EFFECT OF DIETARY FIBER LEVELS ON BROILER PERFORMANCE AND ECONOMIC EFFICIENCY: 2- SOYBEAN HULLS

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SUMMARY

An experiment was conduct to evaluate the effects of soybean hulls (SH) as a dietary fiber source in broiler chicks diets on performance and economic efficiency. Experiment was performed in completely randomized designed with 4 different levels of SH (0% (control), 1.50% (T1), 3.00% (T2) and 4.50% (T3) in the diets fed to 120 chicks of Indian Rivers. Each treatment had 3 replicates of 10 birds, measurements are live body weight (LBW), body weight gain (BWG), feed consumption (FC), feed conversion ratio (FCR), and Relative economic efficacy (REE). Rustles in this experiment showed that the inclusion of 1.50% SH as a dietary fiber source in broiler diets improved LBW, BWG, and FCR compared to other treatments (control , T2and T3), also, chicks were fed on SH 1.50% diets showed the highest figures of performance index (PI), European performance efficiency factor (EPEF) and REE. In conclusion, it is suggested based on economical profitability using SH up to 1.50% broiler diets during starter and grower periods.

Keywords: *Performance, economic efficiency, broilers, fiber and soybean hulls*

INTRODUCTION

Poultry diets usually contain around 50-70% cereal grains; corn or wheat, 25% soybean meal, and some other minor ingredients that make up the rest. The crude fiber (CF) content of such a diet is around 2.5-3%, but when all the nutrients recorded in the matrix are added up, including the minor ingredients, they usually account for less than 90%. The missing 10% represents the rest of the total fiber that is not taken into account in the CF determination. Usually, dietary fiber (DF) has been considered an anti-nutritional factor and a diluent in poultry diets. Also, many researchers have considered that the requirements of broilers for CF are low and recommended reducing its content in broiler diets to less than 2.5- 3.0%, depending on the bird's age (Swennen *et al.*, 2010).

Dietary fiber is the edible parts of plants or analogous carbohydrates that are hardy to be digested and absorbed in the small intestine, with complete or incomplete fermentation in the large intestine. Dietary fiber contains polysaccharides, oligosaccharides, lignin, and associated plant materials. These fibers encourage useful physiological effects, including laxation, blood cholesterol attenuation, and/or blood glucose attenuation (AACC, 2000).

Dietary fiber has received little attention in poultry nutrition for many years. It is well known that dietary fiber can contribute significantly to the nutritive value of diets both directly as an energy source (Jamroz *et al.*, 2002 and Jorgensen *et al.*, 1996) and indirectly through its effects on digestive and metabolic processes (Annison, 1993; Choct *et al.*, 1996; Smits *et al.*, 1997; Smits *et al.*, 1998; Smits *et al.*, 2000 and Montagne *et al.*, 2003).

Growth performance is the totality of all the parameters that influence productive performance. In general, improvements in intestinal morphology and organ development can lead to improved nutrient utilization, which will have an effect on performance (McDonald. 2010; Sacranie *et al.*, 2012 and Yokhana *et al.*, 2016).

Different carbohydrates from dietary fiber can have many modes of action once ingested by poultry. Therefore, to draw conclusions about the effect of fiber, there are a lot of factors that need to be carefully considered. Factors such as fiber source (soluble vs. insoluble), particle size, level of inclusion, species, age, physiological status (laying hen vs. broiler), dietary metabolizable energy and crude protein (amino acids) levels, and duration of inclusion are among the most influential factors determining the effects of fibers on broiler diets (Hetland and Svihus., 2001; Sklan *et al.*, 2003; Amerah *et al.*, 2009; Jiménez-Moreno *et al.*, 2009 and Tejeda and Kim, 2020).

Many researchers are using many sources of fiber for growth production, such as SH, wheat bran, and other sources. Zhang *et al.* (2023) reported the effect of dietary SH with high levels of broiler chicks fed diets with SH as fiber sources and CF levels of 2%, 5%, 8%, and 11% CF on broilers performance. The results showed that during the 29-42 days period, the average daily FC of broilers was higher in the 5% CF and 8% CF groups ($P < 0.05$), and during the 29-35 days period, the average daily gain of broilers was higher and the FCR in broilers was lower in the 5% CF and 8% CF groups ($P<0.05$). While Scapini *et al.* (2017) evaluated the performance productive of broilers fed on corn - soybean meal or corn - SH (4.5% CF) with or without ß-Mannanase supplementation, they found that birds supplemented with ß-mannanase in diets with higher concentrations of fiber improve the feed conversion of broilers from 1 to 21 days and can be an important nutritional and economic strategy in situations of unavailability of raw material of better quality. The corn-soybean meal -SH diet resulted in greater weight gain at 42 days than the corn-SBM diet, in addition to no effect in FC between treatments.

Liebl *et al.* (2022) indicated that there was an increase in body weight and BWG in treatments compared to control groups, with the highest weight found in SH at 1.6%, as well as no effect on feed consumption (FC) and an improvement in feed conversion ratio (FCR).

The particle size can have an effect on growth factors (Tejeda and Kim 2020) observed that diets had high levels of CF (4% and 8% from soy hulls and cellulose as fiber sources, and two barbicel sizes: coarse 600 micron and fine 100 micron. The groups fed 8% CF from cellulose (8% cellulose) had the lowest weight gain regardless of the particle size ($P < 0.01$).

On the other hand, Masoudi and Bojarpou (2020) found that the birds fed on diets with SH at levels of 2.5, 5, and 7.5% diets had a decrease in body weight gain (BWG) and FC but an improved FCR compared to control groups, and Sittiya *et al.* (2019) conducted a study to investigate the effects of dietary fiber from rice hulls and soybean hulls (SH) on growth performance and found that using dietary fiber did not affect growth performance.

Kurul *et al.* (2020) found that increasing the levels of fiber from SH by levels 2, 4, and 6% in male (Ross 308) broilers had no effect on body weight, BWG, FC, or FCR between treatments. But, Leung *et al.* (2018) found that using SH or oat hulls on 65-week-old broiler breeder hen diets led to a decrease in body weight due to decreased FC.

The aim of this study is to determine the effect of using different levels of SH as a source of fiber in broiler diets on productive performance and economic efficiency (EEf).

MATERIALS AND METHODS

This experiment was carried out in Poultry Nutrition farm, Poultry Production department, Faculty of Agriculture, Ain Shams University, Qalubia, Egypt, in order to investigate the productive performance, nutrients utilization, and EEf of broiler chicks Indian River (IR) as affected by using SH as a source of fiber in broiler diets.

During the experimental period, which last 35 days, chicks were fed on the experimental diets, four experimental diets were formulated in which (control diet) was 0.0 (SH) in the other three experimental diets (SH) were incorporated at levels of 1.5, 3.0 and 4.5% to obtain starter (0-21 days) and grower/finisher (22-35 days) as described in Tables (1 and 2).One hundred and twenty one day old unsexed broiler chicks (IR) were randomly allocated to four treatments of 30 birds in 3 replicates (10 chick per replicate). Chicks were reared in electrics heated batteries under similar conditions of management.

Table (1): Composition analysis of the starter experimental diets (0- 21 days).

Ingredients	Treatments			
	Control	Soy hulls 1.5%	Soy hulls 3.0%	Soy hulls 4.5%
Yellow corn	52.96	51.54	50.26	49.00
Soybean meal 46% CP	33.00	34.00	34.00	34.00
Soybean hulls (SH)*	**0**	**1.50**	**3.00**	**4.50**
Corn Gluten meal 60%	7.00	6.00	5.80	5.57
Vegetable Oil	2.40	2.40	2.40	2.40
Calcium Carbonate	0.96	0.95	0.93	0.91
Mono Calcium phosphate	2.50	2.45	2.45	2.45
HCl –Lysine	0.28	0.25	0.24	0.24
DL- Methionine	0.30	0.31	0.32	0.33
Salt (NaCl)	0.30	0.30	0.30	0.30
Premix**	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated composition* **				
Metabolizable energy ,kcal/kg (ME)	3010	2960	2921	2884
Crude protein, % (CP)	24.46	24.37	24.35	24.32
Crude fiber % (CF)	**3.57**	**4.09**	**4.55**	**5.01**
Calcium (%)	0.90	0.90	0.90	0.90
Available phosphorus (%)	0.67	0.66	0.66	0.65
Lysine (%)	1.32	1.32	1.31	1.32
Methionine (%)	0.70	0.70	0.71	0.71
Methionine + Cysteine (%)	1.08	1.08	1.08	1.09
Price / tone (LE)***	8384	8263	8201	8141
Chemical analysis (%)				
Dry matter (DM)	90.82	91.09	90.75	91.10
Ash	1.90	1.95	2.37	2.52
CP	21.13	21.08	21.16	21.02
CF	2.54	3.26	3.72	3.99
Ether extract	5.09	4.89	4.64	4.29

**Chemical composition was DM (88.90%), Ash (4.70%), CP (14.40%), CF (32.90%) and ME (841 k cal/kg).*

***Each 3Kg of premix containing: 15000000 I.U. Vit, A, 3000000 I.U Vit. D 50g. Vit E, 3000mg Vit. K3. 3000 mg Vit. B1, 8000 mg. Vit B2, 4000 mg. Vit. B6, 20mg. Vit. B12, 15000 mg pantothenic acid, 60000 mg. niacin, 1500 mg. folic acid, 200mg. biotin, 200000 mg Vit.C, 700 gm. choline chloride, 80 gm. Mn, 80 gm. zinc, 60 gm. iron, 10 gm. CU, 1 gm. Iodine, and 0.2 gm millennium, where $CaCo_3$ was taken as a carrier up to 3kg, the inclusion rate was 3Kg premix/ton feed.*

**** Calculated analysis of the experimental diets was done according to (Horacio. S.R (2017) Brazilian feed stuffs,).*

Productive performance:

Chicks were individual weight to nearly gram at 0 and 35 days intervals during experimental periods. At the same time, FC was recorded, while BWG, FCR, PI, EPEF, calories conversion ratio (CCR) and protein conversion ratio (PCR) were calculated. Accumulative mortality rate (MR) was obtained during experimental period to get mortality percent.

Apparent nutrients utilization:

During the last 5 d of the experimental period (30-35 day), excreta samples were collected using the partial collection method. Immediately stored in a freezer (-18°C) until the analysis of appearance digestibility of dray matter (DM), CP (Nitrogen 6.25), EE and CF.

Economic efficiency:

Economic efficiency of broiler chicks was calculated and the prices figures were based on the recent prices of local market for ingredients and selling price of chicks in Qalibia region, Egypt at the exact time of the experiment according to North and Bell (1981).

Table (2): Composition analysis of the grower experimental diets (21–35) days).

Ingredients	Treatments			
	Control	Soy hulls 1.5%	Soy hulls 3.0%	Soy hulls 4.5%
Yellow Corn	55.06	53.85	52.64	51.37
Soybean Meal 46% CP	32.10	32.10	32.10	32.10
Soybean hulls (SH)*	**0**	**1.50**	**3.00**	**4.50**
Corn Gluten meal 60% CP	5.00	4.75	4.55	4.30
Vegetable Oil	3.70	3.70	3.70	3.70
Calcium Carbonate	0.88	0.92	0.92	0.92
Mono Calcium Phosphate	2.18	2.08	1.99	1.99
HCL –Lysine	0.21	0.21	0.21	0.21
D-l Methionine	0.27	0.29	0.29	0.31
Salt (NaCl)	0.30	0.30	0.30	0.30
Premix**	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated composition* **				
Metabolizable energy (kcal/kg)	**3100**	**3065**	**3030**	**2994**
Crude protein, %(CP)	21.50	21.50	21.50	21.50
Crude fiber %(CF)	**2.51**	**3.00**	**3.45**	**4.91**
Calcium (%)	0.87	0.87	0.87	0.87
Available phosphorus (%)	0.43	0.43	0.43	0.43
Lysine (%)	1.29	1.29	1.29	1.29
Methionine (%)	0.51	0.51	0.51	0.51
Methionine + Cysteine (%)	0.99	0.99	0.99	0.99
Price / tone (LE)***	8252	8185	8111	8057
Chemical analysis (%)				
Dry matter (DM)	90.82	91.09	90.75	91.10
Ash	1.90	1.95	2.37	2.52
CP	21.13	21.08	21.16	21.02
CF	2.54	3.26	3.72	3.99
Ether extract	5.09	4.89	4.64	4.29

**Chemical composition was DM (88.90%), Ash (4.70%), CP (14.40%), CF (32.90%) and Metabolizable energy (841 k cal/kg).*

***each 3Kg of premix containing: 15000000 I.U. Vit, A, 3000000 I.U Vit. D 50g. Vit E, 3000mg Vit. K3. 3000 mg Vit. B1, 8 000 mg. Vit B2, 4000 mg. Vit B6, 20mg. Vit. B12, 15000 mg pantothenic acid, 60000 mg. niacin, 1500 mg. folic acid, 200mg. biotin, 200000 mg Vit. C, 700 gm. choline chloride, 80 gm. Mn, 80 gm. zinc, 60 gm. iron, 10 gm. CU, 1 gm. Iodine, and 0.2 gm millennium, where $CaCo_3$ was taken as a carrier up to 3kg, the inclusion rate was 3Kg premix/ton feed. *** Calculated analysis of the experimental diets was done according to (Horacio. S.R (2017) Brazilian feed stuffs).*

Statistical analysis:

Data were statistically analyzed using the General Linear Model Procedure of analysis (SAS, 2004). Duncan's multiple range test (Duncan, 1955) was used to test differences within means of treatments, while level of significance was set typically at minimum ($P \leq 0.05$).

The statistical model used for analyzing data was as following:

$$Y=M+T+e$$

Where:

- Y=observation of the parameter measured.
- M=overall mean.
- T=effect of treatment.
- e= random error.

RESULTS AND DISCUSSION

Effect of dietary treatments on productive performance:

The effect of feeding SH on productive performance of broiler chicks can be shown as follows in Table (3):

Table (3): Effect of dietary treatments on productive performance of broilers chick

Items	Treatments				SEM	Sign.
	Control (basal diet)	Soy hulls 1.5%	Soy hulls 3.0%	Soy hulls 4.5%		
Live body weight (g)						
0 days	40.33	40.66	40.83	39.83	0.07	N. S
35 days	1870.33^{ab}	1901.36^{a}	1849.50^{b}	1789.01^{c}	14.07	*
Body weight gain (g)						
0-35 days	1830.00^{b}	1860.70^{a}	1808.67^{b}	1749.18^{c}	12.29	*
Feed consumption (g)						
0-35 days	2755.00^{ab}	2807.01^{a}	2811.33^{a}	2706.66^{b}	17.43	*
Feed conversion ratio (g feed/g gain)						
0-35 days	1.50^{c}	1.51^{b}	1.55^{a}	1.55^{a}	0.02	*
Performance index	124.23^{a}	126.03^{a}	119.06^{b}	115.67^{b}	1.22	*
EPEF*	354.96^{ab}	360.12^{a}	340.17^{b}	319.43^{c}	4.31	*
Mortality rate	0/30	0/30	0/30	0/30	.....	.....

*a,b, and c Means in a raw with different superscripts differ significantly (P≤0.05) , N.S.: non-significant. * EPEF (European performance efficiency factor)*

Live body weight (g) and body weight gain (g):

It is worth to note that broiler chicks fed 1.5% SH (T1) during experimental period (35d) reflect higher significantly body weight (1901.36), in addition to, broiler chicks fed diets containing 4.5% (T3) SH gave the lowest body weight gain being 1789.01 g.

Effect of dietary treatments on BWG of broilers chick are shown in Table (3). Similar trend was observed with BWG since chicks fed T1 (1.5 SH) diets gave the highest significantly BWG, being 1860.7 g compared with those fed control, T2 (3% SH) or T3 (4.5% SH) diets (being 1830.0, 1808.7 and 1749.18 g, respectively). The explanation for this reduction in LBW and BWG for chicks fed T3 diets may be due to its highest fiber content as shown in Tables (1 and 2), which in consequence may reduce digestibility and availability of nutrients (Hermes and Al-Homidan, 2004) and Van der Klis and Van Voorst, 1994).

Similar results were reported by Liebl *et al.* (2022) in broiler chicks who concluded that feeding chicks diets with 1.6% SH increased body weight and BWG compared with control group.

Feed consumption and fed conversion ratio:

Data presented in Table (3) indicate (35d) decreased by feed T3 (4.5% SH) compare with those feed control, T1 or T 2 diet. The corresponding figures were 2706.66 versus 2755.0, 2807.01 and 2811.33 g, with significant differences .This might be due to fact that broiler chicks fed (T1-3) diets contained lower energy and higher CF increase FC (T1-2) to 2807.0 and 2811.3g respectively, could be related to the fact that chicks met their energy requirements by increase FC (Masoudi and Bojarpou, 2020 and Leeson *et al.*, 1996). On the other side, Sittiya *et al.* (2019) found that inclusion of dietary fiber from rice hulls and SH in broiler diets didn't affected growth performance.

The obtained data showed that there were significant differences among treatments during the studied period (35d) in FCR, chicks fed control diet was more efficient in converting their feed in to BWG compared to with those fed other dietary treatment (T1-3).

In the same order, the figures of FCR indicted significant differences between birds fed diets containing SH (T1-3) and the best FCR was detected for the chicks fed control diets On the other hand,

the worst FCR were found in chicks fed high levels of SH at 3.0% or 4.5% being the same figure (1.55). Similar observation was reported by other investigators (Hetland *et al.,* 2004; Gonzalez – Alvardo *et al.,* 2007 and Amerah *et al.*, 2009). They concluded that fibers such as oat hulls wood shavings, wheat bran and soy bean hulls have found to increase feed conversion between 3-5% when included at 3-5% in the diet. On the other hand, these finding are in contrast with the results obtained by Kurul *et al.* (2020) who showed that inclusion of SH by levels 2, 4 and 6% in male (Ross 308) broilers had no effects on BWG, FC or FCR between treatments.

Performance index (PI) and European Production Efficiency Factor (EPEF):

Results of PI and EPEF of broiler chicks fed different experimental diets showed that there were significant differences between treatments. Chicks fed T4 reflected the lowest figures of Pl (115.67) and EPEF (319.43), respectively, compared with other treatments, while chicks fed SH 1.5 %. (T1) showed higher figures of PI (126.03) and EPEF (360.12), respectively.

Mortality rate (MR):

Under the conditions of the present study, all chicks appeared healthy, and the total MR was 0.00% during the total experimental period (0-35 days), without any clear differences between the experimental treatments and the control one.

Effect of dietary treatments on CCR and PCR:

Results presented in Table (4) showed that there was no significant effect at overall experimental period (0-35) days of age in CCR / PCR but numerically the best CCR seen in birds fed SH 1.5 (T1) , or 4.5% T3, being the same figure (4.55) on the other hand, the worst CCR well found in birds fed SH 3.0% being (4.63). However the differences between treatments failed to be significant. In the same order, figures of PCR indicated insignificant differences between birds fed diet containing SH (T1-3) compared with those fed control diets. The best PCR was detected for birds fed control diet (0.33), the best PCR was detected for birds fed 1.5% SH (T1) being (0.37).

Table (4): Effect of dietary treatments on calories and protein conversion ratio.

Items	Treatments				SEM	Sign.
	Control (basal diet)	Soy hulls 1.5%	Soy hulls 3.0%	Soy hulls 4.5%		
Calorie conversion ratio (CCR).						
0 - 35 days	4.59	4.55	4.63	4.55	0.01	N. S
Protein conversion ratio (PCR).						
0 - 35 days	0.33	0.37	0.35	0.35	0.01	N. S

N.S.: non-significant

Effect of dietary treatments on nutrients utilization (%) of broiler chicks:

Data presented in Table (5) showed the effects of using different levels of SH compared with basal diet on DM, either extract (EE), crude protein (CP), or CF.

Table (5): Effect of dietary treatments on some of nutrients utilization (%).

Items	Treatments				Sign.	SEM
	Soy hulls 4.5%	Soy hulls 3.0%	Soy hulls 1.5%	Control (basal diet)		
Dry matter	N. S	0.44	83.24	84.37	84.39	85.22
Ether extract	N. S	0.28	94.64	93.70	93.59	93.36
Crude protein	N. S	0.28	87.20	83.13	81.63	83.91
Crude fiber	N. S	0.26	70.93	70.50	70.45	72.78

N.S.: non-significant

Data showed that there was no significant effect in DM, EE and CP between treatments and control group. The corresponding value ranged between 83.24 and 85.22% for DM, 93.36 and 94.64% for EE, and 81.63 and 87.20% for CP, while in CF utilization, the treatments (T1-3) were non-significantly

affected by levels of SH being 70.45, 70.50, and 70.93% respectively, compared to control group (72.78%).

Effect of dietary treatments on economic efficiency:

The data for EEf of feeding costs of broiler chicks as affected by diet from 0-35 days of age are shown in Table (6). Calculations of EEf were carried out according to the prices of the feed ingredients, and LBW prevailing during February 2022 (the time of the experiment). Economic efficiency values of broiler chicks fed diets SH (T3) compared to those birds fed control diets from 0-35 days of age were 48.92, 45.51, and 44.08%, respectively, while EEf values for control group were 44.03%. Relative economic efficiency (REE) values were improved by 11.18, 3.42, 0.19, and 13.28%, respectively, for the group SH (T3) compared to control group. Therefore, the best REE showed in SH 1.5% (11.18%). These results agree with Scapini *et al.* (2017) who demonstrated that, broiler chicks supplemented with higher concentration of fiber (SF 4.5% CF) with B-mananase in diets improve the feed conversion from 1-21 days and can be important nutritional and economic strategy in situation of unavailability of new material of better quality.

Table (6): Effect of dietary treatments on economic efficiency % (EE) of broilers chicks.

Items	Treatments			
	Control (basal diet)	Soy hulls 1.5%	Soy hulls 3.0%	Soy hulls 4.5%
Average feed consumption (g)	2755.00	2807.01	2811.37	2706.66
Feed cost/chicken (LE)	23.36	22.75	22.59	21.59
Total cost/chicken (LE)	36.36	35.75	35.59	34.59
Live body weight (LBW) (g)	1870.33	1901.36	1849.50	1780.01
Total return (LE)	52.37	53.24	51.79	49.84
Net return (LE)	16.01	17.49	16.20	15.25
EE. %**	44.03	48.92	45.51	44.08
Relative EE %***	100.00	111.18	103.42	100.19

*local price of one kg of LBW of chicken= 28sLE **EE = Net return/ total chicken cost x 100, *** Relative EE = assuming EE of the control equals 100 %.*

CONCLUSION

From the previous results it could be concluded that from the economic point of view, the greatest improvement was recorded by broiler chicks fed 1.5% SH in the diet compare to the control. Treatment above 1.5% SH had negative effect and decreased performance in all parameters.

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تأثير مستويات الالياف في علائق دجاج اللحم على الأداء الإنتاجي والعائد الاقتصادي: 2- قشر فول الصويا

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أجريت التجربة للتعرف على تأثير استخدام قشر فول الصويا كمصدر للألياف في علائق دجاج اللحم على الأداء الإنتاجي والعائد الاقتصادي. أجريت التجربة باستخدام 4 مستويات من قشر فول الصويا (SH) (صفر% ,كنترول - 1.5%, T1 – 3.0%,T2 – 4.5%, T3) في علائق كتاكيت اللحم من سلالة Indian River (IR). استخدم 120 كتكوت سلالة IR وزعت على 4 معاملات غذائية بكل معاملة 3 مكررات بكل مكررة 10 كتكوت. تم قياس الأداء الإنتاجي (الوزن الحى واستهلاك العلف ومعامل التحويل الغذائي) وتم حساب العائد الاقتصادي النسبي في المعاملات المختلفة.

أوضحت النتائج ان: استخدام قشر فول الصويا بمعدل 1.5% كمصدر للألياف في علائق دجاج التسمين حسن الأداء الإنتاجي (الوزن الحى والمكتسب ومعامل التحويل الغذائي) بالمقارنة بالكنترول و (T2-3) وسجل اعلى قيم لدليل الأداء الإنتاجي وعامل كفاءة الاداء الأوربي والعائد الاقتصادي النسبي. الخلاصة: استخدام قشر فول الصويا في علائق دجاج اللحم بمستوى 1.5% يحسن الأداء الإنتاجي والعائد الاقتصادي.