Chemical composition and digestibility (*in vitro*) of cocoa pod husk (*Theobroma cocoa* L.) fermented with *Aspergillus niger*

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ABSTRACT: Cocoa pod husk (CPH) had low nutrition content and low digestibility when it consumed by ruminants. This research aimed to know chemical composition change, digestibility of CPH fermented with *Aspergillus niger* in different chopping sizes and fermentation times. Research was done in Feed Animal Laborotory, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta starting from February to September 2009. *Aspergillus niger* BPT was used 1,0% (DM basis). Chopping sizes were irrigular size (A_1) , 1x5 cm (A_2), 3x5 cm (A_3), and 5x5 cm (A_4). Fermentation times were 0, 5, 7, and 9 days. Analysis of CPH fermented samples was done using Proximate and Goering *and* Van Soest procedures. Data was analyzed using Factorial CRD, four factors for chopping size and four factors of fermentation time (4 x 4), with three replications. Digestibility of CPH fermented in the *rumen* was done using gas production procedure (*In Vitro*) from *rumen* liquid of Etawah grade buck. The CPH sample tested was 200 mg (DM Basis). Gas volume increasing was recorded after incubation for 3, 6, 12, 24, 48, 72, 96 hours. Accumulated gas production was calculated using $P = a + b (1-e^{-ct})$. of the result showed that change of chemical compositions (DM, OM, CFt) after fermentation were significantly differ ($P<0.05$), the highest change was in A_1, followed A_2, A_3, while the lowest was in A_4. Crude protein was significantly differ ($P<0,05$) the highest was in A_2, followed by A_1, A_3, and the lowest was in A_4. CF from chopping sizes were not effected toward chemical compositions change. DM and CFt was significants ($P<0,05$) the highest after fermentation for 5 days, followed by 7 and 9 days. CP was significant ($P<0,05$) the highest after fermentation for 7 days, followed by 9 and 5 days. OM was significant ($P<0,05$) the highest after fermentation for 9 days, followed by 7 and 5 days. Chopping sizes of total degradation (a+b) were the highest of non fermentation (34,53 ml/200 mg), followed by 5 days (23,56 ml/200 mg), 7 days (20,89 ml/200 mg) and the lowest was for 9 days fermentation (18,17 ml/200 mg).

Key words: chemical composition, digestibility, *A. niger*, fermentation, CPH

INTRODUCTION

Limited availability of forage could also caused limited portion on forage feeding given to goat in the pen. This problem in the long time could cause malnutrition of goat for maintaining their life and production. One of alternative feed sources which come from by-product plantation is farmers' cocoa plantation. Farmers' cocoa plantation has a great potency to be feed resources, such as cocoa leaf (prunning by-product), cocoa pod husk, skin of cocoa bean, gliricidea leaf (canopy of cocoa plant). Utilization of CPH as feed additive are expected to fulfill necessary goats' forage in the long year. Cocoa pod husk (CPH) production is higher than cocoa bean production. The cocoa fruit has composition of 73,73 - 74,00% CPH, 2,00% placent, 21,98% cocoa bean and 2,40% cocoa bean skin (Erlinawati, 1986; Ginting, 2004). Result of a research by Munier et al. (2005) showed that average of dry cocoa bean productivity was 1.382 kg/ha/year, estimated that it could result CPH about 5,315.4 kg/ha/year or 129,647.92 tons/year from farmers' cocoa plantation in Central Sulawesi Province.

CPH has low in both nutrient contents and low digestibility when it wass consumed by ruminants. Nutrient content of CPH was 18,7% dry matter (DM), 9,9% crude protein (CP), 9,2% crude fat (CPt) and 32,9% crude fiber (CF) (Munier, 2007). High CF content indicated low quality which could affect on the total of feed consumed and digestibility of goat. CPH have lignocellulotic content, this content generally occurs advanced lignification and its cellulose form in crystal (Jackson, 1977). Increasing of CPH quality could be done with fermentation method using fungi and yeast.

Fermentation process utilized organic matter for energy establishment through electron transfer in citoplasm of fermentative microbial (Purwoko, 2007). Result of research by Laconi et al. (1997) showed that CPH was fermented by *Phanerachaete chrysosporium* fungi could reduce CF content of CPH from 55.67% to 45.56%, and increase CP content from 8.35% to 10.12%. Aspergillus is usually used in fermentation process for agriculture by-product that contain high CF. One of Aspergillus that has been done before by researchers was *Aspergillus niger* (*A. niger*). This is popular innoculum to be used because of easy to be reproduced, not easy to be contaminated by another microorganism and good growth compared with others fungi (Wina, 2005). CPH fermentated is expected to increase both nutrient content and decrease CF content. This research was done to know the chemical composition change and digestibility of CPH, which was fermented with *A. niger* in different chopping sizes and fermentation times.

MATERIALS AND METHODS

Research was done in Feed Animal Laborotory, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta from February to September 2009. Fresh CPH was colleted from farmers plantation. CPH was chopped in three sizes: irrigular size (A_1), 1x5 cm (A_2), 3x5 cm (A_3), and 5x5 cm (A_4). Fermentation times were 0 day (non fermention), 5 days, 7 days and 9 days. Microorganism as decomposer used was *A. niger* BPT with total colony about 9,1 x 10^7 colony/g. Every chopping size was 1 kg which CPH was spreaded in plastic box (size 30 x 18 x 10 cm). Utilization of *A. niger* was 1,0% (in powder form) from total of CPH (Lubis, 2002) or 1,59 g (DM basis). Urea as nitrogen source for *A. niger* was added 1,0% from total of CPH (Lubis, 2002) atau 1,59 g (DM basis). Urea was dissolved in aquadest with ratio 1 g urea : 10 ml aquadest. Every chopping size CPH was spreaded by *A. niger*. CPH in box was covered by transparency plastic and it was put in sterile room. Fermentation process was in aerobic (Purwadaria et al., 2003) in room temperature about 25^o C (Ramanujam et al., 2004) during 0, 5, 7 and 9 days. After fermentation process finished, CPH was drayed by air drayer for 3-4 hours and weighed. Oven was used to dry CPH fermentation for 3 days at temperature 55^o C. Drying CPH was grinded using Willey Mill in screen size 3 mm. Analysis of CPH samples were done using proximate analysis for dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CFt), crude fiber (CF) contents (AOAC, 1990) at Nutrition and Feed Laboratory, Faculty of Animal science, UGM Yogyakarta. Treatment in both chopping size and fermentation times were analyzed using Factorial Design of Completely Randomized Design (CRD) in 4 x 4 with three replications and calculation was done using 17.0 version of SPSS software.

Digestibilityof CPH fermented in the *rumen* was determined by gas production procedure (*In Vitro*) according to Menke and Steingass (1988) from the *rumen* liquid of Etawah Grade buck. Total feed given to goat was 3,5% from life weight on DM basis (NRC, 1981) with composition 70% of King grass and 30% of rice bran. The CPH sample in 1 mm screen size was tested 200 mg on DM Basis. CPH sample was entered to syringe and incubated at temperature 39^o C in the water bath. Increasing of gas volume was recorded after incubation to 3, 6, 12, 24, 48, 72 and 96 hours (Tuah et al., 1996). Cummulative of gas production was analyzed by a formula $P = a + b\ (1\text{-}e^{-ct})$ which was modified by Ørskov (2002), P = gas production in time t, c = constant rate and a + b = total of gas production, using NEWAY software (Chen, 1997).

RESULTS AND DISCUSSION

Chemical Compositions of CPH Fermented in DM

DM content of CPH after fermentation process in all treatments was generally decrease as presented in Table 1. Table 1 showed that chopping sizes had significant effects ($P<0.05$) in all treatments. Average of changing for CPH DM was significantly different ($P<0.05$), the highest was A_1 followed by A_2, A_4 and the lowest was A_3. Fermentation times gave an effect on CPH DM content after fermentation, which had significant differences ($P<0.05$), average of DM content for 5 days fermentation was higher than both in 7 days and 9 days, 7 days fermentation was significantly higher

(P<0.05) than 9 days. CPH at 0 day (non fermentation) had hig DM content. The lowest changing of DM contents occured for A_1 after 5 days fermentation with increasing DM content was 15,64%.

Fermentation of CPH in big chopping size was A_3 and A_4 and it was relatively less utilized of DM because *A. niger* was not optimally fermented the CPH. Changing on average increasing of DM content was the highest in A_3 after fermentation for 9 days by 27,04%. Increasing of CPH DM content for A_3 after fermentation 9 days caused by *A. niger* was not more action to DM degradability of CPH which had bigger chopping size. Different result of research done Sutikno *et al*. (1994) that CPH which was fermented using *A. niger* resulted in decrease of DM as much as 3.38%. This different could be caused by different treatment. In this research, chopping size was bigger, while research before was CPH to be milled in small particle. According to Owens and Goetsch (1988); Bowman and Firkins, (1993), the smaller particle size could increase surface area for microbial in degradation process. Optimal CPH degradation could increase CP, reduce CF and other fiber fractions.

Table 1. Changes of DM Content of CPH (g)

Fermentation times, d	Chopping sizes				
Changings , d	A_1	A_2	A_3	A_4	Average
0	$145.74^{a.b}$	149.30^{a}	144.87^{b}	141.93^{b}	145.46^{a}
5	122.94^{c}	$121.26^{c.d}$	$106.61^{g.h}$	117.54^{d}	117.09^{b}
7	118.50^{d}	$110.95^{e.f}$	$111.31^{e.f}$	$110.25^{e.f.g}$	112.75^{c}
9	113.62^{e}	$111.84^{e.f}$	105.70^{h}	$108.70^{f.g.h}$	109.97^{d}
Average	125.20^{a}	123.34^{b}	117.12^{d}	119.61^{c}	
After 5,%	15.64	18.78	26.41	17.19	
After 7,%	18.68	25.69	23.17	22.32	
After 9,%	22.04	25.09	27.04	23.41	

$^{a.b}$Different superscripts in the same rows denote significant differences (P<0.05).

There is a tendency that organic matter (OM) content of CPH after fermentation was decreasing for all treatments, as presented in Table 2.

Table 2 showed that chopping size has significant effect (P<0.05) on OM content, A_1 was higher than A_2, A_4 and A_3, A_2 was significantly higher (P<0.05) than A_4 and A_3. Fermentation time had effect on average changing of CPH OM content, significant effect was found primarily after fermentation, which 5 days fermentation has significantly (P<0.05) changes compared to both 7 and 9 fermentation; 7 days fermentation was significantly higher (P<0.05) than 9 days fermentation. The lowest changing of CPH OM content was in A_1 after 5 days fermentation, with increasing OM content was 16.28%.

Table 2. Changes of OM Content of CPH (g)

Fermentation Times, d	Chopping Sizes				
Changings, d	A_1	A_2	A_3	A_4	Average
0	129.67^{b}	133.79^{a}	130.06^{b}	128.80^{b}	
5	108.55^{c}	105.86^{c}	95.22^{f}	105.03^{c}	130.58^{a}
7	106.86^{c}	95.17^{f}	$99.02^{d.e}$	$97.43^{d.e.f}$	103.66^{b}
9	99.48^{d}	$99.26^{d.e}$	94.04^{f}	$95.72^{e.f}$	99.62^{c}
Average	111.14^{a}	108.52^{b}	104.59^{d}	106.74^{c}	97.12^{d}
After 5, %	16.28	20.88	26.79	18.46	
After 7, %	17.59	28.86	23.86	24.35	
After 9, %	23.28	25.81	27.70	25.68	

$^{a.b}$Different superscripts in the same rows denote significant differences (P<0.05).

Fermentation of CPH for bigger chopping sizes (A_3 and A_4) was more less use of OM than smaller chopping size (A_2 and A_1) particularly after 5 days fermentation. In both of A_3 and A_4 treatments, *A.*

niger was not optimal decomposed during CPH fermentation, compared ot A_1 and A_2. In treatment A_1 and A_2,, *A. niger* were need higher OM for decomposing fibre component and anti nutrition because media to be composed has smaller size. Decreasing of OM in this CPH was caused by utilisation of OM as energy source by *A. niger*. Basuki (1994) reported that fermentation of farm oil with cellulolitic decomposer microbial in aerobic condition, this microbial was decomposed on simply compounds as in both carbon and energy sources.

Crude fat (CFt) content of CPH after 5 days fermentation process was decreased, incontrast there is a tendency that after 7 and 9 days fermentation, the CFt content was increased, as presented in Table 3.

Table 3. Changes of CFt Content of CPH (g)

Fermentation Times, d	Chopping Sizes				
Changings, d	A_1	A_2	A_3	A_4	Average
0	1.27^{c}	1.37^{c}	1.37^{c}	0.92^{d}	1.23^{b}
5	2.29^{a}	2.08^{b}	2.06^{b}	2.28^{a}	2.18^{a}
7	$0.63^{f.g}$	$0.65^{f.g}$	$0.70^{e.f}$	$0.60^{f.g}$	0.65^{d}
9	$0.83^{d.e}$	0.48^{g}	$0.81^{d.e}$	$0.84^{d.e}$	0.74^{c}
Average	1.26^{a}	1.15^{c}	$1.24^{a.b}$	$1.16^{b.c}$	
After 5, %	-80.15	-52.12	-49.56	-148.59	
After 7, %	50.10	52.71	48.97	34.68	
After 9, %	34.42	64.61	41.13	8.51	

$^{a.b}$Different superscripts in the same rows denote significant differences (P<0.05).

Table 3 showed that A_1 has significantly higher (P<0,05) than A_3, A_4 and A_2, A_3 was significantly (P<0.05) higher than A_4, A_1, but CFt content of A_3 was not significantly difference (P>0.05) compared to A_4. Fermentation times has effect on the changes of CFt content of CPH, 5 days fermentation was significantly higher (P<0,05) changes of CFt content, followed by 0 day, 9 days and the lowest was in 7 days fermentations. The lowest changes of CPH CFt content was occured in A_4 after fermented 5 days, reducing of CFt content of CPH was around 148,59%.

Fermentation of CPH in bigger chopping sizes (A_1 and A_4) were using more CFt compared to small chopping sizes (A_2 and A_3). In both of A_1 and A_4, *A niger* needed longer time to decompose because area of media was wider and needed more energy, but result of decomposing was not optimal, while in A_2 and A_3 the area of media was smaller which it need lower energy but resulting on more optimal decomposition process. Decreasing CFt content of CPH caused by *A niger* used CFt as reservation of energy source. Fat has main function as energy reservation in form of triacilglicerol (Lehninger, 1982; Toha, 2005). Decreasing of CFt in this research was higher than previous research. Result of research by Laconi (1998) showed that CPH which fermented using *Phanerochaete chrysosporium* in 7 days and addition of molasses could reduce CFt content around 35.08%. The high decreasing CFt content of CPH in this research caused by limited energy available for A. *niger* to decompose fibre component of CPH, therefore CFt as reserving energy was used, while in the previous research, addition of molasses can be used as available energy for fungi.

Crude protein (CP) content of CPH after fermentation process was changes, fermentation increased CP content particularly A_1 and A_2 after fermentation of both 5 and 7 days (Table 4). Table 4 showed that A_2 was significantly higher (P<0,05) than A_1, A_4 and A_3. The highest average changes of CP content occured in A_2, followed by A_1, A_4 and the lowest was A_3. Fermentation time could affected the changes of CPH CP content, CP content after fermentation showed significantly differences (P<0.05), 7 days fermentation was higher than 5 days fermentation, but 7 days fermentation was not significantly difference (P>0.05) with 9 days fermentation. The highest average changes of CP content was in 7 days fermentation, followed by 9 days and 5 days fermentations, while the lowest was in 0 day fermentation. The highest changes of CP content occured in A_1 after 5 days fermentation, the changes was 7.60%. In treatment A_2 with 5 days and 9 days fermentations there was a decreasing CP content, namely 1.57% and 1.27%, respectively, but after 7 days fermentation, CP content increased, it was 0.15%. In the treatments A_3 and A_4 at all fermentation times, there was a

tendency that CP content decreased from 0.63% to 32.33%, which indicated that nitrogen discharging by *A. niger* is relatively small amount.

Table 4. Changes of CP Content of CPH (g)

Fermentation Times, d	Chopping Sizes				
Changings, d	A_1	A_2	A_3	A_4	Average
0	$12.69^{b.c}$	13.37^{a}	9.45^{h}	9.27^{h}	
5	11.72^{e}	13.58^{a}	10.05^{g}	10.55^{f}	11.20^{c}
7	13.37^{a}	13.35^{a}	$11.99^{d.e}$	$12.26^{c.d}$	11.48^{b}
9	12.86^{b}	13.54^{a}	11.66^{e}	$12.12^{d.e}$	12.75^{a}
Average	12.66^{b}	13.46^{a}	10.79^{d}	11.05^{c}	12.55^{a}
After 5, %	7.60	-1.57	-6.34	-13.87	
After 7, %	-5.41	0.15	-26.86	-32.33	
After 9, %	-1.33	-1.27	-23.37	-30.78	

$^{a.b}$Different superscripts in the same rows denote significant differences (P<0.05).

Fermentation process of Aspergillus in this research functioned as increasing CP content through protease enzime. Fermentation of CPH in bigger chopping sizes (A_1, A_3 and A_4) were resulted in relatively low increase of CP content compared to smaller chopping size (A_2). It is related to the activity of *A. niger* which in A_1, A_3 and A_4, microbial could not optimal on CPH decomposing during synthesis protein production reversely, in A_2 resulted higher synthesis protein so it will increase CP content of CPH.

Average CP content of CPH in A_2 before fermentation was 13.37% and after fermentation increased to 13.46%, the increase was approximatly 0.09%. Result of this research was lower than previous research. Sutikno et al. (1994) reported that CPH fermented with *A. niger* has significantly effect on increasing of CP content from 5.88% to 10.73% in 4 days fermentation, the increase was 4.85%. Increasing of CP content in CPH fermented was contribution of *A. niger* during fermentation process. According to Kompiang et al. (1994), increasing of CP content was caused by fungi which had optimal growth due to the utilisation of urea and other minerals.

Crude fibre (CF) content of CPH after fermentation process was changes, it was dominated by the decrease of CF content as presented in Table 5.

Table 5. Crude fibre content of CPH (g)

Fermentation Times, d	Chopping Sizes				
Changings, d	A_1	A_2	A_3	A_4	Average
0	$47.18^{d.e.f}$	44.49^{f}	$47.65^{c.d.e}$	$50.68^{a.b}$	
5	51.10^{a}	$50.55^{a.b.c}$	$46.12^{e.f}$	$47.77^{b.c.d.e}$	47.50^{b}
7	$50.06^{a.b.c}$	$45.96^{e.f}$	$50.11^{a.b.c}$	$49.41^{a.b.c.d}$	48.89^{a}
9	$46.84^{d.e.f}$	51.71^{a}	51.17^{a}	$50.32^{a.b.c}$	48.88^{a}
Average	48.79^{ns}	48.18^{ns}	48.76^{ns}	49.54^{ns}	50.01^{a}
After 5, %	-8.33	-13.60	3.21	5.74	
After 7, %	-6.12	-3.29	-5.15	2.52	
After 9, %	0.71	-16.21	-7.37	0.72	

$^{a.b}$Different superscripts in the same rows denote significant differences (P<0.05).
^{ns}Non significant

Table 5 showed that chopping sizes were not significantly effect on changing CF content of CPH fermented, however, there is a tendency that highest average changes of CF content occured in treatment A_2, followed by A_1, A_4 and the lowest was in treatment A_3. Fermentation time had effect on CF content changes of CPH. Crude fibre content after fermentation 9 days was significantly higher (P<0.05) than those of 5 and 7 days fermentations, while for 5 days fermentation was not significantly difference (P>0.05) with 7 days fermentation. Highest average changes of CF content found on 9

days fermentation, followed by 5 days fermentation and the lowest was 7 days fermentation. The highest changes of CF content occured in A_2 after 7 days fermentation which is reduced 9.08%.

Aspergillus include as cellulolitic fungi which could decompose CF in CPH media during fermentation process, which could decrease CF content, however, statistical analysis showed that there is no significant effect although the value of CF content was relatively different. In treatments A_3 and A_4 (bigger chopping sizes), the decrease of CF content was relatively low compared to smaller chopping sizes (A_2 and A_1). This condition could be related to fungi activity during fermentation. In both of A_3 and A_4, *A. niger* was not optimal to decompose CPH fibre but in A_2 and A_1, decomposing activity of CPH fibre is high. The drastically changes (decrease) of CF was occured in treatment A_2 after 7 days fermentation. Reducing CF content in this research was realtively higher than research done by Lateef et al. (2008) who found that the decrease was 7,20% on CPH fermented by fungi strain of *Rhizopus stolonifer* LAU 07 and addition of 20% sucrose. Reduction of CF content in this study was lower than study conducted by Guntoro et al. (2006) who found that CPH chopped in small size and fermented by *A. niger* on 5 days will reduce 38.19% CF content. The different value on the CF decrease might caused by chopping size, in this study the sizes was relatively bigger (1 x 5 cm) so the fungi was not optimal on decomposition process. Decreasing CF content of CPH was affected by enzime activity of Aspergillus. *A. niger* resulted on many enzimes were sucked such as mannase, cellulase and enzimes for carbohydrate degradation, these enzimes were usefull on fungi fermentation to decompose fibre (Wina, 2005).

Gas Production of CPH Fermented (In Vitro)

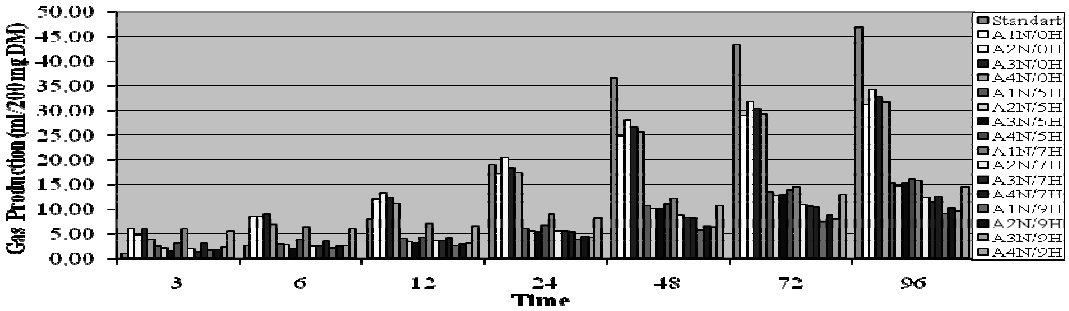

Figure 1. Gas Production of CPH fermented

Gas production (*in vitro*) of CPH fermented was increased from the first 3 up to 96 hours (Figure 1). It was indicated that degradation process of CPH by the *rumen* microbials was effective. In the first 3 hours observation showed that gas production of pongola grass (standart) was remain low, 0.95 ml/200 mg on DM, the lowest gas production of CPH for 5 days fermentation was in treatment A_3 (1.36 ml/200 mg), followed by A_2 (2.02 ml/200), A_1 (1.36), while the highest was A_4 (3.01). For 7 days fermentation, gas production was decreased, the lowest was in A_3 (1.34), followed A_2 (1.84) A_4 (2.97) and the highest was A_1 (6.05 ml/200 mg on DM). Gas production of CPH at 9 days fermentation tended to decrease, the lowest was A_1 (1.56), followed by A_2 (1.82), A_3 (2.25) and the highest was A_4 (5.51 ml/200 mg on DM).

At 96 hours, the highest gas producion of pangola grass was 47.04 ml/200 mg on DM, it caused by high activity of rumen microbials on degrading fibre, while the lowest gas production of CPH at 5 days fermentation was in A_2 (14.64), followed by A_3 (15.25), A_1 (15,36) while the highest was A_4 (16.06 ml/200 mg on DM). Gas production at 7 days fermentation was relatively lower than 5 days fermentation, the lowest was in A_3 (11.54), followed by A_2 (12.38), A_4 (12.62) and the highest was A_1 (15.36 ml/200 mg on DM). After 9 days fermentation, the lowest decrease of gas production was A_1 (9.10 ml/200), followed by A_3 (9.52), A_2 (10.12) and the highest was A_4 (14.50 ml/200 mg on DM). Chopping sizes and fermentation times had effect on CPH degradation process in goat *rumen* (*in vitro*). Figure 1 above showed that CPH fermented had low gas production, but pangola grass (standard) had high fiber degradation and gas production. The result of this study was in line with Teguia et al. (1999) who found that with gas production procedure (*in vitro*) using sheep rumen liquid

for observation of napier grass (*Pennisetum purpureum*) and leucaena (*Leucaena leucocephala*), high gas production (36.00 and 29.00 ml/200 mg on DM) were produced after 96 hours incubation.

The highest average of a+b fraction of CPH fermented was in A_4 (28.41 ml/200 mg on DM) but degradation processs of CPH in the rumen was relatively slow, it was about 0.013 ml/hour. In treatments A_2 and A_3, the average a+b fraction was lower, namely 22.43 and 22.18 ml/200 mg on DM, respectively, but it has faster degradation processs of CPH, 0.017 .and 0.016 ml/hour, respectively. This condition caused by big chopping sizes so that *A. niger* could not optimal on degrading fiber component of CPH during fermentation process, while in A_1 chopping size was smaller therefore *A. niger* could more degrade fibre component of CPH. The value of a+b and c fraction of CPH in this research was lower than previous research particularly in A_1, A_2 and A_3. Teguia et al. (1999) reported that value of a+b fraction of leucaena was 28.8 ml/200 mg on DM with value of c fraction was 0.0519 ml/hour in *in vitro* procedure using sheep rumen liquid. Those differences maybe caused by different fibre content, CPH fermented still had high component of fibre content compared to leucaena, low fibre content could accelerate degradation process to be faster than high fibre content.

Table 6. Degradation and rates (in ml/200 mg on DM) of CPH fermentation

	Chopping Sizes				Average
Fermentation Times, d	A_1	A_2	A_3	A_4	
Fraction of a (degradation)					
0	4.28	2.10	3.97	1.57	2.98
5	1.39	1.14	0.39	2.20	1.28
7	5.39	1.14	0.83	2.65	2.50
9	1.35	1.40	1.83	5.11	2.42
	3.10	1.45	1.76	2.88	
Average Fraction of b (degradation potential)					
0	29.98	33.01	31.32	31.89	31.55
5	21.51	21.34	23.03	23.26	22.29
7	16.41	15.01	12.68	29.46	18.39
9	16.31	14.55	14.67	17.48	15.75
	21.05	20.98	20.43	25.52	
Average Fraction of c (constant rate)					
0	0.024	0.033	0.026	0.029	0.028
5	0.011	0.011	0.011	0.010	0.011
7	0.011	0.014	0.019	0.004	0.012
9	0.007	0.009	0.008	0.008	0.008
	0.013	0.017	0.016	0.013	
Average Fraction of a+b (total of degradation)					
0	34.25	35.12	35.29	33.46	34.53
5	22.89	22.48	23.42	25.46	23.56
7	21.80	16.15	13.51	32.11	20.89
9	17.66	15.95	16.49	22.59	18.17
Average	24.15	22.43	22.18	28.41	

CONCLUSIONS

Chopping sizes and fermentation times had effect to changes chemical compositions and digestibility (degradation) of CPH. The highest changes of chemical compositions of DM, OM, CFt after fermentation were in A_1, followed A_2, A_3, while the lowest was A_4, highest CP was in A_2, followed A_1, A_3, while the lowest was A_4. The highest changes of chemical compositions found after fermentation 7 days, followed 9 and 5 days. Chopping sizes of total degradation (a+b) were the highest in non fermentation, followed by 5 days, 7 days and the lowest was 9 days fermentation.

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