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Potential of eggshell waste as a calcium source for feed additives in layer chickens

Potensi limbah cangkang telur sebagai sumber kalsium untuk bahan tambahan pakan ayam petelur

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Abstract. The poultry industry constantly seeks innovative, sustainable methods to enhance the health and productivity of layer chickens. This review explores the use of eggshell waste as a feed additive, highlighting its potential as a significant calcium source. Eggshells, primarily composed of calcium carbonate, provide a bioavailable form of calcium essential for eggshell formation and overall chicken health. The review delves into the composition, nutritional value, and processing methods of eggshell waste, emphasizing the importance of particle size in optimizing calcium absorption and efficacy. Benefits such as improved egg quality, shell strength, and cost-effectiveness are discussed alongside environmental advantages, including waste reduction and promotion of circular economy practices. Challenges, including contamination risks and variability in eggshell quality, are addressed with proposed solutions. The review also presents case studies and experimental evidence supporting the use of eggshell waste in layer chicken diets. Finally, future research directions and innovations in processing technologies are suggested to enhance the viability of eggshell waste as a sustainable feed additive in the poultry industry.

Keywords: calcium, eggshell, feed additive, layer chicken

Abstrak. Industri perunggasan terus mencari metode inovatif dan berkelanjutan untuk meningkatkan kesehatan dan produktivitas ayam petelur. Tinjauan ini mengeksplorasi penggunaan limbah kulit telur sebagai bahan tambahan pakan, khususnya menyoroti potensi sebagai sumber kalsium yang signifikan. Cangkang telur, dengan komponen utama terdiri dari kalsium karbonat, menyediakan bentuk kalsium yang tersedia secara hayati yang penting untuk pembentukan cangkang telur dan kesehatan ayam secara keseluruhan. Tinjauan tersebut menggali komposisi, nilai gizi, dan metode pengolahan limbah cangkang telur, menekankan pentingnya ukuran partikel dalam mengoptimalkan penyerapan dan efisiensi kalsium. Manfaatnya adalah seperti peningkatan kualitas telur, kekuatan cangkang, dan efektivitas biaya, termasuk manfaat lingkungan, antara lain pengurangan limbah dan promosi praktik ekonomi sirkular. Berbagai tantangan, termasuk risiko kontaminasi dan variabilitas kualitas cangkang telur, dapat diatasi dengan solusi yang diusulkan. Tinjauan ini juga menyajikan studi kasus dan bukti eksperimental yang mendukung penggunaan limbah cangkang telur dalam pakan ayam petelur. Yang terakhir, arah penelitian dan inovasi

di bidang teknologi pemrosesan di masa depan disarankan untuk meningkatkan kelayakan limbah cangkang telur sebagai bahan tambahan pakan berkelanjutan di industri unggas.

Kata kunci: kalsium, cangkang telur, bahan tambahan pakan, ayam petelur

PENDAHULUAN

The global poultry industry is continually seeking innovative and sustainable methods to improve the health and productivity of layer chickens (Wahyuda, Pantaya, Syaikhullah, & Ningsih, 2023). One promising approach is the utilization of eggshell waste as a feed additive (Ningsih, Syaikhullah, Adhyatma, Rofiqi, & Al Huzaini, 2022). Eggshells, primarily composed of calcium carbonate, can serve as an excellent source of calcium, which is crucial for the formation of strong eggshells and the overall health of laying hens. This review examines the potential of eggshell waste as a feed additive, exploring its composition, nutritional value, processing methods, benefits, environmental impact, challenges, and prospects (Khasanah et al., 2021).

Eggshells are predominantly made up of calcium carbonate ($CaCO_3$), constituting about 94-97% of their total composition (Habte et al., 2019). The remaining components include organic matrix proteins, magnesium, and trace elements. These constituents not only provide essential calcium but also contribute additional nutrients that may benefit layer chickens (Fernandes & Litz, 2017). The high bioavailability of calcium in eggshells makes them a viable alternative to traditional calcium sources like limestone and oyster shells (Islam & Nishibori, 2021). The natural structure of the eggshell matrix enhances calcium absorption in the digestive tract of chickens, supporting better utilization of the nutrient (Lee et al., 2021). Additionally, the trace elements and composition in eggshells can offer supplementary nutritional benefits, promoting overall laying hens health and productivity (Syaikhullah, Hertamawati, & Adhyatma, 2024).

The shell of egg is waste product from homes, restaurants, farms and factories (Lichovnikova, 2007). Extenuation of food left-over is a step toward achieving global environmental goals (Olgun, Yildiz, & Cufadar, 2015). The waste disposal shell of egg take part in environmental pollution (Kausar & Naureen, 2021). So, reuse of eggshell as supplement in concrete is superior solution to decrease environmental problem (Kausar & Naureen, 2021). Therefore, in this review article it will be studied in terms of chemical composition and nutrition of eggshell waste as feed additives for layer chickens.

MATERIALS AND METHODS

Literature Search Strategy

A comprehensive literature search was conducted using the databases PubMed, Scopus, Google Scholar, and Web of Science. The search terms included “calcium,” “eggshell waste,” “feed additive,” and “laying hens productivity.” Studies were included if they were peer-reviewed and focused on the impact of calcium feed additives on laying hens. Excluded were non-peer-reviewed articles.

Data Extraction

Data were extracted using a standardized form that recorded information on study design, sample size, and outcomes related to productivity, bone quality, and egg quality. Data were organized in an Excel spreadsheet for analysis.

Assessment of Study Quality

The methodological quality of included studies was assessed and evaluated based on criteria such as study design, sample size, and statistical analysis.

Data Synthesis

Data were synthesized through qualitative methods, identifying common themes and trends across studies with narrative synthesis.

RESULTS AND DISCUSSION

Chemical Composition & Material Study of Eggshell

Table 1 provides the chemical composition of both raw eggshells and synthesized nanoparticles. The data indicates that calcium oxide (CaO) is the predominant component in raw eggshells, primarily present as calcium carbonate ($CaCO_3$) (Yasothai & Kavithaa, 2014). The high ignition loss observed in raw eggshells reflects the transformation of $CaCO_3$ into CaO and carbon dioxide (CO_2) during the calcination process (Habte et al., 2019).

Table 1. Chemical analysis of raw eggshell and nanoparticle.

Chemical Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	Ign. Loss
[a]Raw Eggshell (%)	<0.01	<0.01	<0.01	52.75	0.52	0.04	0.05	<0.01	<0.01
[b]Nano-CaO (%)	0.08	0.04	0.05	86.93	1.08	0.14	1.32	<0.01	<0.01

Source: a (Habte et al., 2019) , b (Yasothai & Kavithaa, 2014)

Figure 1 displays the FTIR spectra of CaO nanoparticles, $Ca(OH)_2$ gel, raw eggshell, and commercial samples of CaO, $Ca(OH)_2$, and $CaCO_3$. This comparison helps characterize the synthesized nanoparticles and assess them against commercial powders.

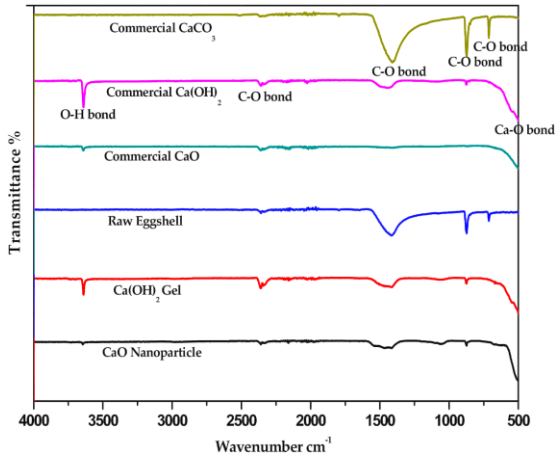

Fig 1. FTIR spectrum of CaO nanoparticle, $Ca(OH)_2$ gel, raw eggshell and commercial CaO, $Ca(OH)_2$ and $CaCO_3$ (Habte et al., 2019).

The FTIR spectrum of the raw eggshell shows a broad peak at 1415.52 cm^{-1} indicative of a C–O bond, which represents the connection between the oxygen atom in the carbonate and the calcium atom (Yasothai & Kavithaa, 2014). Both FTIR and XRD analyses clearly demonstrate that calcium oxide was synthesized from the eggshell, which was predominantly composed of calcium carbonate.

Nutritional Composition of Chicken Eggshell

Egg shell contained protein expected membranes suppress in eggshell. Hen eggshell is chemically composed of 65.6% water, 11.8% proteins,11% fat and 11.7% ash. Eggshell powder is chemically composed of 21.2% C, 0.93 % MgO, 76.9 % CaO, 0.42% P_2O_5, 0.02% $Fe2O_3$ and 0.11% Na_2O. The shell of egg is composed of almost 98.2 percent calcium carbonate (380 mg Ca per gram) (Arabhosseini & Faridi, 2018). So, it is possible eggshell meal in hen's diet provide the best calcium. 0.3% phosphorus is also present in eggshell at low level, but it is very useful for replenishing hen's bone. It is very important to keep away from hypophosphatemia 0.2% magnesium is also present in hen eggshell which have effect on preserve eggshell quality.

Table 2. Nutritional composition of chicken eggshell.

Nutrition	% Weight
Water	29-35
$CaCO_3$	90.9
Calcium	35.1-36.4
Phosphorus**/**Vitamin D	0.12**/**41
Magnesium**/**Vitamin A	0.37-0.40**/**270
Protein	1.4-4
Fat**/**Vitamin E	0.1-0.2**/**0.5
Ash**/** Proline	89.9-91.1**/** 0,54-0.62
Potassium	0.10-0.13
Sulphur	0.09-0.19

Source: Kausar & Naureen (2021)

Shell calcium fulfilled is 28.2 to 41.2% as well as phosphorus fulfilled is 0.102% (Ganjigohari, Ziaei, Ghara, & Tasharrofi, 2018). Calcium has an important role in formation of hard eggshell in hens. Calcium has chief role in control muscle spasms in hens. Calcium is a big ingredient of bone where calcium presence almost 99 percent. Calcium is helpful for interior egg quality (Świątkiewicz et al., 2018).

Uses of Eggshell for the Development of Laying Hens.

Eggshell membranes are often used as a generating agent in the synthesis of nanoparticles (Ahmed, Wu, Younes, & Hincke, 2021). Utilizing eggshells and membranes as calcium sources in layer diets does not negatively impact egg production (Saunders-Blades, Macisaac, Korver, & Anderson, 2009). Lubis, Ginting, Dalimunthe, Hasibuan, & Sastrodihardjo (2017) suggested that calcium utilization from eggshells was higher in cage systems compared to floor systems (Anwar, Ravindran, Morel, Ravindran, & Cowieson, 2017). Diets that included eggshell meal for hens showed optimal results and did not negatively impact study limitations (Tunç & Cufadar, 2015).

Tabel 3. Uses of eggshell for the development of laying hens.

Used for what purpose	Source
Used of eggshell with magnesium and vitamin D3 have positive effect on bone mineral density	(Neijat, House, Guenter, & Kebreab, 2011)
Used of ground eggshell to know gonadal performance (ovarian traits and ovarian follicles)	(Koreleski & Świątkiewicz, 2004)
Used of eggshell and oyster shell to know egg shell strength	(Ketta & Tůmová, 2018)
Used of dried eggshell to know egg quality & Ca digestibility	(Casiraghi, Hidalgo, & Rossi, 2005)
Used of eggshell and oyster shell to know egg production	(Amu, Fajobi, & Oke, 2005)
Used of ground eggshell to know hatching performance	(Rose-Martel, Du, & Hincke, 2012)
Used of eggshell and bone meal to know haematology of layers (RBCs, Hb and WBC)	(Ketta & Tůmová, 2016)

Findings from the current study support that using dried eggshells as a calcium source in diets does not harm egg production or egg weight. In Nys & Gautron (2007), reported that varying amounts of eggshells significantly increased egg weight. Hens did not experience any adverse effects on feed intake when given different amounts of eggshells as a calcium source (Syaikhullah, Rahmasari, & Prasetyo, 2023). Although crushed eggshells were easily digested,

they were insufficient for enhancing eggshell quality, and overall performance metrics were not significantly affected (Glatz & Miao, 2009). The type of dietary calcium did not affect egg quality, except for egg weight (Zaman, Sørensen, & Howlider, 2004). The eggshell positively impacted eggshell weight, even though eggshell thickness was not significantly altered. Some studies have shown that extruded eggshells do not negatively affect feed conversion, egg weight, or egg production (Baláž et al., 2021). These results are consistent with earlier findings by other researchers (Anwar et al., 2017; Saunders-Blades et al., 2009), indicating that feeding hens eggshells as a calcium source does not harm feed intake, bone weight, or egg production. No effect of the nutritional treatment was observed on egg weight, egg production, eggshell weight, bone weight, or bone strength (Neijat et al., 2011). Egg shells have great potential to be used as feed additives. Feed additives in some cases can maintain livestock performance and protect livestock from heat stress (Pantaya, Pratama, Marjiatin, Ningsih, & Syaikhullah, 2021).

CONCLUSION

The use of eggshell waste as a feed additive could increase the productivity and health of laying hens. Eggshells consist mostly of calcium carbonate, provide a bioavailable source of calcium that is important for eggshell formation and chicken health. Research shows that processing and particle size of eggshells affect calcium absorption. The benefits of using eggshell waste include improved egg quality, shell strength, cost efficiency and reduced waste. However, challenges such as risk of contamination and variations in shell quality need to be addressed. Further research is needed to improve processing technology and ensure consistent quality.

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