija

Verwendung von pflanzlichen Futterzusätzen zur Verbesserung der Fleisch- und Dotterfarbe bei Geflügel: Ein Überblick über in Indien durchgeführte Studien

Zusammenfassung

Diese Arbeit zeigt die Verwendung von pflanzlichen Futtermittelzusätzen zur Verbesserung der Fleisch- und Dotterfarbe bei Geflügel, wobei der Schwerpunkt auf in Indien durchgeführten Studien liegt. Der wachsende Wunsch nach natürlichen und sicheren Hühnerprodukten hat Forscher dazu veranlasst, sich mit alternativen Futtermittelzusatzstoffen zu befassen, insbesondere mit pflanzlichen, die in Indien aufgrund der reichen biologischen Vielfalt und der Traditionen der Kräutermedizin reichlich vorhanden sind. Der Artikel fasst die Ergebnisse mehrerer indischer Studien zusammen und konzentriert sich dabei auf wesentliche pflanzliche Zusatzstoffe wie Kurkuma, Paprika, Ringelblume usw. Der Artikel untersucht, wie diese Chemikalien die Farbe beeinflussen, die zugrundeliegenden Mechanismen, den potenziellen Nutzen und die Grenzen sowie künftige Forschungsmöglichkeiten in Indien. Die indische Forschung bietet einzigartige Einblicke in die Vorteile pflanzlicher Futtermittelzusatzstoffe, die zum weltweiten Trend einer natürlichen und nachhaltigen Geflügelproduktion beitragen. Dieser Artikel unterstreicht das Potenzial von pflanzlichen Zusätzen zur Verbesserung der Qualität von Geflügelprodukten und zur Erfüllung der Kundennachfrage nach natürlichen, gesundheitsfördernden Lebensmitteln.

Schlüsselwörter: pflanzliche Futtermittelzusatzstoffe, Geflügel, Indien

Uso de aditivos herbales en la alimentación para mejorar el color de la carne y la yema en aves: Una revisión de estudios realizados en la India

Resumen

Este trabajo muestra el uso de aditivos herbales en la alimentación para mejorar el color de la carne y la yema en aves, con énfasis en estudios realizados en la India. El creciente deseo de productos avícolas naturales y seguros ha llevado a los investigadores a examinar aditivos alimenticios alter-

nativos, particularmente los herbales, que son abundantes en la India debido a su rica biodiversidad y tradiciones médicas herbales. Combina hallazgos de varios estudios indios, centrándose en aditivos herbales esenciales como la cúrcuma, el pimentón, la caléndula, etc. El artículo explora cómo estos compuestos afectan el color, los mecanismos subyacentes, los posibles beneficios y limitaciones, y las posibilidades de investigación futura en la India. La investigación india proporciona perspectivas únicas sobre los beneficios de los aditivos herbales en la alimentación, que contribuyen a la tendencia global de producción avícola natural y sostenible. Este artículo destaca el potencial de las adiciones herbales para mejorar la calidad de los productos avícolas y satisfacer las demandas de los consumidores por alimentos naturales y promotores de la salud

Palabras claves: aditivos herbales, aves, India

Uso di additivi vegetali per migliorare il colore della carne e del tuorlo nel pollame: revisione degli studi condotti in India

Riassunto

Questo articolo presenta l'uso di additivi vegetali nelle miscele di mangimi per migliorare il colore della carne e del tuorlo nel pollame, con particolare attenzione agli studi condotti in India. Il crescente desiderio di prodotti avicoli naturali e sicuri ha spinto i ricercatori a cercare additivi alternativi per mangimi, in particolare quelli a base d'erbe, abbondanti in India, paese caratterizzato da una ricca biodiversità e dall'uso tradizionale di piante medicinali. Attraverso la revisione di numerosi studi, concentrandosi su additivi vegetali a base di piante officinali come la curcuma, il finocchio, la calendula, ecc., viene analizzato il modo in cui queste sostanze biochimiche vegetali incidono sul colore, i meccanismi sottostanti, i potenziali benefici e limiti, nonché le future opportunità di ricerca in India. Le ricerche indiane forniscono una visione unica dei benefici degli additivi vegetali per mangimi, contribuendo alla tendenza globale della produzione di pollame naturale e sostenibile. Questa revisione mette in risalto il potenziale degli additivi vegetali per migliorare la qualità dei prodotti a base di pollame e soddisfare la domanda dei consumatori rivolta ad alimenti naturali e salutari.

Parole chiave: additivi vegetali, pollame, India