



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

NAAS Rating (2026): 4.61

VET 2026; 11(5): 01-05

© 2026 VET

www.veterinarypaper.com

Received: 02-02-2026

Accepted: 04-03-2026

Gautam Shukla

Undergraduate Students,
Arawali Veterinary College,
Sikar, Rajasthan, India

Chandra Sekhar Gudla

Undergraduate Students,
International Institute of
Veterinary Education and
Research (IIVER), Rohtak,
Haryana, India

Dr. Meet Pandya

Postgraduate Student,
Department of Veterinary
Medicine, College of Veterinary
Science and Animal Husbandry,
Kamdhenu University,
Junagadh, Gujarat, India

Subarno Saha

Undergraduate Students,
Arawali Veterinary College,
Sikar, Rajasthan, India

Swati Sikha Barik

Undergraduate Students,
International Institute of
Veterinary Education and
Research (IIVER), Rohtak,
Haryana, India

Ananya Jaitly

Undergraduate Students,
International Institute of
Veterinary Education and
Research (IIVER), Rohtak,
Haryana, India

Krishna Shendge

Undergraduate Students,
Arawali Veterinary College,
Sikar, Rajasthan, India

Corresponding Author:

Gautam Shukla

Undergraduate Students,
Arawali Veterinary College,
Sikar, Rajasthan, India

Canola meal in layers: Nutritional composition, anti-nutritional factors and production performance: A comprehensive review

Gautam Shukla, Chandra Sekhar Gudla, Meet Pandya, Subarno Saha, Swati Sikha Barik, Ananya Jaitly and Krishna Shendge

DOI: <https://www.doi.org/10.22271/veterinary.2026.v11.i5a.3233>

Abstract

Prolong dependence on soybean meal (SBM) for protein supplementation in commercial poultry has led to significant environmental and sustainability issues primarily due to over exploitation of land resources. Canola meal can act as a vital protein source in poultry diets. Even though having lower metabolizable energy (ME) than soybean meal it offers a well-balanced amino acid profile and promotes better egg production in layer birds. High concentration of fiber and anti-nutritional factors like glucosinolates limit its performance by strategic processing and enzyme supplementation improving its nutritional value. This review article summarizes the nutritional characteristics, limitations and strategies to enhance the utilization of canola meal in poultry farming.

Keywords: Canola meal, soyabean meal, glucosinolates, anti-nutritional factor

1. Introduction

The global poultry sector dependence on soyabean meal as primary protein source has become increasingly untenable, driven by volatile commodity prices, land-use concerns and supply chain disruptions. Against this backdrop, canola is now ranked the second most widely cultivated oilseed globally (FAOSTAT, 2024).

Soybean meal has long served as the predominant protein source in commercial poultry diet. But its widespread use has led to economic, environmental, and sustainability problems mainly due to fluctuation in prices and overexploitation of land resources, and thus sparked the growing enthusiasm in other protein sources including canola.

The use of rapeseed varieties was historically limited as feed or food due to high levels of erucic acid and glucosinolates which impair thyroid function and reduce the performance (Mawson *et al.*, 1994) [26]. This limitation was overcome by the work of Dr. Baldur R. Stefansson at the University of Manitoba in releasing low-erucic acid rapeseed varieties, which earned him recognition as the "Father of Canola." (Dao and Moss, 2025) [13].

By definition established by the Canola Council of Canada, 2025; a variety qualifies as canola only if the extracted oil contains no more than 2% erucic acid and resulting meal carries fewer than 30 mol/g of specified aliphatic glucosinolates, applicable to B.napus, B.rapa and B.juncea varieties. Although canola supports bird growth and production, its high fiber content and anti-nutritional compounds deteriorate metabolizable energy (ME). Full-fat canola seed has also proven to be an effective alternative source of both energy and protein, especially when it is economically competitive with conventional feed ingredients (Emmanuel and Jeong., 1988).

2. Nutritional Profiling of Canola meal

2.1.1 Proximate Composition

Canola meal, a co-product of oil extraction from Canola seed, which contains around 40% oil and 17-26% Crude protein, with protein content varying based on the extraction method and degree of processing. (Uppstrom., 1995) [42].

The full fat varieties of canola seeds increase the concentration of polyunsaturated essential fatty acids (omega-3s) in eggs which were indicated by the enhanced level of linolenic and docosahexaenoic acids in yolk. (Emmanuel and Jeong., 1988)

2.1.2 Protein Content and Amino Acid Profile

Canola meal contains approximately 35-40% crude protein. While lower in total protein than soybean meal (SBM), it has an excellent amino acid balance, particularly being a rich source of methionine cysteine, which are often limiting in cereal based diets (Newkirk *et al.*, 2003; Bonnardeaux, 2007) [6, 28] and are crucial for egg production and feathering.

This abundance creates a wonderful opportunity for nutritional complementarity when used along with wheat and

other grains in reduced protein diets. In commercial practices, the Total Sulfur Amino Acid (TSAA) requirement is met with the addition of crystalline methionine for it being more cost effective than cysteine (Kandel *et al.*, 2025) [22] and upon the assumption that methionine can be efficiently converted into cysteine. Under these situations, the higher cysteine content of canola meal offers an important advantage helping to restore a more balanced cysteine to methionine ratio.

The standardized ileal digestibility values in laying hens were reported to ranging between 78%- 84% (Rezvani *et al.*, 2012) [34], showing better digestibility than broilers for methionine, tryptophan and histidine (Adedokun *et al.*, 2009) [1]. Arginine and methionine showed better digestibility compared to lysine and threonine.

Nutrient	Canola meal	Soyabean Meal	References
Dry matter %	92.5	90	Canola Meal, 1984 [9], Canola Council of Canada
Protein %	35-40	44	Newkirk <i>et al.</i> , 2003 [28], Bonnardeaux, 2007 [6]
Fat %	3.8	0.8	Canola Meal, 1984 [9], Canola Council of Canada
Fiber %	11 - 12	6.5	Naczek <i>et al.</i> , 1998
ME, kcal/kg	2000 (solvent)	3100	Khajali and Slominski, 2012
Calcium %	0.7	0.25	Canola Meal, 1984 [9], Canola Council of Canada
Phosphorus %	1.17	0.60	Canola Meal, 1984 [9], Canola Council of Canada
Bulk density, lb/ft	35.2	37.0	Canola Meal, 1984 [9], Canola Council of Canada
Ash %	6.8	5.8	Canola Meal, 1984 [9], Canola Council of Canada

The research indicates that digestibility of amino acids in canola meal is generally lower and variable when compared to SBM (Khajali and Slominski, 2012) [23]. These variations are mostly associated with the processing conditions. Excess heat during the canola seed meal production has shown to reduce the amino acid levels and their availability (Parsons *et al.*, 1992) [33]. Solvent extraction (even though it increases the CP content), desolventization and toasting treatments has been shown to lower the lysine digestibility considerably in canola meal (Anderson-Hafermann *et al.*, 1993) [4], (Newkirk *et al.*, 2003) [28]. In contrast, cold-pressed canola meals have shown retaining more digestible amino acids and energy (Agyekum and Woyengo, 2022) [3].

2.1.3 Fiber and Carbohydrate content

In canola meal, the non-starch polysaccharides constitute roughly 53% to 80 % of the dietary fiber fraction, whereas only a small proportion (around 10% or less) is water-soluble (Lannuzel *et al.*, 2022) [24]. These polysaccharides are minimally digested by poultry, with total tract digestibility ranging from 2.1% to 8.6% (Bryden *et al.*, 2009) [7].

Almost 12% of the crude fiber content is mostly from the hull, consisting of carbohydrate polymers along with proteins and non-starch polysaccharides (Naczek *et al.*, 1998) [27]. The fiber components include lignin with associated polyphenols (8%), cellulose (4-6%), and non-cellulosic polysaccharides (13-16%). The non-cellulosic polysaccharides are largely composed of pectic substances (Canola Council of Canada., 2009) [10]. The small size of canola seed and high oil concentration (42-45%) is the reason for the residual meal retaining its high fiber content.

These high fiber contents is the main constraint which is limiting the wider use of canola meal in the poultry diets (Hanna *et al.*, 2018) [17]. Other constituents include oligosaccharides (2.5%), glycoproteins (approximately 5%, e.g., arabinogalactan-proteins and cell wall proteins), phytate (3.3%), fiber-bound minerals (1%), and gum substances (4%) (Wickramasuriya *et al.*, 2015) [43].

2.1.4 Energy Value

Metabolizable energy (ME) is an important factor which directly affects diet formulation and feed cost evaluations. Compared to SBM, canola meal shows lower ME values approximately 1700- 2000 kcal/kg, mostly due to canola's high fiber and lower protein concentration (Khajali and Slominski, 2012) [23]. Solvent-extracted canola meal provides approximately 2000 kcal/kg, which is around 230 kcal/kg less than non-dehulled soybean meal (Jia *et al.*, 2012) [20]. Expeller-pressed canola meal shows higher ME values than solvent-extracted meal because of its greater residual oil concentration (Smulikowska *et al.*, 1997) [37].

Improvement of canola meals' energy profile can be achieved by dehulling, thereby lowering its fiber levels. A significant difference in digestible energy was observed between the standard (3346 kcal/kg) and dehulled fractions (4063 kcal/kg) of canola meal as a result of removal of the fibrous hull which constitutes almost 12- 16% of the seed (Bell, 1993) [5]. The energy deficits can be lowered through precise formulation strategies that help in balancing nutrient density and bird performance.

2.1.5 Mineral and Vitamin Profile

Canola meal also has appreciable amounts of essential minerals and vitamins supporting its role as a cost effective alternative to expensive protein sources. This is particularly relevant in layer hen diets, where its inclusion has supported high egg production (Canola Council of Canada., 2024) [11].

Canola meal supplies calcium, manganese, iron, selenium, and a variety of trace elements necessary for growth, immune function, and reproductive performance in poultry (New Kirk., 2009). Canola meals have reported higher concentrations of calcium and phosphorus in comparison with SBM (Summers *et al.*, 1989; Swick, 1999) [39, 40].

Approximately 65% of phosphorus is stored as phytate and poorly available to monogastric animals. This limitation is addressed through phytase supplementation improving bioavailability while reducing the phosphorous excretion (Hanna *et al.*, 2018) [17]. The overall contribution of calcium

and phosphorus from canola meal remains greater than that of SBM (Summers *et al.*, 1989; Swick, 1999) ^[39, 40].

Canola meal also contains higher levels of biotin, folic acid, niacin, riboflavin, and thiamin than soybean meal (Newkirk, 2009).

2.1.6 Reduced-Protein Diets and Amino Acid Dynamics

By partially or completely substituting the SBM with lesser protein varieties (like canola meal) may lead to drop in the protein quality affecting the digestion.

This limitation can be overcome by addition of threonine and glycine equivalents to the lesser protein substitutes. This has shown to increase the distal ileal digestibility by almost 8 % and lower the distal ileal starch: protein disappearance rate ratio, helping the digestion of energy and protein in a more balanced manner (Sonia *et al.*, 2021)

3. Anti-Nutritional Factors (ANFs)

The inclusion of canola meal as a protein source in poultry is mainly limited by the presence of anti-nutritional factors which have been linked to reduced growth performance. The primary antinutritional constituents of canola meal are glucosinolates, sinapine, tannins, and phytic acid (Wickramasuriya *et al.*, 2015) ^[43]. Even though modern canola varieties have been bred to contain lower glucosinolate levels than the traditional rapeseed varieties, these compounds can still affect the palatability, nutrient availability of the feed particularly at higher rates of inclusion (Khajali *et al.*, 2012) ^[23].

3.1 Glucosinolate

Concentrations in canola seeds considerably vary across regions and the extraction processes but typically range from 3.6 to 9.2 $\mu\text{mol/g}$. Although these levels are below the associated levels of acute toxicity, higher inclusions of canola meal in diet may still affect the bird negatively (Spragg and Mailer., 2007) ^[38]. In broilers, dietary inclusion levels of canola meal above commonly recommended (20%) has been reported to be tolerable without adverse production effects, providing that total glucosinolate concentration does not exceed 4 $\mu\text{mol/g}$ feed (Khajali *et al.*, 2012) ^[23].

3.2 Sinapine is the main phenolic compound and comprises roughly 1% of canola meal. It has been associated with the development of “fishy” off- flavors in eggs (Bonardeaux., 2007) ^[6]. But further research revealed that this phenomenon is a result of sinapine and also a recessive gene mutation in the suspected hens, causing trimethylamine (TMA) accumulation (Ward *et al.*, 2009). Successful removal of this trait from commercial brown-egg layers through breeding programs, reduced the risk of TMA off- flavor (Oryschak *et al.*, 2020) ^[31].

3.3 Tannins in canola are concentrated primarily in the seed hulls. Studies have shown that rapeseed and canola hulls contain between 1.9 and 6.2g of tannins per 100g of oil free material (Naczka *et al.*, 2000). Proanthocyanids which are responsible for the dark pigmentation of the seeds are from the fraction of insoluble tannins (Khajali *et al.*, 2012) ^[23].

3.4 Phytic acid is one of the most important ANF in canola meals. The phosphorus in canola meal is locked as monogastric animals lack sufficient endogenous phytase to facilitate their digestion (Bonardeaux., 2007) ^[6]. This can be overcome by the supplementation of exogenous phytase to unlock the phosphorus and reduce the mineral waste (Hanna *et al.*, 2018) ^[17].

4. Physiological effect of Canola meal in Layers

Canola Meal has gained recognition as a sustainable protein ingredient for poultry diet (Dao & Moss, 2025) ^[13] though its inclusion warrants careful attention to glucosinolate contents and its physiological effects.

However, sensory quality of Poultry Products can be affected at elevated dietary inclusion levels. Studies have reported reduction in chicken flavor intensity and an increase in off-flavor incidence at higher inclusion rates, Such as at 28% in chick starter. In contrast, Moderate level around 21% in starters did not cause adverse sensory outcomes (R.E. Salmon *et al.*, 1980) ^[35] suggesting balanced appropriate formulation can preserve meat quality.

The concern around glucosinolates become particularly pronounced in laying hens, which appear more metabolically sensitive to these anti-nutritional factors compared to broilers. Dietary glucosinolates concentrations exceeding 1.5 $\mu\text{mol/g}$ have been associated with an elevated risk of hemorrhagic liver syndrome in laying hens. Research indicates that laying hens can tolerate generous inclusion level of canola meal, provided glucosinolate content kept within safe approximately 1.43 $\mu\text{mol/g}$ [Campbell *et al.*, 1991].

Interestingly, while chicks fed glucosinolates did not exhibit significant liver weight changes but thyroid enlargement was observed particularly when glucosinolates were fed alongside nitrites. Notably when purified glucosinolates were added in isolation, Thyroid weight did not increase, implying that interaction between glucosinolates and other dietary components play major organ response role, underscoring the importance of using low-glucosinolate canola meal in a commercial poultry feeding system. (Slominski *et al.*, 1988).

5. Effects of canola meal on Egg quality

Egg quality parameters are highly sensitive to dietary protein sources and nutrient availability, making evaluation of alternative protein ingredients essential in layer nutrition (Mailer *et al.*, 2008) ^[25].

Early studies that formulated diets on a crude protein basis reported reduction in egg weight when canola meal replaced soybean meal primarily due to insufficient lysine content in canola based diet [Kaminska *et al.*, 2003]. This was further supported by [Novak *et al.*, 2004]

Inadequate lysine directly compromise egg weight. However when diets are properly balanced for amino acids, Canola meal can be included at up to 20% of diet without negatively affecting egg production, hen health, egg quality or egg fatty acid content (Oryschak & Beltranena, 2013) ^[32].

Regarding sensory quality, sinapine present in canola meal can be metabolized by intestinal microflora into trimethylamine [TMA], potentially causing fishy or off-odor egg in susceptible hens (Hobson-Frohock *et al.*, 1973) ^[18]. Modern commercial white egg strains, however, possess sufficient hepatic TMA oxidase activity that prevent such accumulation, allowing canola meal use at recommended level without sensory impairment (Hyline international, 2010) ^[19]. Indirect effect of canola meal inclusion, such as enhanced fat-soluble pigment absorption, often result in improved yolk color (Costa *et al.*, 2008) ^[12].

Overall, adverse effects on egg quality can be minimized through use of low glucosinolate canola meal varieties at controlled inclusion level (Khajali & Slominski, 2012) ^[23].

6. Economic efficiency and cost effectiveness of canola meal in poultry diet

When evaluating feed ingredients in poultry production, academic research often focuses primarily on growth rates

and performance metrics. In practice, the industry takes a broader view, one that weighs ingredient cost alongside productivity, animal health and survival rates to arrive at true cost per unit of gain. From this perspective, canola meal presents a compelling case. Even in situations where it may not maximize growth rates outright, its inclusion in poultry diet has been shown to meaningfully lower the overall cost of production, making it an attractive option for producers operating under tight economic margins (Canola council of Canada).

Analyses had already pointed in this direction, suggesting that canola meal could substitute for up to half of convention protein supplements in livestock rations without compromising animal performance, provided market pricing was favorable. This highlight that economic viability of canola meal is not fixed it is sensitive to market dynamics, and producers who track commodity prices closely stand to benefit the most from its strategic inclusion (Agriculture Canada. 1990) ^[2].

The experimental work has added quantitative weight to these economic claims, particularly in the context of layer production. The cost-effectiveness of three canola meal types cold pressed, expeller-pressed and solvent-extracted in wheat based diet for hy-line brown hens across two separate experiments. In the first trial, spanning 21 to 41 weeks of age, cold-pressed canola meal was included up to 200g/kg. Given its lower market price at time (AUD \$450/mt compared to AUD \$650/mt for soyabean meal), this inclusion level reduced diet cost by approximately AUD \$25 per tonne, with projections suggesting potential industry wide saving of up to AUD \$18 million annually. The second experiment, conducted between 46 and 65 weeks of age, compared all the three meal types at fixed inclusion of 150g/kg. Feed cost per kilogram of eggs was most favorable with expeller-pressed canola meal (AUD \$0.615), followed closely by cold -pressed meal (AUD \$0.619), while solvent-extracted meal carried highest cost (AUD \$0.679). (Swick and Wu, 2016) ^[40].

Supporting these finding, also reported a measurable reduction in diet cost as the proportion of soyabean meal replaced by canola meal increased, reinforcing that canola meal serves as economical protein alternative, the available evidence suggest that thoughtful incorporation of canola meal with attention to processing type, inclusion level and prevailing market prices can improve the economic resilience of commercial poultry operations (Moraes *et al.*, 2015).

7. Conclusion

Canola meal presents a nutritionally credible and economically attractive alternative to soybean meal in layer hen diets, provided its inclusion is managed thoughtfully. Its favorable sulfur amino acid profile, micronutrient density and consistent cost advantage over soybean meal make it a legitimate candidate for partial substitution in commercial layer nutrition. The performance concerns documented in literature reduced egg weight, compromised digestibility are now largely attributable to crude protein based formulation practices rather than any fundamental deficiency of canola meal itself. Under modern digestible amino acid formulation frameworks, inclusion level of 15-20% paired with low anti-nutritional factor, consistently support productive performance egg quality and hen health without compromise. The performance of high producing modern laying strains under sustained canola meal inclusion, particularly in tropical production environment and heat stress, is insufficiently characterized. As canola meal breeding continues to push

glucosinolates level lower and processing technologies improve energy availability, the practical ceiling for inclusion may shift upward. Until that evidence matures, a conservative but confident stand canola meal, correctly sourced and precisely formulated, is a sound, sustainable and cost-effective partial replacement for soybean meal in commercial layer production.

Conflict of Interest

Not available

Financial Support

Not available

References

1. Adedokun SA, Utterback P, Parsons CM, Adeola O, Lilburn MS, Applegate TJ. Comparison of amino acid digestibility of feed ingredients in broilers, laying hens and caecectomised roosters. *Br Poult Sci.* 2009;50:350-358.
2. Agriculture Canada. Potential for exports of Canadian canola products to the United States. Ottawa: Agriculture Canada, National Grains Bureau (Grains 2000 Program); 1990.
3. Agyekum AK, Woyengo TA. Nutritive value of expeller/cold-pressed canola meal and pre-pressed solvent-extracted carinata meal for broiler chicken. *Poult Sci.* 2022;101:101528.
4. Anderson-Hafermann JC, Zhang Y, Parsons CM. Effects of processing on the nutritional quality of canola meal. *Poult Sci.* 1993;72:326-333.
5. Bell JM. Factors affecting the nutritional value of canola meal: A review. *Can J Anim Sci.* 1993;73:689-697.
6. Bonnardeaux J. Uses for Canola Meal. Department of Agriculture and Food, Western Australia: Perth, Australia; 2007. Available from: <https://library.dpiird.wa.gov.au/pubns/29/>
7. Bryden WL, Li X, Ravindran G, Hew LI, Ravindran V. Ileal Digestible Amino Acid Values in Feedstuffs for Poultry; No 09/071. Rural Industries Research and Development Corporation Publication: Barton, ACT, Australia; 2009.
8. Campbell LD, Slominski BA. Nutritive quality of low-glucosinolate meal for laying hens. In: *Proceedings of the 8th International Rapeseed Congress*, Saskatoon, SK, Canada; 9-11 July 1991. Vol 2, p. 442-447.
9. Canola Council of Canada. Publication No. 63; 1984.
10. Canola Council of Canada. Canola Meal Feed Industry Guide. 4th ed.; 2009.
11. Canola Council of Canada. Canola Meal Dairy Feeding Guide. 7th ed.; 2024.
12. Costa FGP, Souza JG, Silva JHV, Rabello CB-V, Goulart CdC, Neto L, Cunha R. Influência do óleo de linhaça sobre o desempenho e a qualidade dos ovos de poedeiras semipesadas. *Rev Bras Zootec.* 2008;37(5):861-868.
13. Dao TH, Moss AF. Canola meal: A sustainable protein source for poultry diets. *Animals.* 2025;15:3609.
14. FAOSTAT. Available from: <https://www.fao.org/faostat>. 2015.
15. Gopinger E, Xavier EG, Elias MC, Catalan AAS, Castro MLS, Nunes AP, Roll VFB. The effect of different dietary levels of canola meal on growth performance, nutrient digestibility, and gut morphology of broiler chickens. *Poult Sci.* 2014;93(5):1130-1136. doi:10.3382/ps.2013-03426

16. Hanna CD, Foran CK, Utterback PL, Stein HH, Parsons CM. Phosphorus bioavailability in increased-protein, reduced-fiber canola meal, conventional canola meal, and soybean meal fed to crossbred chicks. *Poult Sci.* 2018;97:188-195.
17. Hobson-Frohock A, Land D, Griffiths N, *et al.* Egg Taints: Association with Trimethylamine. *Nature.* 1973;243:304-305. doi:10.1038/243304a0
18. Hy-Line International. Feeding rapeseed meal or canola meal to Hy-Line brown hens. 2010.
19. Jia W, Mikulski D, Rogiewicz A, Zduńczyk Z, Jankowski J, Slominski BA. Low-fiber canola. Part 2. Nutritive value of the meal. *J Agric Food Chem.* 2012;60:12231-12237.
20. Kaminska BZ. Substitution of soyabean meal with “00” rapeseed meal or its high-protein fraction in the nutrition of hens laying brown-shelled eggs. *Anim Feed Sci.* 2003;12:111-120.
21. Kandel M, Macelline SP, Toghyani M, Chrystal PV, Choct M, Cowieson AJ, Selle PH. The potential of canola to decrease soybean meal inclusions in diets for broiler chickens. *Anim Nutr.* 2025;20:342-354.
22. Khajali F, Slominski BA. Factors that affect the nutritive value of canola meal for poultry. *Poult Sci.* 2012;91:2564-2575.
23. Lannuzel C, Smith A, Mary AL, Della Pia EA, Kabel MA, De Vries S. Improving fiber utilization from rapeseed and sunflower seed meals to substitute soybean meal in pig and chicken diets: A review. *Anim Feed Sci Technol.* 2022;285:115213.
24. Mailer RJ, McFadden A, Ayton J, Redden B. Anti-nutritional components, fibre, sinapine and glucosinolate content in Australian canola meal. *J Am Oil Chem Soc.* 2008;85:937-944.
25. Mawson R, Heaney RK, Zdunczyk Z, Kozłowska H. Rapeseed meal glucosinolates and their antinutritional effects. Part 3. Animal growth and performance. *Nahrung.* 1994;38:167-177.
26. Naczki M, Amarowicz R, Sullivan A, Shahidi F. Current research developments on polyphenolics of rapeseed/canola: A review. *Food Chem.* 1998;62:489-502.
27. Newkirk RW, Classen HL, Edney MJ. Effects of prepress-solvent extraction on the nutritional value of canola meal for broiler chickens. *Anim Feed Sci Technol.* 2003;104:111-119.
28. Novak C, Yakout H, Scheideler S. The combined effects of dietary lysine and total sulfur amino acid level on egg production parameters and egg components. *Poult Sci.* 2004;83(6):977-984.
29. Nwokolo E, Sim J. Barley and full-fat canola seed in layer diets. *Poult Sci.* 1989;68:1485-1489.
30. Oryschak MA, Smit MN, Beltranena E. Brassica napus and Brassica juncea extruded-expelled cake and solvent-extracted meal as feedstuffs for laying hens: Lay performance, egg quality, and nutrient digestibility. *Poult Sci.* 2020;99:350-363.
31. Oryschak M, Beltranena E. Solvent-extracted vs. expeller-pressed B. napus and B. juncea fed to layers: Effects on feed intake, egg production and physical egg quality. *Poult Sci.* 2013;92(Suppl. 1):80.
32. Parsons CM, Hashimoto K, Wedekind KJ, Han Y, Baker DH. Effect of overprocessing on availability of amino acids and energy in soybean meal. *Poult Sci.* 1992;71:133-140.
33. Rezvani M, Kluth H, Bulang M, Rodehutschord M. Variation in amino acid digestibility of rapeseed meal studied in caecectomised laying hens and relationship with chemical constituents. *Br Poult Sci.* 2012;53:665-674.
34. Salmon RE, Gardiner EE, Klein KK, Larmond E. Effect of canola meal on broilers. *Poult Sci.* 1980.
35. Slominski BA, Jia W, Rogiewicz A, Nyachoti CM, Hickling D. Low-fiber canola. Part 1. Chemical and nutritive composition of the meal. *J Agric Food Chem.* 2012;60:12225-12230.
36. Smulikowska S, Pastuszewska B, Mieczkowska A, Ochtabińska A. Chemical composition, energy value for chickens, and protein utilization in rats of rapeseed expeller cakes produced by different pressing technologies. *J Anim Feed Sci.* 1997;6:109-121.
37. Spragg J, Mailer R. Canola Meal Value Chain Quality Improvement. In: Summers JD, Bedford M, Spratt D, editors. Amino acid supplementation of canola meal. *Can J Anim Sci.* 1989;69:469-475.
38. Swick RA. Considerations in Using Protein Meal for Poultry and Swine; ASA Technical Bulletin Volume AN 21. American Soybean Association: St. Louis, MO, USA; 1999.
39. Swick RA. Inclusion levels and economic benefits of canola meals on egg production of laying hens. Final Report. Armidale, NSW: Poultry CRC Ltd; 2016.
40. Uppstrom B. Seed chemistry. In: Kimber D, McGregor DI, editors. Brassica Oilseeds: Production and Utilization. CAB International: Wallingford, UK; 1995. p. 217-242.
41. Wickramasuriya SS, Yi YJ, Yoo J, Kang NK, Heo JM. A review of canola meal as an alternative feed ingredient for ducks. *J Anim Sci Technol.* 2015;57:29.

How to Cite This Article

Shukla G, Gudla CS, Pandya M, Saha S, Barik SS, Jaitly A *et al.* Canola meal in layers: Nutritional composition, anti-nutritional factors and production performance: A comprehensive review. *International Journal of Veterinary Sciences and Animal Husbandry.* 2026; 11(5): 01-05.

Creative Commons (CC) License

This is an open-access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.