

The nutritive value of cocoa bean shell for broilers and Pekin ducks (Nilai pemakanan tepung kulit biji koko bagi ayam dan itik Pekin)

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Key words: cocoa bean shell, broiler, Pekin duck, growth performance, theobromine toxicity, mortality

Abstrak

Dua percubaan ayam pedaging dan satu percubaan itik Pekin telah dijalankan untuk meneliti nilai pemakanan tepung kulit biji koko (KBK) bagi ayam dan itik. Di dalam semua percubaan ini, KBK digunakan pada aras 5, 10, 15 dan 20% dalam makanan pemula dan penamat untuk kedua-dua spesies ayam-itik. Keputusan daripada ketiga-tiga percubaan ini menunjukkan bahawa pengambilan makanan dan penambahan berat badan berkurang apabila aras KBK dinaikkan. Peratus kematian ayam dan itik meningkat dengan peningkatan aras KBK dalam gizi. Pada aras 20% KBK di dalam makanan, peratus kematian ayam pedaging dan itik masing-masing meningkat kepada 70% dan 83.7%. Kematian ini disebabkan oleh kewujudan 1.99% teobromin di dalam KBK yang menyebabkan kerosakan lapisan usus besar spesies-spesies berkenaan. Ayam yang diberi makanan yang mengandungi KBK hanya pada tempoh penamat menunjukkan kadar kematian dan kesan penindihan pengambilan makanan yang berkurangan dan kenaikan berat badan yang lebih baik daripada ayam yang diberi makanan pemula dan penamat yang mengandungi KBK. Memproses KBK dengan autoklaf tidak mengubah kesan racun terhadap pembesaran ayam/itik.

Abstract

Two trials with broilers and one with Pekin ducks were carried out to study the feeding value of cocoa bean shell (CBS) for growing chicken and duck. In all the trials, CBS was included at 5, 10, 15 and 20% of the diets either in the finisher diet alone or in both the starter and finisher diets. Results from the three trials showed a general trend of decrease in feed consumption and body weight gain with increase of dietary CBS levels. Per cent mortality increased with the increased inclusion of CBS. At the 20% dietary CBS level, the per cent mortality were 70% and 83.7% for chicken and duck, respectively. The mortality was due to the presence of 1.99% of theobromine in CBS which caused intestinal lesion in the distal part of the digestive tract. It was also observed that mortality and adverse effect were less serious if the feeding of CBS-based diets were started only at finishing period. Autoclaving CBS did not change its toxic effect on bird growth.

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Introduction

Cocoa has become the third largest plantation crop in Malaysia. The process of seed extraction gives rise to several by-products which include cocoa pod, cocoa bean shell (CBS) and oil cake. Cocoa pod is low in protein and high in fibre and hence it is only suitable for ruminant feeding. However, CBS is high in protein and low in fibre and it could be considered as non-ruminant diets. Reports in using these by-products in non-ruminant feeds are meagre. A few workers had attempted to feed cocoa pod to swine and poultry (Adenyanju et al., 1975, 1977; Oyelaja et al., 1970; Adenyanju and Ilori 1979). Hutagalung and Chang (1978) reported that CBS could be included in layer diets up to 20% with satisfactory egg production and egg weight. Beyond this level egg production was delayed and reduced.

In view of the rapid expansion of cocoa plantation in Malaysia, research to further stimulate the interest of using cocoa by-products in animal feeds is envisaged. A study was therefore conducted to explore the possibility of using CBS as a protein source in broiler and Pekin duck diets.

Materials and methods

Cocoa bean shell (CBS)

The chemical composition of CBS is shown in *Table 1*. In this table, the proximate analysis was conducted according to the procedure of A.O.A.C. (1980) and the metabolizable energy (ME) was determined using the total collection method. The level of theobromine (3, 7-Dimethylxanthine) was measured based on the method described by Gerritsma and Koers (1953). Two broiler chicken trials and one Pekin duck feeding trial with dietary inclusion of cocoa bean shell were carried out successively.

Table 1. Chemical composition of cocoa bean shell*

Constituent	Composition
Dry matter (%)	99.9
Crude protein (%)	17.5
Crude fibre (%)	15.1
Ether extract (%)	6.4
Ash (%)	8.6
Calcium (%)	0.15
Phosphorus (%)	0.37
Lysine (%)	0.85
Methionine + cystine (%)	0.31
ME (kcal/kg)	1 910
Theobromine (%)	1.99

*CBS purchased from a local supplier

Broiler Trial 1

In the first broiler trial, nine dietary treatments were allotted to 540 day-old Hybro broiler chicks in a completely randomised design. Five isonitrogenous and isocaloric diets with the levels of CBS at 0, 5, 10, 15 and 20% were formulated during both the starter (*Table 2*) and finisher periods (*Table 3*), respectively. The crude protein and ME levels for the starter and finisher diets were 23%, 3 000 kcal/kg and 18%, 3 000 kcal/kg, respectively. The four additional dietary treatments with the non-CBS control diet in the starting period followed with different graded levels of CBS in the finishing period were compared with those groups having CBS-based diets throughout the 8-week experimental period in which 4 weeks were for starting and 4 weeks for finishing.

Three-tier boxes comprising 6 compartments each were used for the trial. Each compartment with a floor area of 0.91 m x 0.91 m was used as a replicate of the treatment. Each treatment comprised 12 replicates (2 boxes). Five birds were allocated to each replicate.

During the first 2 weeks, chicks were brooded in the enclosed compartment with electric bulb to provide a warm environment. Feed and water were provided *ad lib*.

Table 2. Broiler starter diet containing different levels of cocoa bean shell

Ingredient (%)	Composition				
Cocoa bean shell	0	5.00	15.00	20.00	
Maize	35.30	32.00	30.40	25.10	—
Broken rice	20.00	18.20	15.00	15.00	33.00
Soybean meal	31.80	30.70	29.50	28.50	27.80
Fish meal	8.00	8.00	8.00	8.00	8.00
Palm oil	2.70	3.80	4.70	5.90	8.70
Dicalcium phosphate	0.60	0.70	0.90	1.00	1.00
Vitamin-mineral premix	0.30	0.30	0.30	0.30	0.30
Limestone powder	0.81	0.80	0.67	0.64	0.60
<i>DL</i> -methionine	0.19	0.21	0.23	0.26	0.30
Salt	0.30	0.30	0.30	0.30	0.30
	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	23.0	23.0	23.0	23.0	23.0
ME (kcal/kg)	3 000	3 000	3 000	3 000	3 000
Lysine (%)	1.42	1.39	1.37	1.36	1.47
Methionine + cystine (%)	0.93	0.93	0.93	0.93	0.93
Calcium (%)	1.00	1.00	1.00	1.00	1.00
Phosphorus (%)	0.70	0.70	0.70	0.70	0.70

Table 3. Broiler finisher diets containing different levels of cocoa bean shell

Ingredient (%)	Composition				
Cocoa bean shell	0.10	5.00	10.00	15.00	20.00
Maize	62.10	65.10	63.10	59.80	54.70
Rice bran	6.90	—	—	—	—
Soybean meal	24.70	23.20	17.30	13.20	12.10
Fish meal	2.00	2.20	5.80	8.00	8.00
Palm oil	1.00	1.00	1.00	1.50	2.60
Dicalcium phosphate	1.20	1.60	1.16	1.00	1.00
Vitamin-mineral premix	0.30	0.30	0.30	0.30	0.30
Limestone powder	1.40	1.11	0.80	0.65	0.70
<i>L</i> -Lysine	—	0.06	0.05	0.05	0.07
<i>DL</i> -methionine	0.10	0.13	0.19	0.20	0.23
Salt	0.30	0.30	0.30	0.30	0.30
	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	18.0	18.0	18.0	18.0	18.0
ME (kcal/kg)	3 000	3 000	3 000	3 000	3 000
Lysine (%)	1.00	1.01	1.00	1.00	1.01
Methionine + cystine (%)	0.72	0.77	0.77	0.77	0.77
Calcium (%)	1.00	1.00	1.00	1.00	1.00
Phosphorus (%)	0.70	0.70	0.70	0.70	0.70

Variables including weekly body weight gain, feed intake, feed efficiency and daily mortality were measured.

Broiler Trial II

In Trial II, experimental diets with 0, 5, 10, 15 and 20% CBS similar to Trial I were used. Two additional diets containing 10% and 20% autoclaved CBS

were compared with unautoclaved CBS diet. The autoclaving procedure for the CBS was done by using an autoclave with steam pressure of 1 kg/cm² at 126 °C for 1 h. The management practices and data recording were similar to Trial I.

Table 4. Duck starter diets with different levels of cocoa bean shell

Ingredient (%)	Composition				
Cocoa bean shell	0	5.00	10.00	15.00	20.00
Broken rice	63.50	60.20	55.50	51.06	46.97
Soybean meal	21.90	20.40	19.20	17.90	16.50
Fish meal	10.00	10.00	10.00	10.00	10.00
Palm oil	1.00	1.10	1.90	2.60	3.00
Dicalcium phosphate	1.80	1.40	1.60	1.70	1.80
Limestone powder	1.00	1.08	0.96	0.85	0.79
Vitamin-mineral premix	0.30	0.30	0.30	0.30	0.30
<i>L</i> -Lysine	—	—	—	0.03	0.06
<i>DL</i> -methionine	0.20	0.22	0.24	0.26	0.28
Salt	0.30	0.30	0.30	0.30	0.30
	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	20.0	20.0	20.0	20.0	20.0
ME (kcal/kg)	2 778	2 750	2 750	2 750	2 721
Lysine (%)	1.24	1.20	1.20	1.20	1.20
Methionine + cystine (%)	0.80	0.80	0.80	0.80	0.80
Calcium (%)	1.10	1.10	1.00	1.10	1.00
Phosphorus (%)	1.00	1.00	0.90	0.90	0.90

Table 5. Duck finisher diets with different levels of cocoa bean shell

Ingredient (%)	Composition				
Cocoa bean shell	0	5.00	10.00	15.00	20.00
Broken rice	75.00	71.00	66.30	61.23	54.92
Soybean meal	13.90	12.10	10.90	10.50	12.40
Fish meal	7.60	8.00	8.00	7.40	5.10
Palm oil	0.70	1.30	2.10	3.10	4.40
Dicalcium phosphate	1.87	1.70	1.95	2.00	2.30
Limestone powder	0.21	0.16	—	—	0.08
Vitamin-mineral premix	0.30	0.30	0.30	0.30	0.30
<i>DL</i> -methionine	0.12	0.14	0.15	0.17	0.20
Salt	0.30	0.30	0.30	0.30	0.30
	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	16.0	16.0	16.0	16.0	16.0
ME (kcal/kg)	2 850	2 850	2 850	2 850	2 850
Lysine (%)	0.93	0.91	0.89	0.86	0.82
Methionine + cystine (%)	0.58	0.58	0.58	0.58	0.58
Calcium (%)	1.00	0.95	0.97	0.98	0.95
Phosphorus (%)	0.85	0.80	0.80	0.85	0.80

Pekin duck trial

In Pekin duck trial, CBS in graded levels at 0, 5, 10, 15, 20% were included in the isocaloric and isonitrogenous starter and finisher diets (Table 4 and Table 5). The ducklings were brooded and reared in the same type of boxes as in broiler Trial I. The durations of the trial were 3 weeks starting and 5 weeks finishing. Twelve replicates were given to each dietary

treatment. Each compartment constituted a replicate. Four ducklings were allocated to each replicate hence a total of 240 day-old ducklings were used in this trial. The variables recorded were feed intake, body weight gain, feed efficiency, carcass quality and daily mortality.

At the end of each trial, data were compiled and subjected to statistical analysis for the analysis of variance and

the means were compared using Duncan multiple range test (Steel and Torrie 1960).

Results and discussion

The results of Trial I are shown in *Table 6*. Mortality increased with increasing levels of CBS in the diet. At 5% level of CBS inclusion, there was no mortality. However, the mortality increased to 15% at 10% CBS inclusion and at 20% level, the mortality rate reached 70%. Death was probably due to the toxicity of theobromine in CBS. Necropsy revealed the inflammation of the intestinal lining including the duodenum, jejunum and ileum up to the function of caecum. In serious cases, the intestinal lining sloughed off and was excreted together with the faeces, which rendered high

mortality of the birds. When the CBS diets were given only during the finishing period, the mortality was lower at 20% inclusion level compared with that when CBS was added to both the starter and finisher diets. It was probably due to the more resistance of the intestinal wall of older chickens against the toxic effect of theobromine. Since the intestinal lining was destroyed, the feed intake and body weight gain were badly affected due to the poor nutrient absorption. As a result, the feed/gain ratio generally deteriorated. The surviving birds were observed making hungry noises for want of food when they were approached.

The results of Trial II are in *Table 7*. This study confirmed the adverse effect of CBS in broiler diets. The feed intake and body weight gain were relatively reduced

Table 6. Preliminary trial on the effects of cocoa bean shell (CBS) inclusion in diets on the performance of broiler chickens

CBS level (%)	Type of feed	Feed intake (g)	Body weight gain (g)	Feed/gain	Mortality (%)
0	SF ⁺	3 447.8b	1 743.9a	1.98c	1.6
5	SF	3 009.5c	1 748.1a	1.73d	0
10	SF	2 667.2d	1 178.8c	2.27b	15.0
15	SF	1 243.6e	972.2d	1.29e	15.0
20	SF	1 089.9e	711.9e	1.63d	70.0
5	F ⁺⁺	3 430.0b	1 466.4b	2.35b	0
10	F	3 392.4b	1 431.7b	2.37b	10.0
15	F	2 968.9c	1 278.5c	2.32b	22.0
20	F	3 839.5a	1 172.2c	3.30a	45.0

⁺CBS in starter and finisher diets

⁺⁺CBS in finisher diets only

Values with different letters in the same column denote significant difference at 5% level

Table 7. Performance of broilers fed diets with cocoa bean shell in Trial II

CBS level (%)	Total feed intake (g)	Total weight gain (g)	Feed/gain	Mortality (%)
0	4 067.7a	1 774.0a	2.30d	0.02
5	3 660.6b	1 493.4b	2.47d	8.30
10	3 215.2c	1 264.0c	2.56cd	11.70
15	2 769.2d	932.7e	2.98b	31.60
20	2 785.1d	791.4f	3.60a	56.00
10 A*	3 160.8c	1 137.8d	2.79bc	25.00
20 A	2 797.5d	778.2f	3.65a	45.00

*A Autoclaved sample

Values with different letters in the same column differ significantly at 5% level

Table 8. Effects of dietary cocoa bean shell on the performance of Pekin ducks (0–3 weeks)

CBS level (%)	Total feed intake (g)	Total weight gain (g)	Feed/gain
0	1 470.4a	943.4a	1.58a
5	1 411.9a	834.8b	1.70a
10	994.6b	594.5c	1.73a
15	704.1c	413.6c	1.73a
20	567.0d	286.9e	2.05b

Values with different letters in the same column differ significantly at 5% level

Table 9. Effects of dietary cocoa bean shell on the performance of Pekin ducks (0–8 weeks)

CBS level (%)	Total feed intake (g)	Total weight gain (g)	Feed/gain
0	7 238.7a	2 438.7a	2.97b
5	7 104.5a	2 396.3a	2.97b
10	6 687.7ab	2 103.0b	3.18b
15	6 070.6b	1 632.2c	3.76a
20	3 242.5c	1 002.5d	3.32b

Values with different letters in the same column differ significantly at 5% level

as the CBS level increased. At 10% CBS, the body weight gain was only 1 264.0 g as compared to 1 774.0 g in non-CBS control group. At 15% and 20% CBS levels, the body weight gains were less than 1 kg. The feed:gain ratios increased as the levels of CBS increased. The mortality reached 56% at 20% CBS level. Autoclaving the CBS was not effective in alleviating the depressant effect of feed intake and body weight gain. However, it seemed to slightly reduce the mortality rate.

The results of Pekin duck trial on CBS-based diets are in *Table 8* and

Table 9. The adverse effect of CBS inclusion is also evident in this trial.

Percentage of mortality rate of Pekin ducks by week is as in *Table 10*. There was no serious effect at 5% CBS inclusion. However, mortality percentage increased to 26.3, 73.6 and 83.7% at 10, 15 and 20% levels of inclusion, respectively. Relative to mortality figures in trials I and II, it appears that theobromine toxicity affects ducks more seriously than chickens. Judging from the mortality percentage of ducks by week, the incidence were spread over the 8-week period, suggesting that age of ducks does not contribute towards tolerance to CBS toxicity.

In conclusion, it was obvious that cocoa bean shell which contained about 2% theobromine was toxic to broiler chicks and ducks even at 5% dietary level of inclusion. The destruction of intestinal linings caused adverse effect on feed intake and body weight gain, which eventually led to high mortality of the birds. Ducks seemed to be more sensitive to theobromine toxicity than chickens. To obtain good and efficient growth performance of broilers and ducklings, it is suggested that cocoa bean shell should not be used as a feed ingredient for growing birds.

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Table 10. Effects of dietary cocoa bean shell on the mortality of Pekin ducks by week

Cocoa bean shell (%)	Mortality (%) by week					Total
	2	3	5	7	8	
0	0.0	2.0	0.0	2.0	0.0	4.1
5	0.0	0.0	0.0	2.0	0.0	2.0
10	5.8	4.1	8.2	8.2	0.0	26.3
15	12.3	4.1	30.6	22.5	4.1	73.6
20	26.5	4.1	20.4	12.3	20.4	83.7

the theobromine content of the cocoa bean shell sample.

References

- Adenyanju, S. A. and Ilori, J. O. (1979). Growth, economics and carcass characteristics of growth/finishing pigs fed cocoa husk diets. *Trop. Agric.* **56**(3): 253-6
- Adenyanju, S. A., Ogutuga, D. B. A., Ilori, J. O. and Adegola, A. A. (1975). Cocoa husk in poultry diets. *Mal. Agri. Res.* **4**: 131-6
- Adenyanju, S. A., Ogutuga, D. B. A., Soniya, E. B. and Eshiett, N. (1977). Evaluation of cocoa husk in finishing diets for broilers. *Turrialba.* **27**(4): 371-5
- A.O.A.C. (1980). *Official Methods of Analysis*, 13th ed. Washington D.C.: Association of Official Analytical Chemists
- Gerritsma, K. W. and Koers, J. (1953). Determination of theobromine in cocoa residues. *Analyst* **78**: 201-5
- Hutagalung, R. I. and Chang, C. C. (1978). Utilization of cocoa by-products as animal feed. *Proc. int. conf. on cocoa and coconut* on 21-24 June, 1978 p. 447-56. Kuala Lumpur: The Incorporated Society of Planters
- Oyelaja, O., Stratman, F. W. and Tompkins, W. A. (1970). Discarded cocoa beans as a substitute for maize and groundnut cake in growing-finishing swine diets. *Niger. Agri. J.* **7**: 76-85
- Steel, R. G. D. and Torrie, J. H. (1960). *Principles and Procedures of Statistics*. New York: McGraw Hill