World Rabbit Sci. 2017, 25: 241-249
doi:10.4995/wrs.2017.6654

EFFECT OF SUBSTITUTING GUINEA GRASS WITH SOYBEAN HULLS ON PRODUCTION PERFORMANCE AND DIGESTION TRAITS IN FATTENING RABBITS

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Abstract: The objective of this study was to evaluate the use of soybean hulls (SH) to substitute guinea grass (GG), traditionally used as fibre source in the diets of fattening rabbits on performance, coefficients of total tract apparent digestibility (CTTAD) of nutrients, gastrointestinal tract development and caecum fermentation. A total of 160 mixed sex Hyla commercial meat rabbits were allocated to 4 experimental groups (40 per treatment) differing in the SH level inclusion in the diet offered to rabbits from 40 to 90 d of age: 0, 50, 100 and 200 g/kg as-fed basis: SH0, SH50, SH100 and SH200 groups, respectively. Growth performance was recorded from 40 to 90 d of age, CTTAD of nutrients from 86 to 90 d of age, and gastrointestinal tract development, caecum fermentation and carcass traits were determined at 90 d of age. Average daily feed intake and the feed/gain ratio were lower in SH100 and SH200 groups than in SH0 group (P<0.05). The digestibility of energy, neutral detergent fibre and acid detergent fibre were higher in SH100 and SH200 than in SH0 group (P<0.05). The relative weights of stomach and caecum were lower in SH200 than in S0 and S50 groups (P<0.05), and the relative length of small intestine was lower in the 3 groups containing SH than in the S0 group (P<0.01). The caecal pH and concentration total volatile fatty acids were lower in SH100 and SH200 groups than in SH0 or SH50 groups (P<0.05). Substitution of GG with SH had no effect on carcass characteristics and meat quality (P>0.05). In conclusion, our results suggest that SH can substitute GG in the diets of fattening rabbits up to 200 g/kg in diet with no adverse effects on the growth performance, feed efficiency, carcass traits and meat quality.

Key Words: soybean hulls, rabbit, production performance, digestibility, gastrointestinal development, caecum fermentation.

INTRODUCTION

Rabbit is a non-ruminant herbivorous animal with a digestive physiology well adapted to a high intake of plant cell walls, and sufficient dietary fibre supply is essential to prevent digestive troubles in growing rabbits. Therefore, dietary fibre is the main constituent of rabbit diet, in concentrations usually ranging from 150 to 500 g/kg (Gidenne, 2003). Several studies based on variations of fibre nature or origin showed that low fibre intake involves lower growth rate during the few weeks after weaning that are often associated with intake troubles or digestive disorders. Guinea grass (GG) is a widely available forage for ruminant production in most areas of China, and is the main traditional fibre source used in rabbit feed. However, the price of GG is rising sharply. Therefore, alternatives are required to produce balanced pelleted feeds using local raw materials, available at a lower price. Soybean hulls (SH) are the skin of the soybean which comes off during soybean seed processing. It contains a variety of substrates usable by intestinal microorganisms (Van Laar *et al.,* 1999; Miron *et al.,* 2001), which can help meet the high fibre requirements of rabbits (around one-third of neutral detergent fibre [NDF] on as-feed, De Blas and Mateos, 1998). However, there is limited information on the effectiveness of using SH to replace GG in the diets of fattening rabbits in recent years. The aim of this study was to assess the use of SH in substitution for GG in the diet of fattening rabbits by examining its

Correspondence: F.C. Li, chlf@sdau.edu.cn. Received *September 2016* - Accepted *March 2017.*
https://doi.org/10.4995/wrs.2017.6654

effect on the growth performance, carcass traits, coefficients of total tract apparent digestibility (CTTAD) of nutrients, gastrointestinal tract development and caecum fermentation.

MATERIALS AND METHODS

Animals and diets

A total of 160 forty-day-old Hyla commercial meat rabbits with similar body weights (1315±50 g) were used in this study. All rabbits were randomly divided into 4 groups (n=40, 20 males and 20 females per group) differing in the diet fed during the experiment from 40 to 90 d of age. Rabbits were individually housed in self-made metabolism cages (60×40×40 cm) which can separate urine from faeces. Each cage contained a feeder to provide free access to feed and a nipple drinker to provide free access to water. During the trial, all the rabbits were housed in a closed building in which the maximum temperature was 25°C and the minimum temperature was 10°C. A cycle of 12 h of light and 12 h of dark was used throughout this trial.

In the 4 experimental diets, the level of SH (purchased from Tai'an Fortune Sunshine Feed Co. Ltd, China) used in substitution of GG were 0, 50, 100 and 200 g/kg as-fed basis (groups SH0, SH50, SH100 and SH200, respectively). The chemical composition of SH and GG are shown in Table 1. The experimental diets (Table 2) were formulated according to the values from NRC (1977) and De Blas and Mateos (1998). The 4 diets were passed through a roller mill prior to being mixed and granulated, pelleted (4-6 mm in length) and stored in the dark.

Experimental procedures

The experimental procedures were approved by the Committee of Ethics in Research of Shandong Agricultural University and performed in accordance with the Guidelines for Experimental Animals of the Ministry of Science and Technology (Beijing, China). The feed was offered *ad libitum* and feeders were refilled at 06:30 and 18:00 daily, after collecting residual feed from the cages. The total experiment consisted of a 7-day adjustment period followed by a 43-day experimental period including a 4-day period (day 86 to day 90) for collection of faeces. Faeces and residual feed were collected from the metabolism cages.

Individual weight was measured at the beginning and end of the trial and the average daily gain (ADG) calculated. The average daily feed intake (ADFI) was calculated according to total feed intake divided by total experimental days. The feed conversion ratio (FCR) was then calculated. The ADG, ADFI, and FCR calculations did not include the 7-day adaptation period.

Table 1: Chemical composition of soybean hulls and guinea grass (g/kg, as-fed basis).

Items	Soybean hulls[1]	Guinea grass
Gross energy (MJ/kg)	16.01	15.95
Dry matter	925.9	912.2
Crude protein	95.3	54.6
Ether extract	16.7	23.6
Crude fibre	404.9	507.8
NDF [2]	668.4	674.5
ADF [3]	473.4	484.6
ADL[4]	9.4	66.6
Ash	46.8	52.3
Calcium	7.00	4.70
Phosphorus	1.80	4.50

[1] Soybean hulls was purchased from Tai'an Fortune Sunshine Feed Co. Ltd, China.

[2] NDF, neutral detergent fibre not assayed with a heat stable amylase and expressed exclusive of residual ash (NDFom).

[3] ADF, acid detergent fibre expressed exclusive of residual ash (ADFom).

[4] ADL, acid detergent lignin, Lignin determined by solubilisation of cellulose with sulphuric acid.

Table 2: Ingredients and chemical composition of the experimental diets (g/kg as fed basis).

	Diets			
Items	SH0	SH50	SH100	SH200
Ingredients				
Corn	200	200	200	200
Soybean meal	200	200	200	200
Wheat bran	100	100	100	100
Wheat middling	125	125	125	125
Medicago sativa	50	50	50	50
Beanstalk	50	50	50	50
Rice hull powder	50	50	50	50
Guinea grass	200	150	100	0
Soybean hull	0	50	100	200
$CaHPO_4$	10	10	10	10
Salt	5	5	5	5
Premix[1]	10	10	10	10
Energy and chemical composition [2]				
Gross energy (MJ/kg)	16.09	16.10	16.11	16.13
Crude protein	163.3	164.3	166.6	169.6
Ether extract	24.1	23.6	22.3	23.5
Crude fibre	183.8	173.7	162.7	156.7
NDF [3]	350.9	338.5	339.4	319.6
ADF [4]	202.3	196.9	194.6	183.7
ADL [5]	34.1	32.9	30.3	29.8
Ash	97.0	92.4	91.9	85.7
Calcium	10.4	9.9	9.7	9.8
Phosphorus	4.0	3.9	3.7	3.8
Digestible energy [6](MJ/kg)	9.04	9.29	10.10	10.61
Digestible protein[6]	119.5	119.4	123.8	126.9

[1] The premix provides the following per kilogram of diet: VA 8000 IU; VD 31,000 IU; VE 50 mg; Lys 1.5 g; Met 1.5 g; Cu 50 mg; Fe 100 mg; Mn 30 mg; Mg 150 mg; I 0.1 mg; Se 0.1 mg.

[2] Measured values.

[3] NDF, neutral detergent fibre not assayed with a heat stable amylase and expressed exclusive of residual ash (NDFom).

[4] ADF, acid detergent fibre expressed exclusive of residual ash (ADFom).

[5] ADL, acid detergent lignin, Lignin determined by solubilisation of cellulose with sulphuric acid.

[6] Calculated from digestibility coefficients obtained in the digestibility trial (see Table 4).

The CTTAD of dry matter and nutrients were measured in an *in vivo* digestibility assay carried out on 32 rabbits: 8 animals of both sexes per diet chosen as representative of the live weight, mean and variability within groups. Following a 3-day period of adaptation to metabolism cages, the feed intake (*ad libitum* access) and the total faecal output (caecotrophy was not prevented) were recorded for each rabbit over a 4-day period. The digestibility trial lasted from 86 to 90 d of age.

At the end of digestibility trial (90 d), the 32 rabbits were weighed (slaughter weight: SW) and lengthened (body length: BL) before slaughtering. After bleeding, the pelts, paws and full contents were removed and the hot carcasses were weighed after slaughter to calculated the dressing percentage. The stomach, small intestine and caecum were removed immediately and weighed before and after emptying their contents. The pH in caecum was immediately measured. A sample of caecal content (200 mg) was diluted with a 15% HPO_3 solution (25%, w/w), and stored at −20°C pending chemical analysis. In addition, the length of the small intestine was measured.

Meanwhile, the whole *longissimus lumborum* (LL; between the 1st and 7th lumber vertebra) was removed from the right side of each carcass. The LL was then divided into 3 sub-samples. One sub-sample was utilised for pH measurements at 45 min and 24 h. The muscle colour (L*, a* and b*), shear force were determined at the end of the chilling period (24h) on the second and third sub-samples, respectively. Carcasses were weighted after 24h of chilling at +4°C. Drip loss (%, at 24h) was calculated as (hot carcass weight–chilled carcass weight)/hot carcass weight. Shear force (kg·f) was measured in triplicate using the Warner-Blatzler meat shear apparatus (C-LM, USA). Each sample were cores (Ø=1.25 cm, thickness=2 cm) obtained from LL samples, cut perpendicularly to the fibre direction and previously cooked in a water bath (80°C, 10 min).

Chemical analyses

The Association of Official Analytical Chemists (AOAC) International (2005) procedures were used to determine the content of dry matter (934.01), crude protein (954.01), crude fibre (978.10) and ash (942.05) in SH, GG, feeds and faeces. The mineral profile (Ca, P) of the diets was analysed by ICP-OES (Spectro Ciros Vision EOP) after microwave digestion (999.10). Crude protein content (6.25×N) and ether extract were determined using a Kjeltec Auto 1030 Analyser and a Soxtec 1043, respectively (FOSS Tecator AB, Höganäs, Sweden). Analysis of fibre components was performed according to Goering and Van Soest (1970) and except NDF (Van Soest *et al.,* 1991). The energy levels of the feed and faeces were measured in a bomb calorimeter (Parr 6300 Calorimeter, Moline, IL, USA). All analyses were performed in duplicate.

The pH value of caecal content was determined for each rabbit 45 min post-mortem with a pH meter equipped with a pH probe (Crison MicropH 2001). The thawed samples of caecal contents were then centrifuged at 2500 *g* at 0°C for 10 min. The ammoniacal nitrogen concentration and volatile fatty acids (VFAs) of the supernatant were measured. Twenty millilitres of supernate samples were poured into stoppered glass flasks, mixed with about 20 mL of 0.2 M hydrochloric acid and stirred for 30 min. The ammoniacal nitrogen concentration was measured using a spectrophotometer according to Weatherburn (1967). A solution of 5% orthophosphoric acid (v/v) plus 1% mercury chloride (w/v) was added to the samples for VFA determination. VFAs were measured using gas chromatography, having a gas column free of fatty acids and containing phenols 10% H_3PO_4, 1% acid-washed chromosorb W, 100-120 mesh. The carrier gas was N_2 (40 mL/min), H_2 (60 mL/min) and air (60 mL/min) flows to the detector. Injector and detector temperatures were 250°C. The oven temperature was 150°C.

Statistical analysis

The experiment was conducted using a completely randomised design (4 treatments, 40 replicates/treatment and one rabbit per replicate). Date on growth performance (n=40/treatment), CTTAD, gastrointestinal tract development, caecum fermentation and carcass traits and meat qualities (n=8/treatment) were analysed using linear models ANOVA (GLM) procedure (SAS, 9.3; SAS Institute Inc., Cary, NC, USA). Differences among treatments were examined using Duncan's multiple range test, and were considered to be significant at $P<0.05$.

RESULTS AND DISCUSSION

Effect of dietary SH level on growth performance

The growth performances of the experimental rabbits are presented in Table 3. ADFI was lower in SH100 and SH200 groups than in SH0 group ($P<0.05$), the SH50 group being intermediate (Table 3). The F/G ratio was lower in the SH200 group than in the SH0 group ($P<0.01$), the SH50 and SH100 groups being intermediate. The final body weights (FBW) and ADG were similar among the 4 groups ($P>0.05$). During the trial, no death occurred, and no rabbit displayed feed intake reduction, weight loss or diseases.

Rabbit is a small-sized monogastric herbivorous animal and fibre is one of the main constituents of diets for intensively reared rabbits (De Blas *et al.,* 1999b). The digestive physiology of the rabbit is well adapted to high intake of plant cell walls. Moreover, sufficient dietary fibre is essential to prevent digestive troubles but not to improve the growth rate in the fattening rabbits. The main constituent of SH is fibre (NDF>66%; Table 1). This study showed that in

Table 3: Growth performance of experimental rabbits from 40 to 90 d (n=40).

	Group					
Items	SH0	SH50	SH100	SH200	R-MSE	*P*-value
IBW (g)	1327.4	1313.0	1311.4	1310.0	171.21	0.966
FBW (g)	2950.2	2955.6	2960.5	2966.9	232.02	0.740
ADFI (g/d)	145.6^{b}	143.5^{ab}	141.6^{a}	140.9^{a}	7.17	0.031
ADG (g/d)	33.9	34.6	34.7	36.3	4.95	0.074
FCR	4.23^{c}	4.12^{bc}	4.06^{ab}	3.95^{a}	0.450	0.0061

Different superscripts within in a row denote a significant difference ($P<0.05$).
R-MSE, Root mean square error. IBW, Initial body weight. FBW, Final body weight. ADFI, Average daily feed intake. ADG, Average daily gain. FCR, Feed conversion ratio.

rabbits of similar initial body weight (Table 3; $P>0.05$), the inclusion of SH in the diet decreased the ADFI and FCR in rabbits between 40 and 90 d of age ($P<0.05$), coinciding with the results of De Blas *et al.* (1999). This result may be due to the difference in digestible energy level in the four diets (Table 2) increasing as SH level increased. Accordingly, the levels of crude fibre and fibre proportions decreased when SH levels increased (Table 2). The degree of lignification is the main factor responsible for a reduction in digestibility of raw feed and feedstuffs (Gidenne and Perez, 1994; García *et al,* 1997). The cell wall lignification is lower in SH than in GG (9.4 *vs.* 66.6 g ADL/kg in SH and GG, respectively; Table 1). Thus, the higher digestible fibre level should explain the higher digestible energy in diets containing SH (Table 2) and the subsequent reduction in ADFI. A similar effect was previously observed in broilers (Jiménez-Moreno *et al.,* 2008; González-Alvarado *et al.,* 2007).

Effect of dietary SH level on CTTAD of nutrients

The digestibility of energy and acid detergent fibre (ADF) were higher in SH100 and SH200 groups than in SH0 and SH50 groups ($P<0.001$; Table 4). Neutral detergent fibre (NDF) digestibility was the highest in SH200 and the lowest in SH0 ($P<0.0001$), the other groups being intermediate. The digestibility of crude protein, ether extract and crude fibre were similar in the 4 groups ($P>0.05$).

Fibre source has an important role in regulation of the intestinal transit, gut flora, intestinal mucosa integrity and digestibility in rabbits (De Blas *et al.,* 1999; Fortun-Lamothe and Boullier, 2007). Additionally, the retention time is linearly reduced with the dietary NDF content (Fraga *et al.,* 1991). Thus, GG substitution by SH, which lowered the dietary NDF level (350.9 *vs.* 319.6 g/kg NDF in SH0 and SH200 diet, respectively; Table 2) may lengthen the retention time, which could explain the higher digestibility of energy and fibre fractions.

Effect of dietary SH level on carcass characteristics and meat qualities

There were no differences among the groups concerning hot carcass weight and dressing percentage ($P>0.05$; Table 5). Likewise, the pH (45 min), pH (24 h), shear force, 24 h drip loss and sensory traits (L*, a* and b*) of LL

Table 4: Coefficients of total tract apparent digestibility of nutrients of experimental rabbits (n=8).

	Group					
Items	SH0	SH50	SH100	SH200	R-MSE[2]	*P*-value
Gross energy	0.562^{a}	0.577^{a}	0.627^{b}	0.658^{b}	0.0291	<0.0001
Crude protein	0.732	0.727	0.743	0.748	0.0318	0.5439
Ether extract	0.789	0.780	0.795	0.826	0.0442	0.2044
Crude fibre	0.161	0.185	0.161	0.162	0.0473	0.7863
NDF	0.232^{a}	0.265^{ab}	0.303^{b}	0.355^{c}	0.0437	<0.0001
ADF	0.156^{a}	0.150^{a}	0.213^{b}	0.205^{b}	0.0248	0.0046

Different superscripts within in a row denote a significant difference ($P<0.05$).
R-MSE, root mean square error. NDF, neutral detergent fibre not assayed with a heat stable amylase and expressed exclusive of residual ash (NDFom). ADF, acid detergent fibre expressed exclusive of residual ash (ADFom).

Table 5: Effects of SH levels on the carcass characteristics and meat quality of experimental rabbits (n=8).

Items	Group				R-MSE	*P*-value
	SH0	SH50	SH100	SH200		
Slaughter weight (g)	2949.6	2956.3	2958.8	2967.5	128.58	0.994
Hot carcass weight (g)	1457.5	1486.3	1499.4	1499.4	77.60	0.983
Dressing percentage (%)	49.40	50.26	50.67	50.58	2.400	0.8097
pH (45 min)	6.68	6.67	6.65	6.61	0.100	0.5594
pH (24 h)	6.31	6.24	6.20	6.29	0.153	0.4516
L*	36.07	34.96	34.36	33.90	1.952	0.1938
a*	36.68	35.26	34.23	33.08	3.472	0.2221
b*	–8.14	–8.60	–9.16	–9.39	1.362	0.3048
Shear force (kg.f)	2.53	2.50	2.51	2.52	0.186	0.9904
24 h Drip loss (%)	9.37	8.77	10.04	9.59	1.763	0.6126

R-MSE, Root mean square error. L*, lightness. a*, redness. b*, yellowness.

muscles were similar in the 4 groups ($P>0.05$). These results agree with previous studies showing no or few effects of fibre sources inclusion (sugar beet pulp: García *et al.,* 1993; Margüenda *et al.,* 2012; olive pomaces: Dal Bosco *et al.,* 2012) on meat composition or physical characteristics such as tenderness, drip loss and colour.

Effect of dietary SH level on gastrointestinal tract development

The relative weights of stomach and caecum were lower in SH200 than in S0 and S50 groups ($P<0.05$), the others groups being intermediate. The relative length of small intestine was lower in the 3 groups containing SH than in the SH0 group ($P<0.01$). The relative weight of content in stomach, intestine and caecum was similar in the 4 groups ($P>0.05$). The rabbit's digestive system is characterised by the relative importance of the caecum when compared with other species. The capacity of the caecum is approximately 0.49 of the total capacity of the digestive tract (Gidenne *et al.,* 1998). Several studies previously showed that the intake of high-fibre diets cause a significant extension of the gastrointestinal tract, mainly its length (García *et al.,*1999; Tao and Li, 2006). The level and type of dietary fibre can play the most important role in controlling gastrointestinal tract development and digestive content (Margüenda *et al.,* 2012). Jehl and Gidenne (1996) pointed out that the caecal weight is related to ADFI. Finally, as in the present study, Jørgensen *et al.* (1996) reported that the relative weight of stomach, caecum and colon (per kg of empty body) and the length of colon were significantly greater in pigs consuming a high-fibre diet than in those consuming a low-fibre diet.

Table 6: Proportion of digestive organs and their contents of experimental rabbits at 90 d of age (n=8).

Items	Group				R-MSE	*P*-value
	SH0	SH50	SH100	SH200		
Stomach relative weight (% SW)	1.34^{b}	1.29^{b}	1.24^{ab}	1.10^{a}	0.001	0.0168
Stomach content relative weight (% SW)	4.99	5.15	4.93	4.99	0.009	0.9652
Small intestine relative length (BL)	10.73^{b}	9.63^{a}	9.46^{a}	9.20^{a}	0.827	0.0066
Small intestine relative weight (% SW)	3.01	3.22	3.35	3.18	0.005	0.5442
Small intestine content relative weight (% SW)	4.99	5.15	4.93	4.98	0.009	0.9652
Caecum relative weight (% BW)	1.64^{c}	1.57^{bc}	1.45^{ab}	1.38^{a}	0.002	0.0215
Caecal content relative weight (% SW)	4.41	4.99	5.37	5.40	0.011	0.2617

Different superscripts within in a row denote a significant difference ($P<0.05$).
R-MSE, Root mean square error. SW, Slaughter weight. BL, Body length.

Table 7: Caecum fermentation of experimental rabbits at 90 d of age (n=8).

	Group					
Items	SH0	SH50	SH100	SH200	R-MSE	*P*-value
Caecal content pH	6.38[b]	6.30[b]	6.14[a]	6.11[a]	0.222	0.0401
Ammoniacal nitrogen (mmol/L)	2.47	1.92	1.88	1.65	0.508	0.0649
Total VFA (mmol/L)	71.11[b]	71.02[b]	66.10[a]	65.54[a]	2.879	0.0005
Acetic acid (% total VFA)	87.64[b]	85.65[b]	82.76[ab]	78.98[a]	4.932	0.0205
Propionic acid (% total VFA)	4.12	5.91	6.93	7.65	2.648	0.1060
Butyric acid (% total VFA)	7.32	8.24	9.94	10.19	4.565	0.5778
Acetic/(Propionic+Butyric)	7.66[b]	6.05[ab]	4.91[a]	4.43[a]	0.429	0.0063

Different superscripts within in a row denote a significant difference ($P<0.05$).
R-MSE, Root mean square error. VFA, Volatile fatty acids.

Effect of dietary SH level on caecum fermentation

The values of caecal pH, ammoniacal nitrogen and total VFA concentrations and individual proportions are reported in Table 7. The pH in caecum and the total VFA concentration were lower in SH100 and SH200 groups than in S0 and S50 groups ($P<0.05$). The acetic acid concentration was higher in SH200 than in SH0 and SH50 groups ($P<0.05$) and the acetic acid/ (propionic + butyric acids) ratio was lower in SH100 and SH200 groups than in SH0 group ($P<0.01$). The ammoniacal nitrogen, propionic acid and butyric acid concentrations in caecum were similar between groups.

Carabaño *et al.* (2009) found that increased availability of a fermentable substrate could decrease the utilisation of protein for energy purposes while promoting microbial protein synthesis, thus reducing the ammoniacal nitrogen level in the caecum. In the present trial, the concentration of ammoniacal nitrogen in the caecal content was not affected by dietary SH levels. This might be linked to similar protein content in the 4 experimental diets. VFAs are the end products of microbial fermentation (Bellier and Gidenne, 1996), and play an important role in the aetiology of digestive disturbances (Gidenne, 1997). Moreover, they also provide an important source of energy for the rabbit (Bellier and Gidenne, 1996). The fermentative parameters previously reported by Gidenne (1996), such as 60-80 mol of acetate, 8-20 mol of butyrate and 3-10 mol of propionate per 100 mol of VFA, agree with those observed in the current study. Meanwhile, Bellier and Gidenne (1996) observed an increase of VFAs production in caecum of rabbits fed a high fibre diet. In this study, the proportion of caecal acetic acid (% total VFA) contents and acetic/(propionic+butyric) ratio were significantly decreased with SH increased in the diets. This may be related to change in the nature of the fibre ingested due to SH inclusion (García *et al.,* 2000; Falcão-e-Cunha *et al.,* 2004). García *et al.* (2002) showed that caecal pH is negatively related to NDF concentrations. Thus, the reduction in dietary NDF level as a consequence of SH inclusion should explain the reduction in caecal pH in rabbit fed diet containing SH. Surprisingly, lower pH was associated with lower total VFA concentration, while VFA are the main source of H^+ in the caecal contents (De Blas *et al.,* 1999a).

CONCLUSION

For fattening rabbits, the use of 200 g/kg SH in substitution for guinea grass could increase the CTTAD of gross energy, NDF and ADF and impaired gastrointestinal tract development. SH could thus be considered as a fibre source which has a higher level of soluble and/or fermentable fibre for the fattening rabbit. Moreover, SH has a higher digestible energy content than GG which lead to a lower feed intake, and improve feed conversion ratio. Therefore, SH can be included in rabbit diets at levels up to 200 g/kg in diet (digestible energy 10.61 MJ/kg, digestible protein 126.9 g/kg; as-fed basis) with almost no adverse effects on the growth performance, CTTAD of nutrients, gastrointestinal tract development, caecum fermentation and carcass traits.

Acknowledgement: This study was supported by the earmarked fund for Modern Agro-industry Technology Research System (CARS-44-B-1).

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