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EVALUATION OF CHEMICAL COMPOSITION AND *IN VITRO* GAS PRODUCTION OF COTTONSEED AND ITS BY-PRODUCTS

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ABSTRACT

This study was conducted to determine chemical composition, *in vitro* gas production and post-incubation parameters of cottonseed (*Gossypium spp*) and its by-products. Cotton seed was processed using four different processing methods to produce four samples (treatments) i.e. raw cotton seed(A), parboiled cotton seed (B), roasted (C) and cotton seed cake (D). Rumen liquor was collected from experimental goats, filtrated, dispensed into the artificial rumen with addition of differently processed cotton seed meal and incubated for 24, 48 and 72 hours. All investigated chemical constituents did not vary in all treatments ($p>0.05$). Cumulative gas production over 24hrs of incubation varied significantly ($p<0.05$) in all the treatments. The result revealed after 24 hrs, that cotton seed cake had highest cumulative gas production, soluble and insoluble fraction, potential extent gas production, short chain fatty acids, organic matter digestibility, metabolizable energy and methane. Conclusively, there were similarities among the chemical compositions of the raw cottonseed and its by-products. It can be concluded from these findings, that cottonseed cake had higher crude protein; digestible or good fibre content, OMD, SCFA, and ME compared to other treatments. *In vitro* gas characteristics result indicated that roasted cottonseed could be regarded and/or defined as a high energy and protein concentrate for ruminant animals that would be expected to generate comparatively less greenhouse gas due to its high fat content. Considering OMD, SCFA, and ME, cottonseed cake proved to be a better feed for ruminants than the other treatments.

Keywords: Fibre fractions, proximate analysis, post-incubation parameters, *in- vitro*, cotton seed and cotton seed cake.

INTRODUCTION

A major problem facing ruminant producers in tropical areas is poor nutrition during the dry season; a time when pastures and crop residues are limiting in nutritional quality (Murphy and Colucci, 1999). Problems such as sickness and weight losses due to poor dietary profiles usually arise during this period (Ravhuhali et al., 2010). However, one of the possible solutions to the aforementioned problems facing farmers is the efficient conversion of feeds which are either inedible by man or surplus to requirements into animal products. In addition, conventional animal feeds are rapidly becoming more expensive due to the continual pressure on world feed resources by the ever increasing human population (Raji, 2009). Tropical plants and agricultural by-products represent an important fodder reserve for livestock in harsh conditions that can be used by grazing ruminants in periods of feed scarcity or drought.

Cotton is grown on every major continent and on West Indies and Pacific Basin islands. Cotton is considered the most prominent source of textile fibre in the world. It makes up

over 40% of the total fibre used in the world (USDA, 2002). The fuzzy or whole cottonseed which is the linted cottonseed remaining after ginning process for removing cotton fibers used in textile (NCPA, 2002) usually waste away without use.

Many agricultural crop residues are poorly digested by ruminants because of their high content of cell wall materials. Physical and chemical methods can be used to break down the lingo-cellulosic components of these crop residues for subsequent improvement of the feeding value. In attempt to feed ruminants with these products to possibly alleviate the problems of dry season, it is however necessary to assess the nutritive value of the cotton seed processed using different methods.

MATERIALS AND METHODS

Experimental sites

The experiment was conducted at the Ruminant Nutrition Laboratory, Department of Animal Science, University of Ibadan, Nigeria. The location lies on latitude 7º 27' N, longitude 3º 45' E and at altitude of 200-300m above sea level. The average annual rainfall was about 1250 mm with a mean temperature of 25 - 29ºC.

Experimental design and sample preparation

The study was designed in a randomized complete block design in which cottonseed was processed into four different treatments namely raw cottonseed (as control; A), parboiled cottonseed (B), roasted cottonseed (C) and cottonseed cake (D). Parboiled cottonseeds were obtained by soaking of raw cottonseeds in boiling water for 10 minutes while treatment C was obtained by roasting raw cottonseed in a frying pan. Cotton seed cake (D) was achieved through extraction of oil from the raw cottonseeds. The samples (A-D) were thereafter oven dried at 100^{o}C, and they were ground separately, using hand mill.

Chemical analysis

Proximate composition was determined according to the procedure of (AOAC, 2000). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL) were determined using the method of (Van Soest, 1991). Cellulose was taken as the difference between ADF and ADL while hemi-cellulose was calculated as the difference between NDF and ADF. *In vitro* gas production was determined following the procedure (Menke and Steingass, 1988). Organic matter digestibility (OMD) and Metabolizable energy (ME) were calculated following the procedure (Menke and Steingass, 1988) while SCFA was calculated as described by (Getachew et al., 2002). At the end of 24 hours of incubation, 4 ml NaOH was added to the substrate in each syringe to determine the methane production. Rates and extent of gas production were determined for each substrate from the linear equation:

$Y = a + b\ (1 - e^{-ct})$ described by (Orskov and MC Donald, 1979) where:

Y = volume of gas produced at time 't',

a = intercept (gas produced from the soluble fraction),

b = Potential gas production (ml/ g DM) from the insoluble fraction,

c = gas production rate constant (h^{-1}) for the insoluble fraction (b),

t = incubation time.

STATISTICAL ANALYSIS

All data collected were subjected to two-way analysis of variance (ANOVA) using (SAS, 1999) and means were separated using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical compositions of cottonseed and cottonseed by-products are presented in Table 1. All investigated chemical constituents did not significantly ($p>0.05$) vary across the treatments. Insignificantly higher CP content (24.72%) obtained for the cottonseed cake was lower than the results reported by (Jagadi et

al., 1987 and Addass et al., 2011). The CP contents was somewhat higher than that reported for wheat straw (5.2 %) (Chariya et al., 1997) while that of the by-products were similar to that reported for tall fescue and soybean stove and hulls (NRC, 1989). The CP of cottonseed cake (26.01%) obtained in this study was somewhat close to that reported for cottonseed short linter residue (30.20 %) and lies within the range reported for different varieties of cottonseed hulls (23.00 – 30.30 % DM) (Fadel, 1999 and Robinson et al., 2001). The CP values were higher than the recommended minimum requirement (6%) for ruminant animals in the tropics (NRC, 1984 and Humphreys, 1991). The CP contents of the cottonseed and cottonseed by-products in this study were higher than the minimum level of 7% required for optimum rumen function (Van Soest, 1994 and Norton, 1994). The EE contents (13.00-17.00%) of the cottonseed by-products obtained in this study were lower than the value reported for cottonseed short linter residue, delinted cottonseeds (Coppock, 1987), whole cottonseeds reported by (Sullivan, 1993 and NRC, 1984). The low fat contents can be associated to low quantity of lipids present in the cottonseeds and perhaps the differences in the varieties. Notwithstanding the treatments, the fibre constituents were all similar.

Table 1: Chemical compositions of raw cottonseed and its by-products.

Constituents (%)	A	B	C	D	SEM
DM	89.35	89.08	90.02	90.07	0.16
CP	18.38	24.07	24.72	26.91	0.15
EE	16.00	13.00	17.00	14.00	0.24
CF	24.00	25.00	27.00	14.00	0.25
ASH	6.00	5.00	6.00	8.00	0.16
NDF	58.00	67.00	55.00	38.00	0.10
ADF	28.00	43.00	27.00	22.00	0.07
ADL	12.00	16.00	10.00	6.00	0.01
HEM	30.00	24.00	28.00	18.00	0.18
CELL	16.00	27.00	17.00	16.00	0.27

[a b c]: means with the same row with the same superscripts did not vary significantly ($p>0.05$); A = Raw Cottonseed; B = Parboiled Cottonseed; C = Roasted Cottonseed; D = Cottonseed cake; SEM = Standard Error of Mean; DM = Dry matter; CP = Crude protein; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin; CELL = Cellulose; HEM = Hemicellulose

(Table 2 and figure 1) presents the cumulative gas production of the cottonseed and its by-products. Gas volumes were significantly different ($p<0.05$) in all the treatments. Digestibility has been reported to be synonymous to *in vitro* gas production (Fievez, 2004) so that high gas production interprets higher digestibility. Gas production has been reported to be more affected by digestible energy content (e.g., the presence of starch and sugars) than by protein or fat content (VanSoest, 1994). High degradable N compounds have been reported to decrease gas production to some extent (Krishnamoorthy et al., 1995) hence high CP contents of the cottonseed and its by-products can be linked to the low volume of gas produced throughout the incubation period. In the present study, a

higher digestibility was observed in cottonseed cake than for other by-products. Therefore, it can be speculated that cottonseed hull-associated protein of raw cottonseed (A), parboiled cottonseed (B) or roasted cottonseed (C) might not be a readily degraded form for rumen microorganisms. In addition, the low gas production of this study might be as a result of the short period of incubation, while the higher gas production in the cotton seed cake can be traced to the higher volume of gas produced from the soluble and insoluble fractions of the sample.

Table 2: *In vitro* gas production of raw cottonseed and its by-products after 24 hours of incubation

Time (hr)	A	B	C	D	SEM
3	2.67^{b}	3.00^{b}	2.33^{b}	6.00^{a}	0.46
6	4.00^{b}	3.67^{b}	3.33^{b}	7.67^{a}	0.55
9	5.33^{b}	5.33^{b}	3.67^{bc}	9.67^{a}	0.44
12	5.33^{b}	5.33^{b}	4.33^{b}	11.00^{a}	0.55
15	6.00^{b}	7.67^{b}	5.67^{b}	18.00^{a}	0.46
18	6.33^{b}	8.33^{b}	5.67^{b}	20.33^{a}	0.50
21	8.67^{b}	8.33^{b}	5.67^{b}	23.00^{a}	0.47
24	8.67^{b}	8.33^{b}	6.00^{c}	23.33^{a}	0.37

$^{a\ b\ c}$: means with the same row with the same superscripts are not significantly different ($p>0.05$); A = Raw Cottonseed; B = Parboiled Cottonseed; C = Roasted Cottonseed; D = Cottonseed cake; SEM = Standard Error of Mean

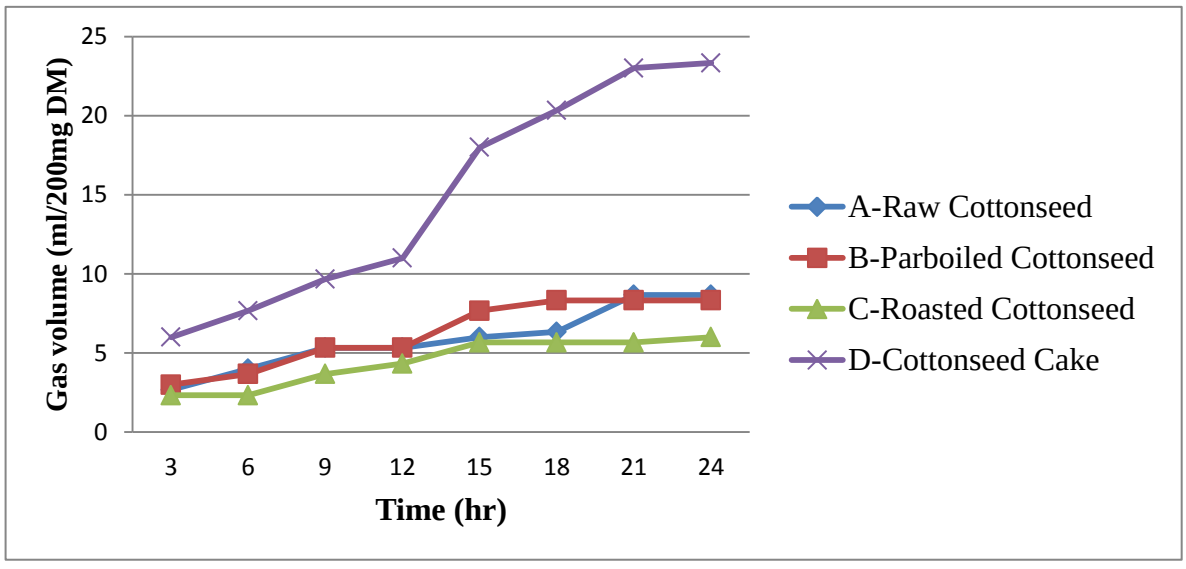


FIGURE 1: Trend of the cumulative *in vitro* gas production of the raw cottonseed and its by-products.

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In vitro gas production and post-incubation or gas production kinetics of cottonseed and its by-products are shown in Table 3. Results revealed that there were significant differences ($p<0.05$) in the post-incubation characteristics except the rate of gas production (c). Approximately 6% of dietary gross energy intake is lost into the atmosphere as CH_4 (Holter and Young, 1992 and De Ramus et al., 2003). This CH_4 in turn contributes to climatic change and global warming (Johnson and Johnson, 1995). Comparatively, higher and least CH_4 proportions were observed in treatment D and C respectively. Supplementation of whole cottonseed to dairy cows has been reported to reduce CH_4 emissions, which might be caused by an overall increase in dietary fat content (Dohme et al., 2001 and Grainger et al., 2010). Thus, the very high fat content of 17.00 (Table 1) could explain why a comparatively high depression of CH_4 would be obtained should the roasted cottonseed is used as a feed. The cottonseed cake produced the highest ME, OMD and SCFA contents of this study (Table 3).

Table 3: *In vitro* gas production and post-incubation characteristics of raw cottonseed and its by- products for 24 hours

Parameters	A	B	C	D	SEM
a (ml)	2.67^{b}	3.00^{b}	2.33^{b}	6.00^{a}	0.46
b (ml)	7.00^{b}	5.33^{bc}	3.67^{c}	17.33^{a}	0.41
a + b (ml)	9.67^{b}	8.33^{b}	6.00^{c}	23.33^{a}	0.37
c (hr^{-1})	0.07	0.09	0.09	0.08	0.01
t (hr)	12.00	11.00	9.00	15.00	1.53
Y (ml)	6.67^{b}	6.33^{b}	4.33^{b}	18.00^{a}	0.65
METHANE	5.00^{b}	5.00^{b}	0.00^{b}	12.00^{a}	0.41
ME (MJ/Kg DM)	4.63^{b}	4.78^{b}	4.50^{b}	6.95^{a}	0.09
OMD (%)	35.65^{b}	36.37^{b}	35.24^{b}	52.94^{a}	0.57
SCFA (µ mol)	0.29^{b}	0.26^{b}	0.20^{c}	0.62^{a}	0.02

$^{a\ b\ c}$: means on the same row with different superscripts varied significantly ($p<0.05$); A = Raw Cottonseed; B = Parboiled Cottonseed; C = Roasted Cottonseed; D = Cottonseed cake; SEM = Standard Error of Mean; a = Intercept (gas production from the soluble fraction); b = the gas production from the insoluble fraction; c = the gas production rate constant per insoluble fraction (b); t = incubation time; (a + b) = the potential extent of gas production; Y = volume of gas produced at time 't'.

CONCLUSIONS

There were similarities among the chemical compositions of the raw cottonseed and its by-products. It can be concluded from these findings, that cottonseed cake had higher crude protein; digestible or good fibre content, OMD, SCFA, and ME compared to other treatments. *In vitro* gas characteristics result indicated that roasted cottonseed could be regarded and/or defined as a high energy and protein concentrate for ruminant animals that would be expected to generate comparatively less greenhouse gas due to its high fat content. Considering OMD, SCFA, and ME, cottonseed cake proved to better feed for ruminants than other treatments.

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