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EFFECTS OF DIETARY SUPPLEMENTATION OF *CASSIA FISTULA* LEAF POWDER ON NUTRIENT DIGESTIBILITY, RUMEN FERMENTATION AND BLOOD PARAMETERS OF GROWING WEST AFRICAN DWARF GOATS

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ABSTRACT

This study investigated the effects of dietary supplementation of *Cassia fistula* leaf powder (CFLP) on nutrient digestibility, rumen fermentation and blood parameters of West African Dwarf (WAD) goats. Fifteen WAD bucks were assigned to three dietary treatments in a completely randomized design with five goats per treatment. Animals were fed guinea grass hay and concentrate in ratio 60:40 daily, on dry matter (DM) basis. The concentrate contained CFLP at 0, 15 and 30 g/kg DM. Nutrient digestibility, rumen fermentation and blood parameters were determined. Goats fed 30 g/kg CFLP diet had the highest crude protein digestibility (69.34%). The goats fed diet without CFLP, voided more nitrogen (5.42 g/day) while more nitrogen was absorbed and retained in those on 30 g/kg CFLP diet. Rumen temperature, pH and volatile fatty acid concentration were similar ($P>0.05$) across treatments. Ruminal ammonia nitrogen decreased ($P<0.05$) with CFLP. Goats offered 30 g/kg CFLP recorded the highest haemoglobin concentration and least creatinine level. Lymphocytes level was higher in goats fed 0 and 15 g/kg CFLP diets. In conclusion, *Cassia fistula* leaf powder can be included at 30 g/kg DM in WAD goats' diet to improve nutrient utilization efficiency without detrimental effects on their health.

Keywords: *Cassia fistula, Medicinal plant, Phytochemicals, Nutrient utilization, Intake, Goats*

INTRODUCTION

Improving the efficiency of feed utilization through manipulation of rumen fermentation with the use of medicinal plants is important for efficient production of farm animals with minimal negative environmental impact (Wang and Wang, 2016; Yusuf *et al*., 2017). A common practice worldwide is the use of chemical feed additives such as ionophores, enzymes, organic acids to modify rumen fermentation for improved animal performance (Quinn *et al*., 2009). However, increasing public concerns over the spread of antibiotics resistance, in form of bacteria pathogens and antibiotic residues in animal products, which pose threat to public health has led to its ban in many countries. Therefore, there is increasing efforts on the search for natural feed additives, for enhancing nutrient utilization and improved production of livestock, without detrimental effects on animal health. Recently, plant bioactive compounds such as tannins, saponin, alkaloids and essential oils have gained much attention by researchers due to their potential role as alternative to growth promoting antibiotics (Panthee *et al*., 2017; Chanu *et al*., 2020). Furthermore, using medicinal herbs in animal ration averts the hazard involved with the use of chemical additives (EI-Kholany *et al*., 2015).

Beneficial effects of supplementing diets with natural or medicinal plant parts on feed intake, rumen fermentation and productivity of large and small ruminants have been reported in many studies. One of the studies showed that inclusion of 2 and 4% *Cistanche deserticola* improved nutrient intake, apparent nutrient digestibility and nitrogen utilization in male

sheep (Liu *et al*., 2020). Another experiment indicated that dried kratom leaves enhanced rumen fermentation by increasing digestibility in goats (Chanjula *et al*., 2022). The use of natural herbs to reduce environmental pollutants such as methane and ammonia generated from livestock production have been evaluated, for instance, blend of eucalyptus oil and Mulethi root extract reduced the rate of ruminal ammonia production without affecting feed digestion. The efficacy of plant bioactive compounds present in these natural herbs were responsible for the success recorded by various authors; essential oils inhibited the breakdown of proteins in the rumen, thus enhancing availability of proteins to ruminants (McIntosh *et al*., 2003). Reduction of ruminal ammonia and methane production through suppression of protozoa by saponin present in some plants has also been reported (Patra *et al*., 2006). In addition, tannins protect protein degradation in the rumen by binding to protein and thus making it available in the abomasum for better utilization (Carulla *et al*., 2005). However, the effect of the various bioactive compounds depends on the types and concentration in the diets.

The West African dwarf goat is the most important and commonest indigenous goat breed in Central and West Africa accounting for about 30% of African's ruminant livestock with production of meat and milk of about 17% and 12% respectively (Wilson, 1991). They are extremely crucial in the economy of the rural village, especially small-holder livestock owners in West Africa. Most of these animals are fed low quality feed as their owners may not afford to supplement their diet with concentrate due to its high cost. Therefore, strategies that will improve the nutrient utilization efficiency without negative environmental impact will go a long way in increasing the animal productivity. Numerous studies have been carried out in this regard with the use of different medicinal plants (Liu *et al*., 2020). Meanwhile, there is still continuous search by animal nutritionist for more natural plants as alternative to chemical additives to improve animal performance and better the environment. The use of *Cassia fistula* leaf powder to modulate rumen fermentation and subsequent effects on nutrient digestibility and blood profile have not been studied.

Cassia fistula generally known as "golden flower" in English is one of the most commonly used plant in traditional herbal medicine in Africa and in many Asian countries. The plant parts (stem, fruits, leaves and bark) contain a variety of biologically active compounds such as flavonoids, anthraquinones, flavon-3-0 derivatives, tannins, saponin, alkaloids and glycosides (Ali, 2014). It has been reported that *Cassia fistula* plant possess antioxidant, hepatoprotective, antibacterial and laxative properties (Abo *et al*., 1999; Duraipandiyana and Ignacimuthu, 2007; Awal *et al*., 2010). The plant is common in this region and is widely distributed in substantial parts of the world which make it readily available for usage. Phytochemical and pharmacological properties of *Cassia fistula* have been reported (Ali, 2014). Despite its abundant bioactive compounds, many studies on it were conducted using mice (Malpani *et al*., 2010) with limited information on its usage in ruminants. Whereas, most of the phytochemicals present in this plant are useful for manipulating the rumen fermentation for better nutrient utilization and enhanced animal productivity. Therefore, *Cassia fistula* leaves was chosen as potential herbal feed additive to study its effects on feed intake, nutrient digestibility, rumen fermentation and blood profile of West African dwarf goats. This study therefore, investigated the dietary effects of *Cassia fistula* leaf powder on nutrient digestibility, fermentation and haematological parameters of West African dwarf goats.

MATERIALS AND METHODS

Preparation of ingredients

Fresh *Cassia fistula* leaves were harvested manually from different parts of the trees (to

obtain both young and mature leaves) at the premises of Federal University of Agriculture, Abeokuta Nigeria on October, 2020. The leaves were air dried under a ventilated shade for a period of 7 days, then milled to pass through 1 mm sieve to obtained *Cassia fistula* leaf powder which was thereafter stored in air tight containers and kept in a cool dry cabinet pending analysis. Fresh guinea grass (*Megathyrsus maximus*) of about 12 weeks old was harvested by cutting 15 cm above the ground level, chopped into 2-4 cm and sun dried for 6 days to form guinea grass hay which was later kept in jute bags under a shade prior to usage.

Experimental animals, diets and design

Fifteen male West African dwarf goats (10 ± 1.50 kg of BW) were randomly assigned to three dietary treatments with 5 goats per treatment group in a completely randomized design for a digestibility study that lasted for 21 days comprising of 14 days feed adaptation and 7 days sample collection periods. Goats were kept individually in disinfected and well ventilated metabolic cages. Three experimental diets were formulated to contain *Cassia fistula* leaf powder (CFLP) at 0, 15 and 30 g/kgDM. The three levels of CFLP were picked based on the preliminary *in vitro* studies earlier carried out. Each animal was fed guinea grass hay at 8.00 am and concentrate diet at 4.00 pm (forage: concentrate ratio of 60:40 on DM basis) on daily basis with *ad libitum* access to clean water. Feed intake was recorded and orts were weighed daily. Samples of the feeds and orts were collected from 14 to 21 days of experimental period and analyzed for dry matter by drying to constant weight in a forced-air oven at 65°C for 48 hours (AOAC, 2005). Samples were pooled for each goat and kept at -20°C pending analysis. *Cassia fistula* leaves were also oven dried and DM determined (AOAC, 2005). Dried Cassia leaves was equally stored at -20°C for further analysis. The ingredients and chemical composition of the experimental diets are presented in Table 1.

Table 1: Gross composition (g/kg) of concentrate diets

Ingredients	CF0	CF15	CF30
Wheat offal	490.00	490.00	49.00
Maize bran	280.00	280.00	280.00
Palm kernel cake	200.00	200.00	200.00
Bone meal	15.00	15.00	15.00
Premix	5.00	5.00	5.00
Salt	10.00	10.00	10.00
Total	1000.00	1000.00	1000.00
Cassia fistula leaf powder (CFLP) (g/kg DM)	-	+	++

0 g/kg DM CFLP (-), 15 g/kg DM CFLP (+), 30 g/kg DM CFLP (++)

Sample collection

For the last 7 days of the study, faecal output of each goat was collected daily, thoroughly mixed and weighed. A 10% aliquot was analysed for DM by drying to constant weight in a forced-air oven at 65^0C (AOAC, 2005). Dried faecal sample of each goat was pooled at -20°C for further chemical analysis. Urine samples were

also collected from each animal daily into plastic containers with 2 mL of 10% H_2SO_4 to prevent N losses. Total daily urine output was measured and recorded. A 10% aliquot was taken, pooled for each goat and stored at -20°C pending analysis. On the last day of the digestibility study (day 21), rumen fluid (100 mL) was collected from each animal. The pH and temperature of the rumen fluid were measured immediately using pH meter (pH, 200 model) and the rumen content was filtered through four layers of cheesecloth. A 50 mL aliquot of the rumen fluid was frozen at -20°C for subsequent determination of total volatile fatty acid concentration. Another 50 mL aliquot of the rumen fluid was acidified with 2.5 mL HCl and frozen at -20°C for later determination of ammonia nitrogen concentration. A 10 mL blood sample was collected from each animal at the same time as ruminal sampling through jugular venipucture, 5 mL of the blood was dropped into vacutainer tubes containing EDTA. The remaining 5 mL was dropped in tubes that were anti-coagulant free and was centrifuged at 4000 rpm for 20 minutes after which the blood serum was separated and preserved in clean and sterile plastic tube at -18°C.

Sample analysis

At the end of the experiment, stored *Cassia fistula* leaves, feed, orts and faecal samples were thawed and later dried in an oven at 65°C for 48 hours before being milled and made to pass through 1 mm screen. Samples were analysed for crude protein, ash and ether extract according to AOAC (2005). Neutral detergent fibre and acid detergent fibre of the samples were determined according to Van Soest *et al*. (1991). Flavonoids content of *Cassia fistula* leaves was determined according to Nasseri *et al*. (2019). Tannins and total phenol contents were determined according to Makkar (2003) and Do *et al*. (2014) respectively while saponin and alkaloids were determined using the methods by Mir *et al*. (2016). Stored urine samples were thawed and analysed for nitrogen according to AOAC (2005) after which nitrogen retention was calculated.

Total volatile fatty acids concentration was determined from stored rumen fluid using Markham apparatus as described by Barnett and Reid (1956). Briefly, two millilitres (2 mL) of rumen fluid was added to the mixture of 1 mL Potassium oxalate buffer (10%) and 1 mL oxalic acid. The final mixture was then injected into Markham apparatus and 100 mL distillate collected was subsequently titrated against a standard 0.01N NaOH with phenolphthalein (2 drops) as indicator. Concentration of total volatile fatty acids was then calculated. Determination of ammonia nitrogen concentration was done by steam distillation procedures of Ogubai and Sereke (1997).

The blood samples stored in EDTA tubes was used for the determination of haematological components such as packed cell volume, haemoglobin, red blood cell, white blood cell, lymphocytes and neutrophil as described by Dacie and Levis (2001). Serum total protein, serum urea, glucose, albumin and creatinine were determined according to Wermer *et al*. (1970).

Calculations and statistical analysis

Apparent digestibility of nutrient (digestibility %) and concentration of total volatile fatty acids (TVFA) were calculated as thus:

$$\text{Digestibility (\%)} = \text{Nutrient consumed (g/day)} - \frac{\text{nutrient excreted (g/day)} \times 100}{\text{Nutrient consumed (g/day)}}$$

$$\text{TVFA (mM)} = \frac{\text{(volume of NaOH x NaOH normality x 1000)}}{\text{Rumen fluid volume}}$$

Data on feed intake, nutrient digestibility, rumen fermentation, haematological and serum parameters were subjected to one-way ANOVA using SPSS statistical package version 23.0 and means were compared using Duncan's multiple

range test with significant data accepted at $P < 0.05$. The model for the experiment is as follows:

$Y_{ij} = \mu + T_i + \xi_{ij}$,

where Y_{ij} is the observation on treatments, μ is the overall mean, T_i is the treatment effect of CFLP, and ξ_{ij} is the random error.

RESULTS AND DISCUSSION

Chemical composition of *Cassia fistula* leaf and experimental diets used in the study is presented in Table 2 while Table 3 shows the nutrient intake and digestibility of West African goats fed the experimental diets. Dietary supplementation of *Cassia fistula* leaf powder (CFLP) did not affect ($P>0.05$) the total dry matter and crude protein intake of the animals. This shows that CFLP did not negatively affect animals' acceptability and palatability of the feed. Tannins higher than 4% may affect feed utilization by reducing palatability and hence depressed intake and animal productivity (Barman, 2004). Yusuf *et al*. (2017) and Wang *et al*. (2018) observed no changes in feed intake when goats and sheep feeds were supplemented with *Andrographis paniculata* plant and *Corylus avellana* leaves respectively. However, the nutrient intakes by animals in this study were sufficient to meet the nutrient requirement of goats as reported by NRC (2007).

No significant differences ($P>0.05$) were observed in the apparent nutrient digestibility of dry matter, ether extract, ash, neutral detergent fibre and acid detergent fibre across the treatments. Apparent crude protein digestibility was affected ($P <0.05$) by CFLP supplementation with highest value (69.34%) recorded in animals fed 30 g/kg CFLP while those on control diet had the least value (57.17%). Similar observation was reported by Wanapat *et al*. (2013) when diet of beef cattle was supplemented with plant herb combinations (lemongrass, peppermint and garlic). However, Yusuf *et al*. (2017) obtained enhanced DM, NDF and ADF digestibility in goats with dietary supplementation of leaf and whole plant of *Andrographis paniculata* while Singh *et al*. (2011) recorded decreased nutrient digestibility when goats were fed *Ficus infectoria* leaves supplemented diet. Meanwhile, increased crude protein digestibility with CFLP supplementation in this study could be attributed to the presence of tannin and other phytochemicals in CFLP which could have stimulated some digestive enzymes or proteolytic enzymes. Tannins have high affinity for binding with macro nutrients such as carbohydrates and protein which reduce their digestibility in the rumen but makes them available at specific sites along the gastro-intestinal tracts. Differences in observations by various authors could be ascribed to the differences in the phytochemical composition of the various medicinal plant parts used which greatly vary within species, between species, maturity stages, location and season (Mehansho *et al*., 1987).

Table 2: Chemical composition (g/kg) of experimental feed materials

Parameters	Guinea grass hay	Concentrate	*Cassia fistula* leaf
Organic matter	887.00	943.00	921.00
Dry matter	824.00	913.00	948.00
Crude protein	68.00	135.00	163.00
Ether extract	16.00	79.00	71.00
Crude fibre	301.00	12.00	286.00
NDF	690.00	284.00	677.00
ADF	405.00	210.00	385.00
Alkaloids	-	-	34.00
Saponin	-	-	102.00
Tannin (mg/100g)	-	-	386.49
Phenol (mg/100g)	-	-	286.48
Flavonoids (mg/100g)	-	-	392.20
Calcium (%)	-	-	2.89
Phosphorous (%)	-	-	1.97
Iron (%)	-	-	0.04
Manganese(%)	-	-	0.01

Table 3: Intake and nutrient digestibility of West African dwarf goats fed diets containing Cassia Fistula leaf powder

	Levels of CFLP (g/kg DM)			
Items	**0**	**15**	**30**	**SEM**
Dry matter intake (g/day)				
Panicum hay	295.33	290.04	286.41	4.38
Concentrate	176.55	179.20	180.18	2.43
Total	472.08	469.24	466.59	4.14
Crude protein intake (g/day)				
Panicum hay	28.78	28.25	27.89	0.43
Concentrate	23.83	24.17	24.31	0.30
Total	52.61	52.43	52.20	0.42
Nutrient digestibility (%)				
Dry matter	69.59	71.15	71.81	0.47
Crude protein	57.17^{c}	64.72^{b}	69.34^{a}	2.54
Ether extract	67.75	65.70	66.38	0.59
Ash	66.62	69.47	68.88	1.00
Neutral detergent fibre	60.98	59.22	56.94	0.67
Acid detergent fibre	42.65	39.70	39.90	1.25

^{abc}Means on the same row having different superscripts are statistically different ($p < 0.05$), CFLP: Cassia fistula leaf powder

Nitrogen balance and rumen fermentation parameters of West African dwarf goats fed diet supplemented with *Cassia fistula* leaf powder is presented in Table 4. Nitrogen intake of all animals was similar ($P > 0.05$) among the treatment groups. Animals on 0 g/kg DM CFLP

recorded highest (P < 0.05) faecal nitrogen (2.71 g/day) content. Urinary nitrogen was higher but similar (P>0.05) in those fed diets with 0 g/kg and 15 g/kg DM CFLP. Total nitrogen was greater in animals fed diet with 0 g/kg DM CFLP (5.42 g/day) and lowest in those on 30 g/kg DM CFLP diet (3.35 g/day). Higher nitrogen was absorbed by animals on CFLP supplementary diets. Animals on 30 g/kg DM CFLP diet retained the highest nitrogen (5.01 g/day) while those on control diet had the least. Nitrogen retained as percentage nitrogen intake followed the same trend. Similar nitrogen intake observed in all animals may be due to the fact that CFLP supplemented diets had no effect on the total dry matter and crude protein intake of animals. Wanapat *et al*. (2013) and Chanjula *et al*. (2022) also observed no changes in nitrogen intake when diets were supplemented with herb combination and dried kratom leaves respectively. Meanwhile, Panthee *et al*. (2017) reported increased nitrogen intake when diet of sheep was supplemented with freeze dried garlic leaves. Lower faecal nitrogen recorded in CFLP supplemented diets may be due to higher crude protein digestibility in CFLP diets compared to control diet.

Table 4: Nitrogen balance and rumen fermentation parameters of West African dwarf goats fed diets supplemented with *Cassia fistula* leaf powder

	Levels of CFLP (g/kgDM)				
Parameters	**0**	**15**	**30**	**SEM**	**P-values**
Nitrogen balance (g/day)					
Nitrogen intake	8.24	8.39	8.35	0.68	0.724
Faecal nitrogen	2.71^{a}	2.12^{b}	1.73^{c}	0.15	0.002
Urinary nitrogen	2.73^{a}	2.31^{a}	1.62^{b}	0.17	0.002
Total nitrogen voided	5.44^{a}	4.43^{b}	3.35^{c}	0.30	<0.001
Nitrogen absorbed	5.54^{b}	6.27^{a}	6.63^{a}	0.17	0.002
Nitrogen retained	2.80^{c}	3.95^{b}	5.01^{a}	0.33	<0.001
% nitrogen retained/N intake	33.98^{c}	47.19^{b}	59.92^{a}	3.79	<0.001
Rumen fermentation parameters					
Temperature (^{o}C)	39.67	39.27	39.57	0.12	0.438
pH	6.73	6.66	6.67	0.09	0.370
Total volatile fatty acids (mM)	110.00	107.00	112.50	1.89	0.557
Ammonia nitrogen (mg/dL)	23.94^{a}	18.38^{b}	17.24^{b}	1.16	0.008

^{abc}*Means on the same row having different superscripts are statistically different (p < 0.05), CFLP: Cassia fistula leaf powder*

The reduction in urinary nitrogen in animals on CFLP supplementation agrees with the findings of Chanjula *et al*. (2022) and it could be a means of reducing volatile nitrogen emission to the environment since ammonia produced from hydrolysis of urea is easily volatilized and lost to the environment. Increased nitrogen absorption and retention at 30 g/kg DM CFLP supplementation might be due to higher crude protein digestibility of this diet. Abdu *et al*. (2012) also noted that nitrogen retention depends on good digestibility of nutrient. Nitrogen retention is the most important indicator for evaluating status of protein metabolism in ruminants (Phesatcha *et al*., 2017). Therefore, reduced nitrogen excretion and higher nitrogen retention at 30g/kg CFLP supplementation could be an indication of better protein metabolism, availability and utilization by the animals.

There was no significant difference (P > 0.05) in the rumen temperature, pH and total volatile fatty acids (TVFAs) concentration of all animals under observation. Values of TVFAs recorded ranged from 107.00 mM in animals placed on 15 g/kg DM CFLP to 112 mM in those on 30 g/kg DM CFLP diet. Rumen pH and temperature are critical for efficient fermentation in the rumen by the activities of microorganisms. Similar rumen pH and temperature obtained in all the treatment groups were normal for efficient fermentation process in the rumen (Gunun *et al*., 2016; Dijkstra *et al*., 2012). The results are in agreement with other studies where rumen pH was unaffected by addition of *Ficus infectoria* leaves (Singh *et al*., 2011), freeze dried garlic leaves (Panthee *et al*., 2017) and dried kratom leaves (Chanjula *et al*., 2022) to ruminant diet. Volatile fatty acids is the main source of energy from rumen fermentation in ruminants (Bergman, 1990) as they supply over 70% of ruminant energy and its concentration in the rumen shows animal feeding efficiency. Similar total volatile fatty acids concentration observed in this study shows that, addition of CFLP to diet of goat did not have negative effect on carbohydrate fermentation. In addition, values obtained were within the normal range as reported by McDonald *et al*. (1996). Similarly, Yusuf *et al*. (2017) and Chanjula *et al*. (2022) did not find changes in total volatile fatty acids concentration of animals when fed medicinal plant parts.

Ammonia nitrogen concentration decreased significantly (P < 0.05) with CFLP supplementation. This might be due to the content of phenolic compounds such as tannins and saponin in CFLP which might have formed tannin-protein complex thereby reducing protein degradation in the rumen and hence decreased ammonia nitrogen concentration. This is reflected in the pH values though not significant but tends to reduce in CFLP supplemented diets compared to the control. Decreased ammonia nitrogen concentration had been demonstrated by Min *et al*. (2002) when fed condensed tannin from *Lotus corniculatus* to sheep and by Pen *et al*. (2006) with supplementation of saponin rich *Yucca schidigera* extract in a continuous incubation system. Similarly, reduction in ammonia nitrogen concentration has been observed in Marwari rams fed herb supplemented wheat straw based diet (Manju *et al*., 2019). Singh *et al*. (2011) attributed decreased ammonia nitrogen concentration to reduction in proteolytic activity in the rumen of pakar leaves fed animals while Chanu *et al*. (2020) ascribed it to direct inhibition of HAB (hyper ammonia producing bacteria) by additive blends of eucalyptus oil and mulethi extract. HAB are lower in number compared to other rumen microbes but they produce ammonia at a much faster rate. Aside these, concentration of ammonia nitrogen in the rumen is also influenced by the rate of its incorporation into microbial protein synthesis, degradation of nitrogen in the ingested feed and absorption rate by the rumen wall (Oosting, 1993). However, the range of ammonia nitrogen concentration observed in the current study is higher than the minimum of 5 mg/dL needed for microbial protein synthesis and similar to the range of 10 – 20 mg/dL reported by Leng (1990) for optimum fibre degradation in the rumen. Ruminal ammonia nitrogen serves as indicator for effective microbial activities in the rumen since it is a major source of nitrogen for microbial protein synthesis.

The effect of diets supplemented with *Cassia fistula* leaf powder on haematological and serum biochemical parameters in West African dwarf goats is presented in Table 5. Diets supplemented with *Cassia fistula* leaf powder had no effect (P>0.05) on packed cell volume, red blood cell and neutrophil of animals monitored. Goats fed diet with 30 g/kg CFLP had the highest haemoglobin concentration (10.08 g/dL) compared with other two treatments. White blood cell was higher in animals fed 0 g/kg DM CFLP which was similar (P>0.05) to those on 15 g/kg DM CFLP diet but

different (P<0.05) from animals fed 30 g/kg CFLP diet. Lymphocytes were more in goats fed 0 g/kg and 15 g/kg CFLP compared to those placed on 30 g/kg CFLP diet. However, the PCV and RBC in all the treatment groups fell within the range reported by Jiwuba *et al*. (2021) for goats fed phytogenic plant parts and was within the normal range reported by Radostits *et al*. (2006). Though, haemoglobin differed significantly across treatments but the values was normal for healthy goats (8.0 – 12.0 g/dl) as stated by Radostits *et al*. (2006). This is indicating absence of anaemia caused by iron deficiency and improper utilization of iron for the formation of haemoglobin. The major roles of white blood cells and its differential are to defend the body against foreign organisms and to produce and distribute antibodies for immunity response. The normal range of WBC for a healthy goat is 4.0- 13.0 X 10^9/L (Radostits *et al*., 2006) which is comparable with values obtained in this study. Low white blood cell count exposed animals to high risk of infection while high WBC count enables generation of antibodies and hence high degree of disease resistance (Soetan *et al*., 2013) which is good for adaptability to disease prevalent areas or conditions (Kabir *et al*., 2011). According to the findings by Olafadehan *et al*. (2010), haemopoietic tissue in animals were depressed by toxic substances in feed, leading to low WBC count. The normal WBC obtained in this study, demonstrates that supplementation of goats' diet with CFLP had no detrimental effects on their immune system. Lymphocytes and neutrophils play critical roles in the development of acquired immunity and killing of invading pathogens respectively. Interestingly, values obtained for lymphocytes and neutrophil counts in this study were within the normal range (47 -82% and 17-52% respectively) for healthy West African dwarf goats (Daramola *et al*., 2005), indicating that supplementing up to 30 g/kg CFLP in the diet of goats was not harmful.

Table 5: Haematological and serum biochemical parameters of West African dwarf goats fed diets containing *Cassia fistula* leaf powder

Items	Levels of CFLP (g/kgDM)					
	CF0	CF15	CF30	SEM	P-values	Reference values
Haematological parameters						
Packed cell volume (%)	36.00	34.00	36.00	0.38	0.095	22 – 38
Haemoglobin (g/dL)	8.12^b	8.50^b	10.08^a	0.33	0.005	8.0 – 12.0
Red blood cell (x 10^{12}/L	12.00	12.00	13.35	0.33	0.163	8.0 – 18.0
White blood cell (x 10^9/L)	10.00^a	7.60^{ab}	5.60^b	0.76	0.026	4.0 – 13.0
Lymphocytes (%)	61.67^a	59.50^a	56.00^b	0.88	0.002	47.0 – 82.0
Neutrophil (%)	39.67`	37.50	37.00	0.54	0.081	17.0 – 52.0
Serum biochemical parameters						
Total protein (g/l)	64.33	65.67	67.67	1.31	0.642	64.0 – 70.0
Albumin (g/l)	34.00	33.00	38.33	2.35	0.679	27.0 – 39.0
Globulin (g/l)	30.33	32.67	29.33	1.82	0.796	27.0 – 41.0
Urea (mg/dl)	15.56	13.70	13.50	1.26	0.100	10.0 – 20.0
Creatinine (µmol/l)	106.00^a	95.33^{ab}	88.67^b	2.98	0.023	88.4 – 159.0

^{ab}Means on the same row having different superscripts are statistically different (P < 0.05),
CFLP: Cassia fistula leaf powder

All serum parameters measured were similar (P>0.05) across the treatment groups except creatinine which was higher (106.0 µmol/l) in the control diet and least (88.67 µmol/l) in diet with 30 g/kg CFLP. Total protein values obtained in the current study were comparable with the range of 61 – 74.5 g/l reported by Fraser and Mays (1986). However, the values were lower than 7.48 g/dl reported by Zubcic (2001) and 9.8 g/dl by Ibrahim *et al*. (2005). Age, breed and feed of these goats might be responsible for the differences observed. Meanwhile, the values observed fell within the range (6.4 – 7.0 g/dl) reported for clinically healthy goats by Dhanotiya (2004) indicating a tolerable level of the phytochemicals in the diet which could have caused disruption in nutrient absorption process along the gastrointestinal tract of the goats. Also, the results of albumin and globulin were within the normal range of 2.7 – 3.9 g/dl and 2.7 – 4.1 g/d respectively noted by Dhanotiya (2004). The serum urea values obtained, compared favourably with that reported by Jiwuba *et al*. (2021) for WAD goats fed phytogenic plant parts and was within the range of 10 – 20 mg/dl noted by Kaneko *et al*. (1997) for healthy goats. This indicated that the protein consumed by the animals might have been used for amino acid synthesis which could have led to normal release of urea in the serum. The creatinine levels of all animals in this study also follow the normal trend for healthy goats as reported by some authors (Kaneko *et al*., 1997; Jiwuba *et al*., 2021). This showed that the kidneys of all the experimental animals functioned effectively.

CONCLUSION

Dietary supplementation of CFLP had no effect on total voluntary intake of animals but improved the crude protein digestibility. Ruminal ammonia nitrogen concentration decreased with CFLP supplementation without affecting other rumen fermentation parameters such as pH and total volatile fatty acids concentration. Considering the increase in the trend of utilizing medicinal natural plant to manipulate rumen fermentation, inclusion of up to 30 g/kg DM *Cassia fistula* leaf powder in the diet of goats is a way of improving the nutrient utilization efficiency as evident in the N utilization aspect of this work without detrimental effects on animal health.

REFERENCES

Abdu, S. B., Ehoche, O. W., Adamu, A.M., Bawa, G.S., Hassan, M. R., Yashim, S. M and Adamu, H. Y. (2012). Effect of varying levels of *Zizyphus mauritiana* leaf Meal inclusion in Concentrate diet on performance of growing Yankasa Ram lambs fed maize stover basal diet. *Iranian Journal of Applied Animal Science* 2 (4) 253-256

Abo, K. A., Lasaki, S. W. and Deyemi, A. A. (1999). Laxative and antimicrobial properties of Cassia species growing in Ibadan. *Nigerian Journal of Natural Products and Medicine*, 3: 47-50

Ali, M. A. (2014). *Cassia fistula* Linn: a review of phytochemical and pharmacological studies. *International Journal of Pharmaceutical Sciences and Research*, 5(6): 2125

AOAC. (2005). Official Method of Analysis. 15th edition. Association of Official Analytical Chemists, Washington, DC.

Awal, M. A., Ahsan, S. M., Haque, E. Asghor, Q.H. and Ahmed M. (2010). *In-vitro* Antibacterial Activity of Leaf and Root Extract of *Cassia fistula*, *Dinajpur medical College Journal* 3: 10-13

Barnett, J. G. A. and Reid, R. L. (1956). Studies on the production of volatile fatty acids from the grass by rumen liquor in an

artificial rumen. *Journal of Agricultural Science* 48, 315–321

Bergman, E. (1990). Energy contributions of volatile fatty acids from the gastrointestinal tract in various species. *Physiological Review*, 70, 567–590

Barman, K. (2004). Biodegradation of tanniniferous feeds and their influence on nutrient utilization and productivity of the dairy animals (Doctoral dissertation, National Dairy Research Institute; Karnal)

Carulla, J. E., Kreuzer, M., Machmüller, A. and Hess, H. D. (2005). Supplementation of Acacia mearnsii tannins decreases methanogenesis and urinary nitrogen in forage-fed sheep. *Australian Journal of Agricultural Research*, 56, 961–970.

Chanjula, P. Wungsintaweekul, J., Chiarawipa, R., Rugkong, A. Khonkhaeng, B. Suntara, C. Cherdthong, A. (2022). Effect of Feed Supplement Containing Dried Kratom Leaves on Apparent Digestibility, Rumen Fermentation, Serum Antioxidants, Hematology and Nitrogen Balance in Goats. *Fermentation*, 8, 131.

Chanu, Y. M., Paul, S. S., Dey A. and Dahiya, S. S. (2020). Reducing Ruminal Ammonia Production With Improvement in Feed Utilization Efficiency and Performance of Murrah Buffalo (*Bubalus bubalis*) Through Dietary Supplementation of Plant-Based Feed Additive Blend. *Frontiers in Veterinary Science*, 7:464.

Dacie, J. V. and Lewis, S. M. (2001). Practical haematology 9th ed. Churchhill Livingstone, London, pp.633

Daramola, J. O., Adeloye, A. A., Fatoba, T. A. and Soladoye, A. O. (2005). Haematological and biochemical parameters of West African Dwarf goats. Livestock Research for Rural Development, 17(8)

Dhanotiya S. R. (2004). Text Book of Veterinary Biochemistry, College of Veterinary Science and Animal Husbandry, India, 448.

Dijkstra, J., Ellis, J.L., Kebreab, E., Strathe, A. B., López, S. and France J. (2012). Ruminal pH regulation and nutritional consequences of low pH. *Animal Feed Science Technology*. 172:22–33.

Do, Q. D., Angkawijaya, A. E., Tran-Nguyen, P. L., Huynh, L. H., Soetaredjo, F. E., Ismadji, S. and Ju-Hsu, Y. (2014). Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica. *Journal of Food and Drug Analysis* 22, 296-302.

Duraipandiyana, V. and Ignacimuthu, S. (2007). Antibacerial and antifungal activity of *Cassia fistula* Linn.: An Ethnomedicinal plant. *Journal of Ethanopharmacology*, 112: 590-94

EI-Kholany, M. E., Mehany, A. A., Maged, G. A and EI-Mowafy, A. A. (2015). Performance and some rumen and blood parameters of Baladi cows fed rations supplemented with productive chamomile flowers during late pregnancy and lactating periods. *Journal of Animal and Poultry Production*, Mansoura University, Vol. 6 (12): 705-717.

Fraser, C. M. and Mays, A. (1986). The Merck Veterinary Manual. A handbook of diagnosis, therapy and disease prevention and control for the Veterinarian. Sixth Edition. Merck & Co., Inc. Rahway, New Jersey, USA, 905–908

Gunun, P., Wanapat, M., Gunun, N., Cherdthong, A., Sirilaophaisan, S. and Kaewwongsa, W. (2016). Effects of condensed tannins in mao (*Antidesma thwaitesianum* Muell. Arg.) seed meal on rumen fermentation characteristics and nitrogen utilization in goats. *Asian-*

Australasian Journal of Animal Sciences; 29:1111–9

Ibrahim, M. Y., Abdelatif, A. M. and Hassan, Y. M. (2005). Erythrocytic and leukocytic Indices and serum proteins in Sudanese Nubian goats. *Sudan Journal of Veterinary Science and Animal Husbandary*. 44 (1&2).

Jiwuba, P. C., Amaduruonye, W., Okoye, L. E. and Obasi, K. U. (2021). Haematology and serum biochemical profile of West African dwarf goats fed four phytogenic browse plant parts in their diets. *Nigerian Journal of Animal Science and Technology*, 4(3): 72-81

Kabir, M., Akpa, G. N., Nwagu, B. I., Adeyinka, I. A. and Bello, U. I. (2011). Sexual dimorphism, breed and age characteristics of rabbits in Zaria, Nigeria (p.133-137). Proceedings of the 16th Annual Conference of Animal Science Association of Nigeria

Kaneko, J. J., Harvey, J. W. and Bruss, M. L. (1997). Clinical biochemistry of domestic animals. 5th ed. New York, Academic Press.

Leng, R. A. (1990). Factors affecting the utilization of 'poor-quality' forages by ruminants particularly under tropical conditions. *Nutrition Research Reviews*. 3:277–303

Liu, X., Liu, F., Yan, T., Chang, S., Wanapat, M. and Hou, F. (2020). *Cistanche deserticola* Addition Improves Growth, Digestibility, and Metabolism of Sheep Fed on Fresh Forage from Alfalfa/Tall Fescue Pasture. *Animals*, 10(4): 668

Makkar, H. P. (2003). Quantification of tannins in tree and shrub foliage: A laboratory manual. Springer Science & Business Media

Malpani, S. N., Manjunath, K. P., Hasanpasha, S., Savadi, R. V., Akki Kusum S. and Darade S. S. (2010). Antidiabetic activity of *Cassia fistula* Linn. Bark in alloxan induced diabetic rats. *International Journal of Pharmaceutical Sciences*, 2: 382-85

Manju, R. K., Dhuria, R. K., Khinchi, M. P. and Meel, M. S. (2019). Effect of Herbs as Feed Additive on Rumen Fermentation Patterns and Haemato-Biochemical Parameters in Marwari Rams Fed Wheat Straw Based Complete Feed, *International Journal of Livestock Research*, 9(2): 32-40

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D. and Morgan, C. A. (1996). Animal Nutrition. 5th Edition. Longman Scientific and Technical, Essex, England, 607 pp.

McIntosh, F., Williams, P., Losa, R., Wallace, R., Beever, D. and Newbold C. (2003). Effects of essential oils on ruminal microorganisms and their protein metabolism. *Applied and Environmental Microbiology*, 69:5011–14

Mehansho, H., Butler, K. G., Carlson, D. M. (1987). Dietary tannins and salivary praline-rich proteins: Interaction, induction and defence mechanisms. *Annual Review of Nutrition* 7: 423-440.

Min, B., Attwood, G., Reilly, K., Sun, W., Peters, J. and Barry, T. (2002). Lotus corniculatus condensed tannins decrease *in vivo* populations of proteolytic bacteria and affect nitrogen metabolism in the rumen of sheep. *Canadian Journal of Microbiology*, 48:911–21.

Mir, M. A., Parihar, K., Tabasum, U. and Kumari, E. (2016). Estimation of alkaloid, saponin and flavonoid, content in various extracts of Crocus sativa. *Journal of Medicinal Plants Studies* 4, 171-174

Nasseri, M. A., Behravesh, S., Allahresani, A. and Kazemnejadi, M. (2019). Phytochemical and antioxidant studies of *Cleome heratensis* (Capparaceae) plant

extracts. *Bioresources and Bioprocessing* 6, 5.

National Research Council, (2007). Nutrient requirements of small ruminants (1st edition). NRC, National Academy Press: Washington, DC, USA.

Ogubai, M. and Sereke, B. S. (1997). *Analytical methods for feeds, animal excrements and animal tissues. Nutrition Laboratory*, ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 90 p

Olafedehan, C. O., Obun, A. M., Yusuf, M. K., Adewumi, O. O., Oladefedehan, A. O., Awofolaji, A. O., and Adeniji, A. A. (2010). Effects of residual cyanide in processed cassava peal meals on haematological and biochemical indices of growing rabbits (p.212).Proceedings of 35th Annual Conference of Nigerian Society for Animal Production.

Oosting, S. J. (1993). Wheat straw as ruminant feed. Effect of supplementation and ammonia treatment on voluntary feed intake and nutrient availability. PhD thesis, Agricultural University of Wageningen, The Netherlands, 232 pp.

Panthee, A., Matsuno, A., Al-Mamun, M. and Sano, H. (2017). Effect of feeding garlic leaves on rumen fermentation, methane emission, plasma glucose kinetics, and nitrogen utilization in sheep. *Journal of Animal Science and Technology*, 59:14, DOI 10.1186/s40781-017-0139-3

Patra, A., Kamra, D. and Agarwal, N. (2006). Effect of spices on rumen fermentation, methanogenesis and protozoa counts in *in vitro* gas production test. *International Congress Series*. 1293, 176–179.

Pen, B., Sar, C., Mwenya, B., Kuwaki, K., Morikawa, R., Takahashi, J. (2006). Effects of yucca schidigera and quillaja saponaria extracts on *in vitro* ruminal fermentation and methane emission. *Animal Feed Science and Technology*. 129:175– 86. doi: 10.1016/j.anifeedsci.2006.01.002 51.

Phesatcha, K. and Wanapat, M. (2017). Tropical legume supplementation influences microbial protein synthesis and rumen ecology. *Journal of Animal Physiology and Animal Nutrition*, 101, 552–562.

Quinn, M. J., May, M. L., Hales, K. E., Dilorenzo, N., Leibovich, J., Smith, D. R. Galyean, M. L. (2009). Effects of ionophores and antibiotics on *in vitro* hydrogen sulfide production, dry matter disappearance, and total gas production in cultures with a steam-flaked corn-based substrate with or without added sulfur. *Journal of Animal Sciences*, 87, 1705–1713.

Radostits, O. M., Gay, C. C., Hinchcliff, K. W., Constable, P. D. (2006). Veterinary Medicine E-Book: A textbook of the diseases of cattle, horses, sheep, pigs and goats. 10th ed. Saunders, Elsevier New York.

Singh, B., Chaudhary, L. C., Agarwal, N., Kamra, D. N. (2011). Effect of feeding *Ficus infectoria* leaves on rumen microbial profile and nutrient utilization in goats. *Asian-Australian Journal of Animal Science*, 24(6): 810-817

Soetan, K. O., Akinrinde, A. S. and Ajibade, T. O. (2013). Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn (Sorghum bicolor) (p. 49-52). Proceedings of 38th Annual Conference of Nigerian Society for Animal Production

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fiber neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74, 3583–3597.

Wang, S., Terranova, M., KreuzerI, M., Marquardt, S., Eggerschwiler, L. and Schwarm, A. (2018). Supplementation of pelleted Hazel (*Corylus avellana*) leaves decreases Methane and urinary nitrogen emissions by sheep at unchanged forage intake. *Scientific reports*, 8: 5427

Wang, S. P. and Wang, W. J. (2016). Effects of dietary supplementation of Chinese herb medicine mixture on rumen fermentation, nutrient digestion and blood profile in goats. *South Africa Journal of Animal Science*, 46(3): 247 – 260.

Wanapat, M., Kang, S. Khejornsart, P. and Wanapat, S. (2013). Effects of plant herb combination supplementation on rumen fermentation and nutrient digestibility in beef cattle. *Asian Australasian Journal of Animal Science*, 26(8): 1127-1136

Wermer, W. H., Rey, H. G. and Weielinger, H. (1970). Method of plasma glucose determination. *Journal of Analytical Chemistry* 252: 224 - 228

Wilson, T. (1991). Small ruminant production and the small ruminant genetic resource in tropical Africa. Rome: Food and Agriculture Organization of the United Nations (FAO), 231 pp. (FAO Animal Production and Health Paper 88) 231-

Yusuf, A. L., Adeyemi, K. D. and Samsudin, A. A. (2017). Effects of dietary supplementation of leaves and whole plant of *Andrographis paniculata* on rumen fermentation, fatty acid composition and microbiota in goats. *BMC Veterinary Research*, 13: 349. https://doi.org/10.1186/s12917-017-1223-0

Zubcic, D. (2001). Some biochemical parameters in the blood of grazing German improved fawn goats from Istria, *Croatia veterinarski Arhiv*, 71: 237-244.