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Effect of different insoluble dietary fibre sources and level on growth performance and nutrient utilization in broilers

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ABSTRACT

To assess the effect of insoluble dietary fibre sources and level on growth performance and nutrient utilization, a feeding experiment was conducted on day old broiler chicks (n=270) for 35 days under 2×3 factorial arrangement. The day old chicks were randomly divided in to six groups (T_1 to T_6) of 45 each. Two sources of dietary fibre (soy hull or rice husk) were used at 0, 2 or 4 % level and each dietary level have the three replicates of 15 chicks each. The T_1, T_2 and T_3 were allocated to soy hull group, wherein T_4, T_5 and T_6 were fed rice husk at 0, 2 and 4% dietary level, respectively. Inclusion of rice husk (4% level) significantly ($P<0.05$) improved the feed intake and body weight of chicks at 35th d. Although, source of fiber did not affect the feed intake and FCR both source of fiber at 4% level had higher ($p<0.05$) feed intake. The DM metabolizability was higher ($P<0.05$) in control group of chicks fed diet with soy hull, whereas metabolizability of EE was significantly ($P<0.05$) higher in control group of chicks fed rice husk. The metabolizability of EE was significantly ($P<0.05$) better in rice husk group as compared to soy hull. The energy and Ca retention were similar among the groups, but per cent P retention was higher ($P<0.05$) in chicks of control group (T_1). It may be concluded that the inclusion of 2 and 4% level of coarse insoluble fiber sources such as rice husk (42.68%CF) and soy hull (27.25% CF) in diets had no comparative adverse effect on overall performance of broiler birds. Inclusion of rice husk in broiler finisher diet at 4% level resulted in improved performance of broiler birds.

Keywords: Broiler, Growth performance, Insoluble dietary fibre, Nutrient utilization

Dietary fiber is an important component in plant feedstuffs and it varies in amount, structure, digestibility and solubility depending on the origin (Hetland *et al*. 2004). Generally, in poultry feed formulation, dietary fiber (DF) is considered as a diluent of the diet with negative impact on voluntary feed intake and nutrient digestibility (Rougiere and Carre, 2010). Therefore, the commercial poultry diet especially those for young poultry are formulated to contain less than 4% crude fiber. However recent studies have confirmed that the dietary fiber affect the growth performance of poultry (Sadeghi *et al*. 2015) and modulate their gastrointestinal tract (Owusu-Asiedu *et al*. 2006). The insoluble fibers are regarded as functional nutrients because of their ability to escape digestion and modulate nutrient digestion and general intestinal parameters (Tejeda and Kim, 2021). Incorporation of moderate amount of fiber in broiler feed may have favourable effects on gizzard activity, it improves the mixing of the digesta and motility of the GIT **(**Mateos *et al*. 2012), improvement in villi height and crypt depth (Sklan *et al*. 2003). The physico-chemical characteristics of the fiber sources, including particle size, solubility and degree of lignification, affect the passage rate and pH of digesta in the different segments of the GIT (Moreno *et al*. 2009).

Coarse textured insoluble fibers like oat hulls, sunflower hulls, and cereal straw, increase retention time in the upper part of the gut and stimulate gizzard development and endogenous enzyme production resulting in improved digestibility of starch, lipids, and other dietary components (Mateos *et al*. 2002). In India, rice husk is a by-products of rice processing industries, having cellulose (35%), hemicellulose (25%), lignin (20%) and 17% ash (Maruf *et al*. 2017). Soybean hull is a by-product of soybean processing and soybean hulls contains 11-12% CP, 65-70% TDN, 35-40% CF, 29-51% cellulose, 10-25% hemicelluloses, 2-4% lignin, 0.49% Ca and 0.21% P (Liu and Li*,* 2017). The use of soy hull and rice husk on broiler performance have not much studied, therefore, the present study was planned to assess the effect of two different sources of insoluble dietary fiber - soy hull or rice husk on growth performance and nutrient utilization in broiler chicken.

MATERIALS AND METHODS

Broilers chicks and dietary treatments: The experimental broiler chicks (Ross AP strain) from the same hatch (n = 270) were reared under deep litter system for a period of

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35 days. The experiment was carried out following 2×3 factorial arrangements, wherein two insoluble fibre source *i.e*. namely soy hull and rice husk were used at 0, 2 and 4% level in the diet of chicks. Each fibre source had three replicates (15 chicks in each) for each level of inclusion. The dietary treatments were designated T_1, T_2 and T_3 for soy hull group and T_4, T_5 and T_6 for rice husk group at 0, 2 and 4% level of inclusion respectively.

Experimental diet: The feed ingredients *viz*., maize, deoiled soybean cake, soy hull, rice husk, dicalcium phosphate (DCP), limestone powder (LSP), soy oil and premixes containing minerals, vitamins and feed additives were used to formulate six types of diets for each pre starter (0-14 d), starter (15-21 d) and finisher phase (22-35 d) as per (ICAR 2013) specifications. Diet 1 and 4 were fed to chicks of T_1 and T_4 (control), diet 2 and 3 fed to chicks of T_2 and T_3 contained soy hull at 2 and 4% level, respectively, and diet 5 and 6 fed to chicks of T_5 and T_6 group had rice husk as a source of insoluble fibre at 2 and 4% level, respectively.

Growth performance: Body weight of chicks was recorded every week and weight gain was calculated. Feed intake was recorded weekly after subtracting the left over feed and feed conversion ratio was calculated.

Nutrient utilization and balance: To evaluate the nutrient utilization and balance [Energy, Nitrogen (N), Calcium (Ca) and Phosporus (P)], metabolic trial of four days collection period was conducted between 30-35 d of experiment. During this period, chicks were kept in metabolic cages with provision for individual feeding, watering and collection of excreta. The excreta voided over during metabolic trial period were collected with the caution to prevent contamination from the foreign materials. The excreta sample was dried at 60^0C in a hot air oven to a constant weight and then ground. The dried sample of diet and excreta were analyzed for various proximate principles as per AOAC (2000) to determine the nutrient utilization (crude protein, ether extract and crude fibre). The samples were also analyzed for gross energy using Bomb calorimeter, Ca (Talapatra *et al*. 1940) and P (Fiske and Subba Rao, 1925) to determine the energy, Ca and P balance.

RESULTS AND DISCUSSION

The nutrient composition of soy hull and rice husk (Table 1) indicated that soy hull is a good source of protein and NFE. The chicks fed diet with soy hull at 4% level had lower ((P<0.01) average body weight in comparison to chicks of control diet during pre- starter phase, whereas rice husk fed chicks had similar body weight (Table 3). The chicks of rice

Table 1. Chemical composition of soy hull and rice husk

Particulars	Soy hull	Rice husk
Dry matter (%)	89.79	90.88
Crude protein (%)	14.10	2.50
Crude fat (%)	1.06	0.04
Crude fiber (%)	27.25	42.68
NFE (%)	52.09	39.69
Total ash (%)	5.50	15.09
AIA (%)	1.13	14.39

Table 2. Chemical composition of pre starter, starter and finisher broiler diet (on DM basis)

Attributes	Pre starter						Starter						Finisher					
	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
Dry matter (%)	93.05	90.26	90.58	93.05	91.95	90.11	89.80	90.01	90.63	89.80	90.86	90.72	90.64	90.36	90.34	90.64	90.36	90.36
Moisture (%)	6.95	9.47	9.42	6.95	8.05	9.89	10.20	9.99	9.37	10.20	9.14	9.28	9.36	9.64	9.66	9.36	9.64	9.64
Crude protein (%)	21.94	21.76	22.12	21.94	22.00	21.90	21.56	21.48	21.61	21.56	21.44	21.70	19.68	19.63	19.50	19.44	19.63	19.68
Crude fat (%)	4.41	4.95	5.38	4.41	4.89	5.27	4.81	4.97	5.66	4.81	5.85	5.94	4.35	5.10	5.71	4.35	5.13	5.89
Crude fibre (%)	4.38	4.58	5.24	4.38	4.88	5.71	4.61	4.91	4.97	4.61	5.05	5.43	4.80	5.93	6.38	4.80	6.03	6.92
NFE (%)	61.87	61.03	59.79	61.87	60.73	59.19	61.55	61.54	59.43	61.55	60.79	59.65	65.42	63.27	62.14	65.66	62.96	60.45
Total ash (%)	7.40	7.68	7.47	7.40	7.50	7.93	7.07	6.73	7.90	7.07	6.59	7.11	5.75	6.07	6.27	5.75	6.25	7.06
AIA (%)	1.01	1.06	1.14	1.01	1.41	1.74	1.09	1.03	1.41	1.03	1.37	1.73	1.08	1.03	1.59	1.08	1.34	1.75
Ca (%)	1.04	1.05	1.10	1.07	1.10	1.17	1.10	1.07	1.04	1.08	0.98	1.07	1.31	1.33	1.29	1.20	1.21	1.23
Total P (%)	0.63	0.62	0.65	0.64	0.63	0.64	0.61	0.67	0.63	0.70	0.61	0.65	0.64	0.65	0.65	0.64	0.62	0.67

Table 3. Effect of different dietary levels of soy hull and rice husk on performance of broiler chicken

Particulars		Soy Hull (SH)			P value	Rice Husk (RH)			P value
		T_1 (0%)	T_2 (2%)	T_3 (4%)		T_4 (0%)	T_5 (2%)	T_6 (4%)	
Body weight (g)	14 d	500.51^{a} ± 4.99	480.17^{ab} ±4.16	477.20^{b} ± 1.20	0.011	488.00 ±5.20	492.22 ±14.38	518.47 ± 3.01	0.105
	21 d	967.70 ± 6.01	942.70 ±15.68	947.26 ± 15.68	0.284	974.91 ±6.60	963.37 ±19.61	997.76 ± 2.08	0.201
	35 d	2218.55 ± 23.15	2200 ±16.91	2221.31 ± 25.46	0.562	2216.32^{b} ±19.11	2250.38^{b} ±45.33	2376.75a ± 5.94	0.017
Feed intake (g)	0-14	502.70 ± 6.80	495.63±5.78	498.76± 9.42	0.806	511.77^{ab} ±2.96	498.70^{b}±6.42	528.41^{a}±4.96	0.016
	0-21	1109.36± 14.54	1101.41±18.15	1125.32± 27.35	0.721	1115.93^{b} ± 10.00	1122.03^{b} ±18.76	1198.28^{a} ±9.37	0.008
	0-35	3125.79± 55.59	3116.28± 52.17	3147.51± 65.56	0.928	3125.96^{b} ± 31.42	3151.7^{b} ±44.31	3369.78^{a} ±34.49	0.004
FCR (feed: gain)	0-14	1.12± 0.02	1.15± 0.02	1.16± 0.02	0.494	1.16± 0.02	1.12±0.04	1.13±0.01	0.528
	0-21	1.20^{b}± 0.01	1.23^{ab}± 0.02	1.25^{a}± 0.03	0.024	1.20^{b} ± 0.01	1.23^{ab} ±0.01	1.26^{a} ±0.01	0.024
	0-35	1.44± 0.03	1.45± 0.02	1.45± 0.01	0.647	1.44± 0.01	1.43±0.01	1.45±0.01	0.647

Means in the same row with different superscripts a, b, c are significantly different

husk fed group attained higher (P<0.05) live weight than the soy hull group (Table 4) at 4% inclusion level. Inclusion of rice husk (4% level) significantly (P<0.05) increased the body weight of birds in group T_6 as compared to T_4 and T_5 at 35th d, however no significant variation in body weight was recorded in soy hull group. Although the source of fiber did not affect the live weight of chicks during pre-starter (15 d) phase, it was significantly affected the live weight of chicks at the finishing phase (35 d), which was higher (P<0.05) in the chicks of rice husk groups (Table 4). The present findings are in agreement with previous research (Incharoen, 2013; Adibmoradi *et al*., 2016; Moreno *et al*., 2016, Tejeda and Kim, 2020) which also reported higher weight gain when different insoluble fibre sources were included in broiler diets. The response of broiler to addition of fibre varies depending on many factors such as level and type of fibre sources, ingredient composition of the diet, age and growth potential (Alvarado *et al*., 2010; Mateos *et al*. 2012 and Moreno *et al*. 2016).

The cumulative feed intake of chicks in soy hull groups were similar whereas chicks fed rice husk had significantly (P<0.01) higher feed intake in T_6 as compared to T_4 and T_5 groups during pre-starter phase (Table 3). The birds of rice husk group consumed significantly (P<0.05) more feed as compared to soy hull groups. During starter and finisher phase, the feed intake in soy hull groups were similar whereas the chicks of rice husk group had significantly (P<0.01) higher feed intake. Overall, the effect of different level of feeding and fiber source on feed intake was significant (P<0.01) during different phases of chicks growth and the chicks fed insoluble fiber at 4% level consumed significantly (P<0.05) more feed, whereas insoluble fiber source (soy hull and rice husk) did not affect the feed consumption of chicks (Table 4). The higher feed intake in birds fed 4% rice husk diet may be associated with significantly higher weight gain in this group. The present findings are in agreement with reports (Tejeda and Kim, 2020; Sklan *et al.* 2003), who reported the highest feed intake in broilers fed 4% soy hull group and increased average daily feed intake (ADFI) in turkey with higher levels of soybean hull respectively. The increased feed intake in chicks with higher level of insoluble fiber may be associated with a faster passage of ingesta through the distal part of the GIT (Alvarado *et al*. 2010), and the increase in the gut volume (Hetland and Svihus, 2001; Mourao *et al*. 2008).

Table 4. Overall effect of level and source of insoluble fibre on performance of broiler chicken

Particulars	Period	Level effect			P value	Source effect		P value
		0%	2%	4%		Soy hull	Rice husk	
Body weight (g)	14 d	494.26 ± 4.27	486.20 ±7.22	497.83 ±9.36	0.130	485.96 ± 4.16	499.56 ± 6.55	0.09
	21 d	971.21± 4.32	953.04 ±10.43	972.51 ±13.33	0.052	952.49 ± 6.50	978.68 ± 7.84	0.02
	35 d	2217.44^{b} ± 23.43	2225.19^{b} ± 4.39	2299.53^{a} ± 2.00	0.026	2213.29^{b} ± 2.19	2281.15^{a}±28.24	0.03
Feed intake (g)	0-14 d	507.23^{ab} ± 3.89	497.16^{b} ±3.93	513.59^{a}±8.17	0.028	499.03 ±3.88	512.96 ± 4.97	0.04
	0-21 d	1112.65^{b} ± 8.03	1111.72^{b} ± 2.55	1161.8^{a} ± 20.81	0.022	1112.03 ± 0.94	1145.41 ± 4.85	0.08
	0-35 d	3125.88^{b} ± 28.56	3133.99^{b} ± 1.62	3258.65^{a} ± 8.66	0.020	3129.86 ± 9.39	3215.81 ±42.28	0.11
FCR (feed: gain)	0-14 d	1.14 ± 0.01	1.14 ± 0.02	1.14 ± 0.01	0.699	1.23± 0.01	1.23± 0.01	0.87
	0-21 d	1.21^{b} ±0.006	1.23^{ab} ± 0.01	1.25^{a} ±0.01	0.035	1.32± 0.01	1.31±0.01	0.97
	0-35 d	1.44 ± 0.01	1.44 ± 0.01	1.45 ± 0.01	0.907	1.45±0.001	1.44±0.006	0.57

Means in the same row with different superscripts a, b, c are significantly different

Table 5. Effect of different dietary levels of soy hull and rice husk on nutrient metabolizability, energy and mineral balance

Particulars (%)	Soy hull			Rice husk		
	T_1 (0%)	T_2 (2%)	T_3 (4%)	T_4 (0%)	T_5 (2%)	T_6 (4%)
DM Metabolizability (%)	83.09^{a} ± 1.37	79.42^{ab} ±1.32	76.42^{b} ±1.69	82.20 ±1.37	81.86±1.32	79.65±2.34
CP Metabolizability (%)	71.95 ± 1.70	67.67 ± 1.35	69.07±2.43	69.59 ±1.69	72.59±1.74	72.02±1.40
EE Metabolizability (%)	89.02 ± 0.68	88.35 ± 0.77	87.75±0.60	88.32^{b} ±0.68	90.43 ^{ab} ±0.94	91.50 ^{a} ± 0.97
AME /GE (%)	81.34 ±1.02	80.33 ±1.05	80.21± 0.85	80.29 ±1.21	80.85±1.13	81.21± 1.23
Ca Retention (%)	52.29± 0.97	47.62 ± 0.41	45.88 ±0.70	52.83 ± 0.90	45.74±0.78	54.11± 0.90
P Retention (%)	52.02^{a} ±2.96	40.30^{b} ±3.20	41.86^{b} ±1.61	49.62±2.96	41.11±1.25	44.83± 2.64

Means in the same row with different superscripts a, b, c are significantly different.

The source and level of fiber of soy and rice did not affect FCR during the different phases of chicks growth (Table 2). The findings of FCR corroborate favorably with the results of Sadeghi *et al.* (2015) and Kimiaeitalab *et al*. (2017), who also not observed any effect on feed: gain ratio of broilers. In contrast to this better FCR was reported by Sarikhan *et al*. 2010 and Moreno *et al*. 2016 when different sources of insoluble fibre were included in broiler feed.

The fiber sources did not affect the metabolizability of DM, crude protein and EE. The effect of different dietary levels of insoluble fibre source (soy hull or rice husk) on nutrient metabolizability and mineral retention is presented in table 5. The DM metabolizability was significantly ($P<0.05$) better in chicks of control group as compared to chicks fed diet with 4% soy hull. However, in rice husk fed groups, the DM metabolizability was similar. The crude protein metabolizability was not different among the groups, whereas ether extract metabolizability was non-significant within soy hull group, however in rice husk group the metabolizability of EE was significantly ($P<0.05$) higher as compared to control (0%). The findings of the present study corroborate with the result of Adibmoradi *et al.* (2016) who observed that inclusion of rice hull consistently improved the crude protein digestibility. Abdallah *et al.* (2015) also observed significantly higher nitrogen retention in bird fed higher level of fiber. Similarly, Moreno *et al.* (2009) also reported that the inclusion of fiber in the diet has beneficial effect on metabolizability of ether extract in 21-d old broilers. It has been reported that the role of the gizzard is enhanced when feeds high in CF content are included in the diet. A well-developed gizzard improves the GIT function and vitality of the mucosal surface of the different segments of SI, improving nutrient digestibility and absorption and reducing the capability of bacteria to adhere to the mucosal surface.

In energy balance study, the apparent metabolizable energy (AME) as % of GE due to different dietary inclusion levels and of fibre sources was similar among the groups (Table 5). The per cent retention of Ca was similar among the groups, whereas P retention was significantly ($P<0.05$) higher in chicks of control group (T_1) as compared to chicks fed soy hull in T_2 or T_3 groups, whereas, P retention (%) was comparable among the rice husk group. The present study concluded that the inclusion of 2 and 4% level of coarse insoluble fiber sources either as rice husk (42.68% CF) or soy hull (27.25% CF) in diets had no adverse effect on overall performance of broiler chicks, rather inclusion of rice husk in broiler finisher diet at 4% level improved growth performance.

REFERENCES

Abdallah A G, Beshara M M and Ibrahim A F. 2015. Effect of different levels and sources of dietary fiber on productive and economic performance in local laying hens 1-during growing period and subsequent laying performance. *Egyptian Poultry Science Journal* **35** (1): 367–398.

Adibmoradi M, Navidshad B and Jahromi M A. 2016. The effect of moderate levels of finely ground insoluble fibre on small intestine morphology, nutrient digestibility and performance of broiler chickens. *Italian Journal of Animal Sciences* **15** (2): 310–17.

Alvarado J M, Jiménez-Moreno E, Lázaro R and Mateos G G. 2007. Effect of type of cereal, heat processing of the cereal and inclusion of fiber in the diet on productive performance and digestive traits of broilers. *Poultry Science* **86** (8): 1705–15.

Alvarado J M, Jiménez-Moreno E, González-Sánchez R, Lázaro R and Mateos G G. 2010. Effect of inclusion of oat hulls and sugar beet pulp in the diet on productive performance and digestive traits of broilers from 1 to 42 days of age. *Animal Feed Science and Technology* **162**: 37–46.

AOAC. 2000. Official Methods of Analysis. 17th ed. *Association of Official Analytical Chemists*, Verginia, USDA, Washington, D.C.

Fiske C H and Subbarao Y. 1925. The colorimetric determination of phosphorus. *Journal of Biological Chemistry.* **66**:375.

Hetland H and Svihus B. 2001. Effect of oat hulls on performance, gut capacity and feed passage time in broiler chickens. *British Poultry Science* **42**: 354–361.

Hetland H, Choct M and Svihus B. 2005. Role of insoluble non-starch polysaccharides in poultry nutrition. *World Poultry Science* **60**: 415–22.

Incharoen T. 2013. Histological adaptations of the gastrointestinal tract of broilers fed diets containing insoluble fiber from rice hull meal. *American Journal of Animal and Veterinary Sciences* **8** (2): 79-88.

Kimiaeitalab M V, Cámara L, Mirzaie Goudarzi S, Jiménez-Moreno E and Mateos G G. 2016. Effects of the inclusion of sunflower hulls in the diet on growth performance and digestive tract traits of broilers and pullets fed a broiler diet from zero to 21 d of age- A comparative study. *Poultry Science* **96(**3): 581–92.

Liu H M and Li H Y. 2017. Application and Conversion of Soybean Hulls. In *Soybean-The Basis of Yield, Biomass and Productivity*. In Tech open, Ed. Minobu Kasai.

Maruf A, Pramudono B and Aryanti N. 2017. Lignin isolation process from rice husk by alkaline hydrogen peroxide: Lignin and silica extracted. In *AIP Conference Proceedings.* 1823, 020013. doi.org/10.1063/1.4978086.

Mateos G G, Lazaro R and Gracia M. 2002. The feasibility of using nutritional modifications to replace drugs in poultry feeds. *Journal of Applied Poultry Research* **11**:437–52.

Mateos G G, Jimenez-Moreno E, Serrano M P and Lazaro R P. 2012. Poultry response to high levels of dietary fiber sources varying in physical and chemical characteristics. *Journal of Applied Poultry Research* **21**: 156–74.

Moreno E, González-Alvarado J M, González-Serrano A, Lázaro R and Mateos G G. 2009. Effect of dietary fiber and fat on performance and digestive traits of broilers from one to twenty-one days of age. *Poultry Science* **88**: 2562–74.

Moreno E, Coca-Sinova A D, González-Alvarado J M and Mateos G G. 2016. Inclusion of fiber sources in mash or pellet diets for young broilers- Effects on growth performance and water intake. *Poultry Science* **95** (1): 41–52.

Mourão J L, Pinheiro V M, Prates J A M, Bessa R J B, Ferreira L M A, Fontes C M G A and Ponte P I P. 2008. Effect of dietary dehydrated pasture and citrus pulp on the performance and meat quality of broiler chickens. *Poultry Science* **87**: 733–43.

Owusu-Asiedu A, Patience J E, Laarveld B, Van Kessel A G, Simmins P H and Zjlstra R T 2006. Effect of guar gum and cellulose on digesta passage rate, ileal microbial population, energy and protein digestibility and performance of grower pigs. *Journal of Animal Science* **84**: 843–52.

Rougière N and Carré B. 2010. Comparison of gastrointestinal transit times between chickens from D+ and D- genetic lines selected for divergent digestion efficiency. *Animal* **4**: 1861–72.

Sadeghi A, Toghyani M and Gheisari A. 2015. Effect of various fiber types and choice feeding of fiber on performance, gut development, humoral immunity, and fiber preference in broiler chicks. *Poultry Science* **94** (11): 2734–43.

Sarikhan, M, Shahryar H A, Gholizadeh B, Hosseinzadeh M H, Beheshti B and Mahmoodnejad A B B. 2010. Effects of insoluble fiber on growth performance, carcass traits and ileum morphological parameters on broiler chick males. *International Journal of Agriculture Biololgy* **12** (4): 531–36.

Sklan D, Smirnov A and Plavnik I. 2003.The effect of dietary fiber on the small intestines and apparent digestion in the turkey. *British Poultry Science* **44**: 735–40.

Talpatra S K, Ray S N and Sen K C. 1940. Estimation of phosphorus, chlorine, calcium, magnesium, sodium and potassium in food stuffs. *Indian Journal of Veterinary Science and Animal Husbandry* **10**: 243–46.

Tejeda O J and Kim W K. 2020. The effect of cellulose and soybean hulls as sources of dietary fibre on the growth performance, organ growth, gut histomorphology and nutrient digestibility of broiler chicken. *Poultry Science* **99**: 6828–36.

Tejeda O J and Kim W K. 2021. Role of dietary fibre in poultry nutrition. *Animals*. 11, 461. https://doi.org/ 10.3390/ani 11020461.