International Journal of Food, Agriculture and Veterinary Sciences ISSN: 2277-209X
An Open Access, Online International Journal Available at http://www.cibtech.org/jfav.htm
2023 Vol.13, pp.1-9/Odedire et al.
Research Article

GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY OF WEST AFRICAN DWARF (WAD) SHEEP FED *ZINGIBER OFFICINALE* AND *ALLIUM SATIVUM*

***JA. Odedire[1], AI. Sekooni[1] and SK. Ayandiran[2]**
[1]*Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria*
[2]*Department of Animal Science, College of Agriculture, Osun State University, Osogbo, Osun State, Nigeria*
**Author for Correspondence: skayandiran@gmail.com*

ABSTRACT
The performance of West African Dwarf (WAD) sheep was investigated in an experiment that lasted 84 days. Twenty-four West African Dwarf (WAD) sheep, aged 5 – 7 months, were allotted to seven treatments in a 2 x 3 factorial arrangement with three animals per treatment. Seven experimental diets were compounded for the purpose of the study. *Zingiber officinale* and *Allium sativum* were included in a typical concentrate ration for WAD sheep at graded levels of 1, 2 and 3% respectively, plus 0% level of inclusion for the control diet. The compounded diets were offered to growing WAD sheep at 2% of their body weight as supplement to a basal ration of guinea grass (*Panicum maximum*). Feed samples were analyzed for proximate and fibre fractions while faecal and urine samples were analyzed for chemical composition and total urinary nitrogen estimation. Performance indicators were weight change, nutrient intake, nutrient digestibility and feed conversion efficiency. Results showed Proximate composition improvement of the supplemented diets with increasing *Zingiber officinale* and *Allium sativum* inclusion. Digestibility in terms of crude protein, crude fibre and ether extracts intake improved significantly ($P<0.05$) with increasing levels of both additives in concentrates diets while nitrogen utilization in terms of nitrogen retention (%) were similar in *Zingiber officinale* and *Allium sativum* concentrates. Growth performance results showed that diet consisting 3% *Zingiber officinale* elicited the best performance in terms of final live weight, average daily gain (ADG) and feed conversion ratio compared to Allium sativum and control diets. The results suggest that the use of *Zingiber officinale* and *Allium sativum* as feed additives improved its nutrient quality, utilization and the performance of West African Dwarf sheep.

Keywords: *Performance, Supplements, Concentrate, Digestibility, Utilization, WAD sheep*

INTRODUCTION
The search for alternative source to the use of antibiotics as growth promoters in animal production has been on the increase. One option that has been receiving increased attention is the use of herbs and herb mixtures in livestock feeding (McDonald and Wood, 2002). Although the administration of antibiotics can achieve good performance, the potential side effects become a real public health concern (Donoghue, 2003) which suggests ban of the products, especially in the western world (Nweze and Nwankwagu, 2010). The use of feed additives, such as ginger (*Zingiber officinale*) and garlic (*Alium sativum*) in livestock feed and human diets are becoming more popular because of their beneficial health and preservative importance as well as ability to serve as natural growth promoters (Demir *et al.,* 2003). Pourali *et al*. (2010) reported that allicin in garlic promotes the performance of the intestinal flora and as such, improving digestion and enhancing the utilization of energy which leads to improved growth. In addition to its antimicrobial activities, garlic increases feed palatability and consequently, feed intake (Horton *et al*., 1991). A number of researchers have reported the beneficial effects of feeding ginger and garlic as growth promoters in poultry and rabbits (Onu and Aja, 2011). However, limited data are

available on the effects of ginger and garlic on subsequent utilization by ruminant livestock. The present study evaluated the effect of different dietary levels of ginger and garlic supplements on growth performance, nutrient digestibility and nitrogen utilization of WAD sheep.

MATERIALS AND METHODS

Experimental Site

The experiment, which lasted 84 days, was conducted at the Sheep and Goat Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife.

Preparation of Zingiber officinale and Allium sativum

Raw ginger (*Zingiber officinale*) and garlic (*Allium sativum*) were procured from an open market. The ginger and garlic were bulked, washed and oven – dried at 55°C for seven days and subsequently ground to fine powder, for incorporation into the concentrate diet of WAD sheep.

Experimental animal and design

Twenty – four growing WAD sheep of both sexes, aged 5-7 months were used for the experiment. The WAD sheep were allotted to seven treatments in a 2 x 3 factorial arrangement.

Experimental diets

Seven experimental diets were compounded for the study. Ginger and garlic were mixed with a typical concentrate ration for ruminants at graded levels each of 1, 2 and 3% inclusion while the control diet contains 0 % level of the feed additives. The compounded diets were offered to growing sheep at 2% of their body weight as supplements to a basal ration of guinea grass (*Panicum maximum*), offered at 3% body weight.

Management routine

The sheep were subjected to a 14-day adaptation period during which they were given prophylactic treatment against ecto – and endo – parasites. Growth trials lasted for 84 days. Animals had access to clean cool water and mineral salt lick. Pens were cleaned each morning before fresh feed were offered to the WAD sheep.

Measurements

Each sheep was weighed at the commencement of the growth study and subsequently weekly throughout the period of the experiment. Experimental diets were fed to the sheep for a period of 84 days. Forages and treatment diets were also weighed daily and the left-overs were weighed to estimate the previous day's feed consumption. Data collected were: feed intake and weight gain. Feed conversion ratio was calculated from the feed intake and weight gain.

Digestibility and Nitrogen balance trials

Digestibility and nitrogen utilization studies were carried out between the 12th and 14th week of the experiment. Ten percent of voided faecal sample per day was dried in a forced-draught oven at 70° C for 48 hours. The daily stored samples of faeces were bulked, thoroughly mixed, ground and sub-sampled for chemical analysis. Feed and water were offered *ad-libitum* for the 14-day period. Data on feed intake and faecal output were used to calculate the digestibility co-efficient of nutrients. Five ml of urine was collected and aliquot preservative of 0.1NHCl was added to it and stored in the deep freezer for the purpose of nitrogen utilization determination.

Chemical Analysis

At the end of the trials, the daily stored faecal samples were bulked, thoroughly mixed, and dried in a forced draught oven at 70° C for 72 hours. The faecal samples were ground and sub-sampled for chemical analysis. The stored *Zingiber officinale* and *Allium sativum* samples were also subjected to residual moisture determination using a forced-draught oven at 70° C for 48 hours and sub-sampled for chemical analysis.

The feed and faecal samples were analysed for crude protein, crude fibre, ether extracts, ash and nitrogen-free extracts as described by AOAC (2000).

Statistical Analysis

Data obtained were statistically analyzed with the Factorial analysis of variance using SAS (2008) and significant differences between treatments means were separated using Duncan`s New Multiple Range Test option of SAS of the same package.

RESULTS

The result of chemical composition of *Zingiber officinale* and *Allium sativum* (Table 2) shows that crude fibre of *Zingiber officinale* and *Allium sativum* were similar but the crude protein values of *Allium sativum* doubles the values of *Zingiber officinale* and also the energy content of *Allium sativum* were higher than that of *Zingiber officinale* respectively.

Presented in Table 3 is the nutrients composition of the experimental diets fed to the WAD Sheep. Dry matter values range from 89.63% - 92.12%, crude protein, crude fibre, ash, nitrogen free extract, neutral detergent fibre, acid detergent fibre and acid detergent lignin content of the concentrate increases with increased level of *Zingiber officinale* and *Allium sativum* in the concentrate diets. Ether extract values obtained in this study differ significantly ($P<0.05$) and ranged from 9.23% in the control to 11.56% in Diet 6 which contains 3% *Allium sativum* additive.

Effects of additives at varying inclusion levels on the growth performance of WAD sheep fed experimental diets are presented in Table 4. There were differences ($P< 0.05$) in the effect the inclusion level of the additives on intake and weight gain of the animals as sheep fed diets containing *Zingiber officinale* recorded the highest feed intake and total weight gain but there were no differences ($P< 0.05$) in the feed intake of sheep fed diets containing *Allium sativum* and the control diets. Average daily weight gain was highest ($p < 0.05$) and similar in the WAD sheep fed diets 1 – 5 and least for animals on diets without any additive. Effects of additives at varying inclusion levels on nutrients digestibility of WAD sheep fed experimental diets are presented in Table 4. There were significant effect of additives on inclusion level of digestibility coefficients of dry matter, crude fibre, ether extract, nitrogen free extract and ash. Sheep fed 1% inclusion level of garlic utilized more nutrients than 2, 3% inclusion level of garlic supplement. For ginger, 3% inclusion level utilized nutrients better than other dietary treatment and control diets. Digestible dry matter intakes across the treatment groups were similar. The crude protein, crude fibre, ether extract and ash digestibility increased as ginger inclusion level increases thus decreased as garlic inclusion level increases. Interaction effects between additives and inclusion levels on nutrients digestibility of WAD sheep fed experimental diets are also shown in Table 4. There was significant interaction effect of additives on inclusion level of digestibility coefficients of dry matter, ether extract and ash.

Effect of additives at varying inclusion levels on nitrogen utilization of WAD sheep fed experimental diets is presented in Table 5. There was no significant effect of the level of additives inclusion on faecal nitrogen and urinary nitrogen of WAD Sheep, except on nitrogen intake, nitrogen balance and nitrogen utilization which were significantly higher ($P<0.05$) in sheep fed garlic at 3% inclusion level (6.95, 4.07 and 58.56) respectively compared to dietary treatments. Interaction effects between additives and inclusion levels on nitrogen utilization of WAD sheep were also presented in Table 5. There was no significant interaction effect of additives inclusion level on the faecal nitrogen and urinary nitrogen of WAD sheep. However, there were significant interaction effects of additives on inclusion level of nitrogen intake, nitrogen balance and nitrogen retention.

DISCUSSION

The reported values for composition of ginger by various authors are in the following range; for protein, 7.2 - 8.7, fat, 5.5 - 7.3 and ash, 2.5 - 5.7 g/100 g (Odebunmi et al., 2009). This variation could be attributed to varietal difference, soil conditions and agronomic practices. Ash contents of *Zingiber officinale* in this study was much lower than those determined by Nwinuka *et al.*, (*2005*). Crude protein content of *Zingiber officinale* was in agreement with the previous documented crude protein contents in

Zingiber officinale by Shirin *et al.*, (2010). The crude protein composition observed for ginger in the present study is less than 17.56% indicated by Faniyi *et al.*, (2015). Similarly, ash content was lower in ginger compared to garlic, an indication that *Zingiber officinale* is a poor source of minerals compared to garlic. The high crude protein content of garlic may be due to the presence of active ingredients such as allicin and ajoene. The result on crude protein especially in garlic suggests that they can be used to enhance low-protein plant extracts. The values of the proximate components recorded for *Panicum maximum* in this study were higher than those obtained by Alasa *et al*., (2010) while the values were similar to the values reported by FAO (2003) where they reported crude protein value of 7.20 - 8.25 % CP and dry matter value of 17.89 % - 71.2 9% DM. The difference in values may be connected with the age of the grass and time or season of harvesting.

For Chemical composition of the experimental diets fed to WAD sheep, DM content of the formulated diets increased as the level of inclusion of ginger and garlic increased in the experimental diets. This could probably due to the fact that they were prepared from dried ingredients which were characteristically high in dry matter (Okoruwa *et al*., 2013). The CP content of the diets in this study is more than the 10% crude protein level recommended by Bengaly *et al*., (2007) for minimum growth in ruminant animals. Crude fibre and ash were highest in the diets containing 3% inclusion of ginger and garlic respectively and similarly, these results indicated that ginger diets had lower ash contents compared to garlic diets. The higher ether extract values obtained in the diets containing feed additives explains the better quantity of fats and oil in the diet compared to control used in the study. Nitrogen free extract value was highest in the diet containing 3% inclusion of garlic. The variation in the values of neutral and acid detergent fibre in the study was a reflection of the crude fibre contents in the diets. Thus, variation of different levels of ginger and garlic as feed additives in diets of Sheep met the minimum energy and protein requirement for maintenance and production functions of WAD Sheep.

Animals fed ginger dietary treatment had the highest feed intake compared to animal fed control and garlic diets. Feed intake, weight gain increased in all treated group than control diets and those on 3% ginger inclusion had the highest feed intake and final weight. This may be due to ginger roots which contains ingredients like Aryl alkanes that give ginger pungent taste that enhances the appetite of animal thus improving the nutrients palatability which finally caused increased of feed intake (Shirin *et al*., 2010), or it may be due to the fact that ginger helps to increase the absorption of essential nutrients, thus improving the growth of the animal (Belewu *et al*., 2006). This is in line with the result of Qussay *et al*., (2015) that supplementation of ginger powder significantly increased feed intake in cow. The higher the level of garlic in feed the lower the feed intake and weight gain. This trend may be as a result of the presence of allicin has been reported (Lawson *et al*., 1992) to be unstable and poorly absorbed from the digestive tract leading to garlic pungent odour. The result of this study are in agreement with the reports of Aid *et al.*, (2008) who observed a decrease in feed consumption as garlic oil supplementation to rice straw increases. The result obtained from this study is also similar to Nidaullah e*t al.*, (2010) who reported a reduction in the feed intake of calves fed garlic supplement. Likewise Yang *et al.*, (2007) clearly demonstrated that garlic had a greater feed intake response at low dose (0.4 g/day) whereas higher doses have no effect on intake (1.6 g/day) in steers. Diets supplemented with 2% garlic powder, fed to the growing WAD sheep tends to improve digestibility coefficients of all nutrients. The findings reveals in this study that 1% inclusion of garlic powder may be the most suitable concentration for rumen activity. Also, there were improvement in Crude fibre digestibility and Ether ester digestibility compared to control diet. On the other hand, treatment 6 supplemented with 3% of garlic powder was the least value of digested which indicated that the level may inhibit the rumen activity. These results are in agreement with those found by El Ashy *et al.* (2006). Culen *et al.*, (2005) reported that the inclusion of garlic oil at higher level caused a significant reduction in dry matter and organic matter digestibility. Ginger fed to the growing WAD sheep tends to improve digestibility coefficients of all nutrients and showed the highest values compared to other treatments fed garlic and control diets this may be attributed to the fact that ginger increase the secretion of saliva which caused increased secretion and activity of digestion enzymes which finally increased the digestion processes (Erust et al., 2000). Furthermore, Difference that was observed in the fibre digestibility of animals placed on the experimental diets may be as a result of variation in NDF and ADF content of the experimental diet. This agreed with the findings of Norton, (1994) who reported that the fibre fraction of food has the greatest influence on digestibility.

Nitrogen balance is described as a good indicator of the protein value of a diet (Babayemi and Bamikole, 2006). The result obtained for nitrogen intake may be attributed to the fact that the crude protein values of the diets were above the 10% crude protein level recommended by Bengaly *et al*., (2007) for minimum growth in ruminant animals there by reduced the production of endogenous nitrogen which is an additional factor increasing apparent nitrogen digestibility (Jorgensen *et al.*, 1996). All the diets in this study had positive nitrogen balances, which indicated adequacy in protein requirement for maintenance. The nitrogen balance here was higher than 1.34 – 1.69g/day obtained by Babayemi and Bamikole (2006). The higher nitrogen loss (3.13g/day) in diet corroborates with the findings of (Van Soest *et al.*, 1994) which stated that when the requirement of nitrogen is met, additional dietary nitrogen increases nitrogen loss. Nitrogen utilization is the proportion of nitrogen utilized by farm animals from the total nitrogen intake for body process, hence the more the nitrogen consumed and digested, the more the nitrogen retained and vice versa, as observed by (Okeniyi *et al*., 2010). The nitrogen utilization percentage was lower than range of 68.37 – 81.17% obtained by (Okoruwa *et al*., 2015).

Table 1: Gross composition of the concentrate diet offered to the WAD sheep

Ingredients	Control	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Corn bran	45.00	44.00	43.00	42.00	44.00	43.00	42.00
BDG	30.00	30.00	30.00	30.00	30.00	30.00	30.00
PKC	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Zingiber officinale	-	1.00	2.00	3.00	-	-	-
Allium sativum	-	-	-	-	1.00	2.00	3.00
Bone meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin. Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated values:							
Crude protein (%)	14.40	14.20	14.00	13.80	14.20	14.00	13.90
Energy (Kcal/kg)	2215.80	2164.00	2115.50	2066.80	2164.20	2115.70	2067.10

Control: No additive inclusion; *Diets* 1, 2 and 3: *Zingiber officinale* inclusion at 1, 2 and 3% respectively; Diets 4, 5 and 6: *Allium sativum* inclusion at 1, 2 and 3% respectively

Table 2: Chemical composition of *Zingiber Officinale, Allium sativum*

Parameter (%)	*Zingiber officinale*	*Allium sativum*
Crude protein	8.55	15.30
Crude fiber	3.20	3.25
Ash	2.0	6.05
Nitrogen free extracts	63.02	59.34
Gross energy (Kcal/kg)	385.2	411.5

Table 3: Nutrient composition of concentrates fed to experimental WAD sheep

	Control	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	SEM	Prob
Dry matter	89.63	90.11	90.22	89.70	91.00	90.80	92.12	1.25	0.2342
Crude protein	13.15	13.52	13.75	13.93	14.00	14.25	14.50	0.43	0.1324
Crude fiber	8.25	8.40	8.45	8.48	8.50	8.89	8.95	0.12	0.3435
Ether extract	9.23^{b}	11.25^{a}	11.29^{a}	11.33^{a}	11.30^{a}	11.43^{a}	11.56^{a}	0.65	0.0456
Ash	11.60	12.20	12.22	12.00	12.30	12.40	12.80	0.23	0.0645
NFE	47.40	44.74	44.51	43.96	44.90	43.83	44.31	2.32	0.1734
Fibre analysis									
NDF	52.00	52.80	53.40	53.83	53.20	53.80	54.20	2.12	0.2343
ADF	19.14	20.22	20.95	21.15	20.88	21.22	21.88	1.34	0.1289
ADL	4.10	5.25	5.84	6.01	5.44	5.85	6.20	0.21	0.0743

[a, b] *Means within row with different superscripts are significantly different (p<0.05); Control: No additive* inclusion; *Diets* 1, 2 and 3: *Zingiber officinale* inclusion at 1, 2 and 3% respectively; Diets 4, 5 and 6: *Allium sativum* inclusion at 1, 2 and 3% respectively.

Table 4: Performance characteristics of WAD sheep fed graded levels of dietary *Zingiber officinale* and *Allium sativum*.

Parameters	Control	T1	T2	T3	T4	T5	T 6	SEM	Additive	Level	A*L
Panicum	191.94	220.99	164.69	195.94	175.68	181.86	179.61	22.98	NS	NS	NS
Concentrate	190.00^{c}	252.20^{ab}	256.9^{ab}	291.11^{a}	233.50^{b}	218.90^{b}	204.10^{b}	29.74	**	NS	NS
ADFI (g/d)	381.95^{b}	472.19^{a}	421.59^{ab}	487.04^{a}	409.18^{b}	400.76^{b}	383.71^{b}	1.75	*	NS	NS
AILW (Kg)	11.17	11.17	11.33	11.17	11.00	11.00	11.17	1.09	NS	NS	NS
FLW(Kg)	14.50^{c}	16.90^{b}	18.23a	18.83^{a}	16.83^{b}	17.07^{ab}	16.23^{b}	1.29	**	NS	NS
TWG(Kg)	3.33^{c}	5.73^{ab}	6.90^{a}	7.66^{a}	5.83^{ab}	6.07^{ab}	5.06^{b}	0.33	***	*	*
ADWG (g/d)	39.64^{c}	68.21^{ab}	82.14^{a}	91.19^{a}	69.40^{ab}	72.26^{ab}	60.24^{b}	3.97	***	*	*
FCR	9.64	6.92	5.13	5.34	5.89	5.55	6.37	1.98	NS	NS	NS

*Note: P Value, *, ** and *** for P < 0.05, P < 0.01 and P < 0.001 respectively; NS = Not significant (P > 0.05)*
[a, ,b, c] *Means within each row with different superscript are significantly different (p< 0.05)*
(control) 0% ginger, garlic meal inclusion: T1, T4 (1%) ginger, garlic meal inclusion: T2, T5 (2%) ginger, garlic meal inclusion: T3, T6 (3%) ginger, garlic meal inclusion. SEM (± Standard error of mean), ADFI (Average daily feed intake), AILW (Average initial live weight), AFLW (Average final live weight), TWG (Total weight gain), ADG (Average daily gain), FCR (Feed Conversion Ratio).

Table 5: Effects of additive at varying inclusion level on the Nutrients digestibility of WAD sheep

Parameters (%)	Ginger		Treatments		Garlic						
	Control	T1	T2	T3	T4	T5	T6	SEM	Additives	Level	A*L
DDM	72.03^{b}	72.79^{b}	73.67^{ab}	74.41^{a}	73.53^{ab}	70.98^{c}	69.45^{c}	0.95	***	***	***
DCP	55.86	61.89	63.96	67.61	66.23	65.11	64.06	2.57	NS	NS	NS
DCF	45.43^{c}	53.23^{b}	54.43^{b}	56.47^{a}	51.03^{b}	49.32^{c}	47.13^{c}	0.45	***	NS	NS
DEE	57.64^{c}	60.43^{b}	62.45^{a}	60.04^{b}	61.35^{ab}	58.45^{c}	59.04^{c}	0.69	***	NS	**
DASH	56.65^{b}	58.43^{ab}	59.54^{ab}	60.76^{a}	60.44^{a}	59.78^{ab}	58.34^{ab}	0.43	***	NS	**
DNFE	64.43	67.88	66.76	67.53	62.88	61.76	60.56	0.57	***	NS	NS

*Note; P Value, *, ** and *** for P < 0.05, P < 0.01 and P < 0.001 respectively;* NS = Not significant (P > 0.05)
$^{a, b, c}$ *Means within each row with different superscript are significantly different (p< 0.05)*
(control) 0% ginger, garlic meal inclusion: T1, T4 (1%) ginger, garlic meal inclusion: T2, T5 (2%) ginger, garlic meal inclusion: T3, T6 (3%) ginger, garlic meal inclusion. SEM (±): Standard error of mean; DDM: Digestible dry matter; DE: Digestible energy; DCP: Digestible crude protein; DCF: Digestible crude fibre; DEE: Digestible ether extracts; DASH: Digestible ash; DNFE: Digestible nitrogen free extract

Table 6: Effect of additives at varying inclusion level on the nitrogen utilization of WAD sheep

	Ginger			Treatment			Garlic				
Parameters	Control	T1	T2	T3	T4	T5	T6	SEM	Additive	Level	A*L
Nitrogen Intake (g/day)	6.49^{b}	6.62^{ab}	6.71^{ab}	6.85^{ab}	6.66^{ab}	6.89^{ab}	6.95^{a}	0.12	**	**	***
Feacal nitrogen (g/day)	2.82	2.83	2.65	2.51	2.49	2.58	2.55	0.07	NS	NS	NS
Urinary nitrogen (g/day)	0.29	0.30	0.29	0.33	0.42	0.36	0.33	0.06	NS	NS	NS
Nitrogen balance (g/day)	3.38^{b}	3.49^{b}	3.77^{ab}	4.01^{a}	3.75^{ab}	3.95^{a}	4.07^{a}	0.16	**	*	***
Nitrogen utilization (%)	52.08^{b}	52.72^{b}	56.18^{ab}	58.54^{a}	56.31^{ab}	57.33^{ab}	58.56^{a}	1.04	**	**	***

*Note; P Value, *, ** and *** for P < 0.05, P < 0.01 and P < 0.001 respectively;* NS = Not significant (P > 0.05)
$^{a, b}$ *Means within each row with different superscript are significantly different (p< 0.05)*
(Control) 0% ginger, garlic meal inclusion: T1, T4 (1%) ginger, garlic meal inclusion: T2, T5 (2%) ginger, garlic meal inclusion: T3, T6 (3%) ginger, garlic meal inclusion

CONCLUSIONS

The nutritive values of *Zingiber officinale* and *Allium sativum* were adequate as feed and met the minimum nutrient requirements for growing WAD sheep. Inclusion of ginger at 3% gave the best performance in terms of feed intake, weight gain and feed conversion ratio of WAD sheep. Garlic should be fed at 2% inclusion level for efficient growth performance

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