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Incorporating Extruded Rapeseed Meal in Broiler Diets: Effects on Performance and Nutrient Absorption

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ABSTRACT

This study investigates the utilization of extruded rapeseed meal (ERSM) in broiler diets and its effects on nutrient digestibility and growth performance. Two-hundred-and-forty-day-old broiler chicks were divided into four groups, including a control group with no ERSM and three experimental groups with 5%, 10%, and 15% ERSM inclusion levels. The experiment spanned 35 days, with diets formulated to meet NRC recommendations for starter (0–21 days) and finisher phases (22–35 days). The results revealed no significant differences in feed intake across groups, indicating that ERSM did not adversely affect palatability. Notably, Group 2 (10% ERSM) exhibited the highest weight gain and the lowest feed conversion ratio (FCR), suggesting enhanced growth efficiency. Nutrient digestibility analysis showed that Group 2 achieved maximum dry matter (77.47%), crude protein (79.42%), and fat digestibility (85.10%), surpassing the control and other treatment groups. In contrast, the highest ERSM level (15%) resulted in decreased nutrient absorption, likely due to the elevated presence of anti-nutritional factors inherent in rapeseed. These findings underscore the potential of moderate ERSM inclusion (10%) to improve broiler productivity by providing an economical and nutritionally viable alternative to traditional protein sources like soybean meal. The study confirms the suitability of ERSM in broiler diets, advocating for its broader application in poultry nutrition to reduce feed costs and enhance sustainability. Future research should explore further processing techniques to mitigate anti-nutritional factors in ERSM, optimizing its efficacy in poultry feed formulations.

INTRODUCTION

Poultry feed supplementation plays a crucial role in optimizing the health and productivity of animals, ensuring they receive balanced nutrition for growth and development (Hafeez *et al*., 2023; Subhan *et al*., 2023; Hafeez *et al*., 2024), including natural products (Gul and Alsayegh, 2022; Ahmad *et al*., 2023; Anwar *et al*., 2023; Hassan *et al*., 2023). The incorporation of cost-effective non-traditional feed ingredients, such as rapeseed meal (RSM), offers a promising strategy to address feed shortages in the poultry industry. Rapeseed meal, a byproduct of oil extraction from rapeseed, is a valuable protein source that ranks second only to soybean meal in global production of protein-rich feed (USDA, 2016). Given its high nutritional value, rapeseed meal is extensively used as a feed additive (Downey and Bell, 1990). RSM contains a well-balanced amino acid profile and offers approximately 40% protein, making it an excellent alternative to traditional feed components (Naczk *et al*., 1998). Additionally, it is rich in fiber and contains a variety of essential vitamins and minerals such as calcium, magnesium, zinc, and copper. Key nutrients that enhance the nutritional profile of rapeseed meal

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include tocopherols, B vitamins, and choline (Saini and Keum, 2018).

Rapeseed is notably high in phenolic compounds, which include tannins, free phenolic acids, and esterified phenolic acids (Krygier *et al*., 1982). Among oilseed plants, rapeseed is recognized as a significant source of phenolic compounds, particularly in its meal form (Naczk *et al*., 1998).

Rapeseed, a valuable protein source, is limited in poultry diets due to high levels of anti-nutritional factors (ANFs) such as glucosinolates and erucic acid. These compounds, found abundantly in conventional rapeseed, reduce feed intake due to their bitter taste and pungent flavor, while also impacting thyroid function, making them unsuitable for poultry (Cartea *et al*., 2021). Erucic acid poses toxicity risks, complicating rapeseed meal's use in poultry feed (Rakow and Raney, 2017). Additionally, rapeseed meal contains tannins and sinapin, which decrease protein digestibility, and phytic acid, which binds essential minerals, reducing their bioavailability (Inglett and Daigle, 2014). The high fiber and low lysine content further limit its inclusion in monogastric diets (Koivunen *et al*., 2016). Despite these challenges, rapeseed meal's rich nutritional profile offers potential benefits if ANF levels can be reduced through breeding or processing innovations. This study aims to evaluate the effects of extruded rapeseed meal (RSM) on the growth performance, nutrient digestibility, and overall health of broiler chicks.

MATERIALS AND METHODS

The experiment was conducted at the Global Feeds Environmentally Controlled Broiler Farm in District Lodhran. The trial was divided into two phases: Phase 1, the starter period, spanned from day 0 to day 21, while Phase 2, the finisher phase, covered days 22 to 35.

Experimental setup and chick management

Two hundred and forty day-old commercial broiler chicks were provided by global hatchery for a study conducted at the global protein farm, unit 9 in Dunyapur. The chicks were divided into four groups, each with six replicates. Each replicate consisted of ten chicks, resulting in a total of twenty-four pens, prepared before the chicks arrival. Prior to the chicks arrival, the pens were fumigated and equipped with rice hull bedding. All equipment, including drinkers, feeders, and heat lamps, was meticulously set up. Temperature and humidity levels were continuously monitored using a digital thermometer and hygrometer, respectively. Feed bags were stored appropriately and numbered according to their designated group to ensure proper management and feeding practices throughout the study.

Extrusion of rapeseed meal

A batch of 1000 kg of RSM was extruded for experimental diets using a single-screw Henan Lima extruder at a private fish feed company. The extrusion temperature ranged from 80°C to 120°C, maintaining moisture at around 15%. This process yielded 910 kg of ERSH, with 90 kg lost during extrusion. The extrusion process involved several steps: Materials were crushed to an optimal particle size, crucial for cost-effective feed production and quality. Thorough mixing of crushed materials ensured uniformity, vital for feed quality. A wet extruder produced 500-600 kg/h of feed pellets by mixing, shearing, and heating under high pressure, air heated in dryers absorbed moisture from the product, followed by cooling with ambient air.

Formulation of experimental diets

Experimental diets were formulated using locally available resources to meet the NRC (National Research Council) recommendations for broiler chickens. Three levels of extruded rapeseed meal (5%, 10%, and 15%) were incorporated into the feed for three experimental groups: G1, G2, and G3, respectively. Group G4 served as the control and did not receive any RSM. The experiment was divided into two phases: starter phase (0-21 days) and finisher phase (22-35 days) as shown in Tables I and II. Separate finisher feeds were prepared for each group to optimize growth during the later stage. Each feed phase was tailored to the dietary needs of the broilers for their respective growth stages, ensuring adequate nutrition throughout the study.

Growth performance

Feed intake, body weight gain, and feed conversion ratio (FCR) were measured over a five-week period to assess the growth performance of broilers. Daily feed intake was recorded for each group, allowing for the calculation of cumulative intake over the study period. Body weight gain was monitored weekly, providing insights into the growth trajectory of the broilers. Additionally, FCR, calculated as the ratio of feed intake to weight gain, was evaluated as an indicator of feed efficiency.

Digestibility

The direct technique was used to determine the nutrient's digestibility. Polythene bag was placed on floor at 33th day of trail. Faeces were collected on the final two days of a one-day trial that served as an adaptation phase. (34th and 35th day).

Table I. Feed composition and chemical analysis during starter phase (1-21 days) of broiler chickens.

Ingredients (%)	Extruded rapeseed meal			
	G1 (5%)	G2 (10%)	G3 (15%)	G4 (Control)
Maize	56.9	56.9	56.9	56.9
Canola meal	10	10	5	10
Rapeseed meal	5	0	0	7
Extruded rapeseed meal	5	10	15	0
Soybean meal	5	5	5	8
Fish meal 50%	6.91	6.91	6.91	6.91
Gaur meal	4	4	4	4
Wheat bran	4.87	4.87	4.87	4.87
Marble chips	0.87	0.87	0.87	0.87
Poultry oil	0	0	0	0
Soda bicarb	0.1	0.1	0.1	0.1
Salt	0.1	0.1	0.1	0.1
Feed premix	1.25	1.25	1.25	1.25
Chemical analysis (%)				
Dry matter	86.1	86.6	85.8	87.44
Moisture	13.9	13.34	14.2	12.56
Crude protein	21.43	21.06	22.09	21.02
Crude fibre	4.71	4.73	4.7	4.69
Ether extract	5.3	4.96	3.7	6.7
Ash	4.9	4.86	5.16	4.0

Where G1 5% extruded rapeseed meal G2 10% extruded rapeseed meal G3 15% extruded rapeseed meal and G4 control group.

$$\text{Digestibility coefficient (\%)} = \frac{\text{Intake of nutrient in feed} - \text{nutrient in feces}}{\text{Intake of nutrient}} \times 100$$

Statistical analysis

One-way Analysis of Variance (ANOVA) was employed to compare the across the four groups. Where significant differences were detected ($p < 0.05$), Tukey's Honest Significant Difference (HSD) post hoc test was used to identify pairwise differences between groups.

RESULTS

Table III shows feed intake, weight gain and FCR of the control and experimental groups at different weeks in broiler chickens. In week 1, feed intake did not change significantly between the control and the treatment groups. In the same week, weight gain and FCR was significantly (P<0.05) higher in G2 compared to G1, G3 and the control groups. In week 2, feed intake and weight gain was significantly (P<0.05) lower in G3 compared to G2, however, FCR was significantly (P<0.01) lower in G2 compared to G1 and G3. During week 3, significantly (P<0.01) higher feed intake and weight gain was observed in G2 while lowest FCR was observed in the same group. During week 4 and 5, significantly (P<0.01) lower feed intake and weight gain was observed in G3, while lowest FCR was found in G2.

Table II. Feed composition and chemical analysis during finisher phase (22-35 days) of broiler chickens.

Ingredients (%)	Extruded rapeseed meal			
	G1 (5%)	G2 (10%)	G3 (15%)	G4 (Control)
Maize	61.1	61.1	61.1	61.9
Canola meal	10	10	5	10
Rapeseed meal	5	0	0	7
Extruded rapeseed meal	5	10	15	0
Soybean meal	5	5	5	8
Fish meal 50%	7.6	7.6	7.6	7.6
Gaur meal	4	4	4	4
Wheat bran	0	0	0	0
Marble chips	0.79	0.79	0.79	0.79
Poultry oil	0.24	0.24	0.24	0.24
Soda bicarb	0.1	0.1	0.1	0.1
Salt	0.07	0.07	0.07	0.07
Feed premix	1.1	1.1	1.1	1.1
Chemical composition (%)				
Dry matter	86.6	87. 0		86.9
Moisture	13.4	13.0		13.1
Crude protein	21.0	20.09		20.08
Crude fibre	4.66	4.68		4.66
Ether extract	4.0	4.7		6.28
Ash	4.67	5.06		4.58

G1: 5% extruded rapeseed meal; G2: 10% extruded rapeseed meal; G3: 15% extruded rapeseed meal and G4 control group

Table IV shows feed intake, body weight gain and FCR of starter, finisher and overall phases ERSM in broiler chickens. During the starter phase, finisher phase and overall basis, significantly (P<0.05) higher feed intake, weight gain and lowest FCR was observed in G2 compared to G3. It is pertinent to note that feed intake, weight gain and FCR were lower in G3 showing the effective of the supplementation of G2 compared to the control, G1 and G3.

Table III. Weekly feed intake, body weight gain and FCR in broilers fed different levels of extruded rapeseeds meal in broiler chickens.

Group	Feed intake	Weight gain	FCR
Week 1			
G1 (5%)	128.00^{ab}	137.00^{c}	0.93^{ab}
G2 (10%)	130.00^{ab}	152.00^{a}	0.85^{c}
G3 (15%)	126.00^{b}	132.00^{c}	0.95^{a}
Control	131.00^{a}	145.00^{b}	0.90^{b}
P-Value	0.08	0.01	0.01
SEM	1.39	1.91	0.01
Week 2			
G1 (5%)	282.00^{ab}	217.50^{bc}	1.29^{b}
G2 (10%)	286.00^{a}	232.00^{a}	1.23^{c}
G3 (15%)	280.00^{b}	211.00^{c}	1.32^{a}
Control	284.00^{ab}	226.50^{ab}	1.25^{bc}
P-Value	0.15	0.001	0.001
SEM	1.83	3.09	0.01
Week 3			
G1 (5%)	526.00^{b}	392.00^{c}	1.34^{b}
G2 (10%)	532.50^{a}	418.00^{a}	1.27^{d}
G3 (15%)	520.83^{c}	384.50^{d}	1.35^{a}
Control	527.00^{b}	407.17^{b}	1.29^{c}
P-Value	0.0000	0.001	0.01
SEM	0.5028	1.1984	3.959E-03
Week 4			
G1 (5%)	1079.0^{a}	657.50^{c}	1.64^{b}
G2 (10%)	1071.3^{b}	670.33^{a}	1.59^{d}
G3 (15%)	1056.3^{c}	631.83^{d}	1.67^{a}
Control	1079.8^{a}	664.50^{b}	1.62^{c}
P-Value	0.01	0.01	0.01
SEM	0.6423	1.6512	4.35
Week 5			
G1 (5%)	1106.0^{b}	603.83^{c}	1.83^{b}
G2 (10%)	1134.0^{a}	656.50^{a}	1.72^{d}
G3 (15%)	1074.2^{c}	580.50^{d}	1.85^{a}
Control	1107.3^{b}	624.33^{b}	1.77^{c}
P-Value	0.01	0.01	0.01
SEM	0.6593	1.5096	1.70

Mean values bearing different superscripts in a column differ significantly (P<0.05). G1: 5% extruded rapeseed meal; G2: 10% extruded rapeseed meal; G3: 15% extruded rapeseed meal.

Table IV. Feed intake, body weight gain and FCR of starter, finisher and overall phases extruded rapeseed meal in broiler chickens.

GROUP	Feed intake (g)	Body weight gain (g)	FCR
Starter phase			
G1 (5%)	935.0^{bc}	746.5^{c}	1.25^{b}
G2 (10%)	948.5^{a}	802.0^{a}	1.18^{d}
G3 (15%)	926.8^{b}	727.5^{d}	1.27^{a}
Control	942.6^{ab}	778.6^{b}	1.20^{c}
P-Value	0.03	0.01	0.01
SEM	2.93	3.56	5.02
Finisher phase			
G1 (5%)	2185.0^{c}	1261.3^{c}	1.73^{b}
G2 (10%)	2205.3^{a}	1326.8^{a}	1.66^{d}
G3 (15%)	2130.5^{d}	1212.3^{d}	1.75^{a}
Control	2187.2^{b}	1288.8^{b}	1.69^{c}
P-Value	0.001	0.001	0.001
SEM	0.85	1.65	2.47
Overall mean			
G1 (5%)	3120.0^{b}	2007.8^{c}	1.55^{b}
G2 (10%)	3153.8^{a}	2128.8^{a}	1.48^{d}
G3 (15%)	3057.3^{c}	1939.8^{d}	1.57^{a}
Control	3129.2^{b}	2067.5^{b}	1.51^{c}
P-Value	0.001	0.001	0.001
SEM	3.34	3.46	2.41

Mean values bearing different superscripts in a column differ significantly (P<0.05). G1: 5% extruded rapeseed meal; G2: 10% extruded rapeseed meal; G3: 15% extruded rapeseed meal.

Table V. Digestibility of dry matter (DM), crude protein (CP) and ether extract (EE) in broilers fed different levels of extruded rapeseed meal.

Name	DM	CP	EE
G1 (5%)	72.06^{c}	72.842^{c}	77.5^{c}
G2 (10%)	77.4^{a}	79.420^{a}	85.1^{a}
G3 (15%)	69.5^{d}	69.20^{d}	72.9^{d}
Control	75.0^{b}	75.482^{b}	80.8^{b}
P-Value	0.01	0.01	0.01
SEM	0.07	0.02	0.02

Mean values bearing different superscripts in a column differ significantly (P<0.05). G1: 5% extruded rapeseed meal; G2: 10% extruded rapeseed meal; G3: 15% extruded rapeseed meal.

Table V shows digestibility of dry matter (DM), crude protein (CP) and ether extract (EE) in broilers fed different levels of extruded rapseed meal. These results showed that digestibility of DM, CP and EE was significantly ($P<0.05$) higher in G2 compared to G3, G1 and the control.

DISCUSSION

The findings from Table III highlight the effects of various levels of ERSM on broiler performance, with a particular focus on feed intake, weight gain, and FCR in starter, finisher and overall basis. These results provide valuable insights into the potential benefits and limitations of ERSM as a feed component in poultry diets. The feed intake among different groups at different phases of starter, finisher and overall basis showed significant variations This aligns with previous studies that suggest the incorporation of ERSM, up to a certain level, does not impact feed consumption negatively (Alagawany *et al*., 2016; Vieira *et al*., 2020). The control group exhibited the highest feed intake of 131.0 g, while G3 had the lowest at 126.0 g. The slight variation in feed intake across the groups suggests that the inclusion of ERSM in the diet was generally well-tolerated by the broilers. This observation is supported by other research indicating that extruded rapeseed meal can be a viable alternative protein source in poultry diets without affecting feed intake (Chwastowska-Siwiecka *et al*., 2020).

The effect of ERSM on weight gain was more pronounced across different phases of growth. The highest average weight gain was recorded in G2 in starter, finisher and overall basis, which suggests that moderate inclusion of ERSM might enhance growth performance. This is consistent with findings from Oladokun *et al*. (2017), who reported that moderate levels of rapeseed meal could support adequate growth in broilers. Conversely, G3 exhibited the lowest weight gain at 132.0 g, suggesting that higher levels of ERSM might have a diminishing effect on growth performance, possibly due to anti-nutritional factors such as glucosinolates and fiber content, which can impair nutrient utilization and absorption (Naseem *et al*., 2020). The intermediate values for G1 and the control group indicate a potential threshold for ERSM inclusion that maximizes growth without introducing negative effects.

The FCR results are particularly noteworthy in starter, finisher and overall basis, with G2 showing the lowest FCR. This suggests that the inclusion of ERSM at moderate levels can enhance feed efficiency. These findings are in line with previous research indicating that ERSM can improve FCR due to its high protein content and balanced amino acid profile (Swiatkiewicz *et al*., 2016; Naczk *et al*., 1998). The higher FCR observed in G1 and G3 suggests that either lower or higher ERSM concentrations might not be as effective in improving feed efficiency, possibly due to suboptimal protein-to-energy ratios or the presence of anti-nutritional factors at higher inclusion levels (Tripathi and Mishra, 2007).

The study underscores the potential of ERSM as a cost-effective feed ingredient that can improve broiler performance when used at optimal levels. The high protein content and balanced amino acid profile of ERSM contribute to its effectiveness in enhancing growth and feed efficiency (Bell and Keith, 1990). However, the anti-nutritional factors inherent in rapeseed, such as glucosinolates and fiber, can pose challenges at higher inclusion levels, affecting nutrient utilization and growth performance (Tripathi and Mishra, 2007; Swarup and Agarwal, 2007). The results support the hypothesis that ERSM, when extruded and included at moderate levels, can be a valuable component of broiler diets. It enhances growth performance and improves feed efficiency, making it a viable alternative to traditional protein sources like soybean meal. Future research should focus on optimizing ERSM inclusion levels and mitigating the effects of anti-nutritional factors to maximize its benefits in poultry nutrition.

The results presented in Table V reveal the impact of different concentrations of extruded rapeseed meal (ERSM) on nutrient digestibility in broilers, particularly focusing on DM, CP, and fat digestibility compared to a control group. These findings offer critical insights into the efficacy of ERSM as a dietary component and its influence on the overall nutrient absorption and utilization in broilers.

The highest dry matter digestibility was observed in G2 at 77.4%, while the lowest was in G3 at 69.5%. The control group and G1 showed intermediate values of 75.03% and 72.07%, respectively. These results align with existing literature suggesting that moderate levels of ERSM can improve the digestibility of feed components due to its balanced nutritional profile (Woyengo *et al*., 2014). The reduction in DM digestibility at higher ERSM concentrations, as seen in G3, could be attributed to the increased fiber content and anti-nutritional factors such as glucosinolates, which are known to interfere with nutrient absorption and digestive efficiency (Tripathi and Mishra, 2007; Kracht *et al*., 2004).

Crude protein digestibility showed similar trends, with the highest value in G2 at 79.4% and the lowest in G3 at 69.2%. The control group and G1 reported values of 75.4% and 72.8%, respectively. These findings suggest that ERSM can enhance protein digestibility when included at moderate levels in broiler diets. Previous studies have highlighted that rapeseed meal, when processed correctly, can serve as a high-quality protein source, comparable to soybean meal, owing to its rich amino acid profile (Swiatkiewicz *et al*., 2016; Naczk *et al*., 1998). The lower protein digestibility in G3 suggests that higher ERSM levels may introduce anti-nutritional factors that inhibit protein absorption and utilization, consistent with reports by Kanakri *et al*. (2017).

The fat digestibility results indicated a maximum of 85.10% in G2 and a minimum of 72.9% in G3, with the control group and G1 showing values of 80.8% and 77.5%, respectively. This pattern mirrors the trends observed in DM and CP digestibility, underscoring the potential of moderate ERSM levels to enhance nutrient absorption. The high fat digestibility in G2 suggests that ERSM can improve the bioavailability of dietary lipids, possibly due to the extrusion process enhancing the breakdown and emulsification of fat components (Chwastowska-Siwiecka *et al*., 2020). However, the decreased fat digestibility in G3 highlights the adverse effects of excessive ERSM, which may introduce compounds that hinder lipid digestion, as noted in research by Adebiyi *et al*. (2019).

The results underscore the importance of optimal ERSM inclusion levels in broiler diets. Moderate inclusion, as demonstrated by G2, can enhance the digestibility of key nutrients such as dry matter, crude protein, and fat. These findings are supported by literature suggesting that processed rapeseed meal, particularly when extruded, can be an effective alternative to traditional protein sources like soybean meal (Bell and Keith, 1990; Oladokun *et al*., 2017). The diminished nutrient digestibility at higher ERSM levels observed in G3 highlights the necessity to balance the benefits of rapeseed meal with its anti-nutritional factors, which can impair digestive efficiency and nutrient absorption (Tripathi and Mishra, 2007; Kanakri *et al*., 2017).

Overall, these results suggest that incorporating moderate levels of ERSM in broiler diets can enhance nutrient digestibility and improve feed efficiency. This has significant implications for the poultry industry, providing a cost-effective and nutritionally valuable feed alternative that can reduce reliance on traditional protein sources. Future research should focus on refining the processing and inclusion levels of ERSM to mitigate the effects of anti-nutritional factors and maximize its benefits in poultry nutrition.

CONCLUSION

The findings demonstrated that moderate levels of ERSM (10%) significantly enhanced nutrient digestibility, particularly for dry matter, crude protein, and fat, as observed in Group 2 (G2). This group also exhibited improved feed conversion ratios (FCR) and notable weight gain compared to the control group and other treatment groups.

DECLARATIONS

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IRB approval

This study was approved by the Ethical committee on ethics on animal rights and welfare, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar.

Ethical statement

This study was approved by the Departmental Committee on Ethics and Animal Welfare, The University of Agriculture, Peshawar (12/FAVS/2022).

Statement of conflict of interest

The authors have declared no conflict of interest.

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