Adapted Local Feed Supplement for African Dwarf Sheep in the Rainy Season

Dokui F[1*], Houndonougbo FM[1], Babatoundé S[1], Mouteïrou AAA[1], Chrysostome CAAM[1]

[1]*Laboratory of Animal Science, Faculty of Agronomic Sciences, University of Abomey-Calavi, Abomey-Calavi, Benin*
E-mail : dofaust@live.fr

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ABSTRAK

Dokui F, Houndonougbo FM, Babatoundé S, Mouteïrou AAA, Chrysostome CAAM. 2025. Suplemen pakan lokal yang diadaptasi untuk domba kerdil Afrika di musim hujan. JITV 30(1):52-58. DOI:http://dx.doi.org/jitv.v30i1.3298.

Tujuan dari penelitian ini adalah untuk membuat dan mengidentifikasi suplemen pakan terbaik untuk domba kerdil Afrika selama musim hujan. Untuk itu, dua jenis suplemen pakan (batu jilat multi-nutrisi dan pakan konsentrat) dibuat berdasarkan bahan pakan lokal. Empat perlakuan diet ditetapkan, dan masing-masing diuji pada sekelompok 6 domba yang ditempatkan di kandang individu. Kelompok pertama tidak diberi suplemen, kelompok kedua diberi suplemen pakan konsentrat, kelompok ketiga diberi suplemen pakan konsentrat dan batu jilat, dan kelompok terakhir diberi suplemen batu jilat saja. Hewan-hewan tersebut berada di padang rumput alami selama 5,30 jam setiap hari. Percobaan ini dilakukan selama 84 hari. Asupan pakan dicatat setiap hari dan berat badan diukur setiap dua minggu. Asupan pakan, rasio konversi pakan, pertambahan bobot badan harian rata-rata, biaya pakan, dan efisiensi pakan ekonomis dihitung. Domba-domba tersebut memakan pakan konsentrat dalam jumlah yang lebih besar daripada batu jilat. Performa pertumbuhan domba yang disuplementasi dengan konsentrat (5,51 kg) lebih baik daripada domba yang tidak disuplementasi (3,52 kg); domba yang disuplementasi dengan batu jilatan memiliki rasio konversi pakan terbaik dan keuntungan ekonomis terbaik (28,49 unit uang yang diperoleh dari 1 unit yang diinvestasikan dalam pakan). Batu jilat yang terbuat dari bahan pakan lokal lebih cocok daripada pakan konsentrat untuk domba kerdil Afrika selama musim hujan. Tidak menarik untuk menggabungkan pakan konsentrat dan batu jilat sebagai suplemen pakan untuk domba kerdil Afrika di musim hujan.

Kata Kunci: Domba Kerdil Afrika, Keuntungan Ekonomi, Suplemen Pakan, Kinerja Pertumbuhan, Musim Hujan

ABSTRACT

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This study aimed to manufacture and identify the best feed supplements for African dwarf sheep during the rainy season. Two feed supplements (multi-nutritional lick stone and concentrate feed) were made based on local feedstuffs. Four different dietary treatments were set for four groups; each group contained 6 sheep but in individual pens. The first group was not supplemented, the second was supplemented with concentrate feed, the third was supplemented with both concentrate feed and lick stone, and the last was supplemented with lick stone alone. The animals were in a natural pasture for 5.30 hours each day. The experiment was carried out over an 84-day period. The feed intake was registered daily, and the body weight was measured biweekly. Feed intake, feed conversion ratio, average daily gain, feed cost, and economical feed efficiency were calculated. The sheep ate more significant amounts of concentrate feed than of the lick stone. The growth performance of the sheep supplemented with the concentrate (5.51 kg) was better than that of the non-supplemented sheep (3.52 kg); those supplemented with lick stone had the best feed conversion ratio and the best economic return (28.49 Unit of money gained for 1 unit invested in the feed). Lick stone based on local feedstuffs is more suitable than concentrate feed for African dwarf sheep during the rainy season. It is of no interest to mix feed concentrate and lick stones together as feed supplements for African dwarf sheep in the rainy season.

Keywords: African Dwarf Sheep, Economic Return, Feed Supplements, Growth Performance, Rainy Season

INTRODUCTION

A great part of ruminants' feed consists of fodder. Hence, the problem of feeding small ruminants is increasing due to urban fringe development, which negatively affects small ruminant production through the widespread use of weedicides and destruction of natural pastures (Shinde & Mahanta 2020; Khan et al. 2021; Abdulai 2022). Some years ago, feeding problems were not noticed during the rainy season, but the situation has changed due to population growth. According to the United Nations (United Nations 2019), the world population is projected to grow from 7.7 billion in 2019 to 10.9 billion in 2100. The impact of this growth will be most significant in lower-income regions such as sub-Saharan Africa (Bajagai et al. 2016; United Nations 2019). Feeding this population will require an increase of more than 60% in food and an important contribution by livestock, which represent more than 40% of the global value of agricultural production (Alexandratos & Bruinsma 2012). The already substantial trend toward destroying natural resources, especially pastureland, will increase further if an adequate solution is not found.

To deal with this situation, the wise management of natural resources is essential (Dokui et al. 2023). Especially in small ruminant feeding and nutrition, managing the industrial and agricultural by-products that are widely considered waste to produce adequate feed supplements could be a great solution. It could help to maintain and increase productivity as well as contribute to a reduction of greenhouse gas emissions (Haque 2018). Apart from the conflicts between breeders and farmers noticed in many countries because of bad land management, the destruction of natural pasture is the source of climate change due to the imbalance between animals and crops. According to Teague et al. (2016), ruminants reduce overall GHG emissions, facilitate essential ecosystem services, increase soil carbon (C) sequestration, and reduce environmental damage. Increasing the dietary level of concentrate in ruminant feeding reduces methane production (because of less use of fiber sources) and increases livestock productivity (Haque 2018). In sub-Saharan countries such as Benin, where ruminants represent more than 60% of all protein (FAOSTAT 2019), wise management of the agricultural and industrial by-products to provide an efficient feed supplement for ruminants seems to be a suitable solution (Montcho et al. 2016; Dokui et al. 2023). But when it comes to ruminants, there are numerous types of feed supplements.

This study aimed to test two feed supplements for their impact on the growth and economic performance of African dwarf sheep and determine which option is most appropriate for them during the rainy season in Benin.

MATERIALS AND METHODS

Study area

The study was conducted in the rainy season on a farm in the village of Houngbo in the municipality of Toffo, southern Benin, which is characterized by a subequatorial climate with two dry and two rainy seasons. The annual rainfall is 1100 mm during the rainy season and 800 mm during the dry season. The average temperature varies between 27 and 31ºC. Apart from some forest galleries, the flora consists mainly of herbaceous and shrubby savannah. On the various plantations, the oil palm (*Elaeis guinensis*), which holds a part of the natural grassland, is especially observed.

Experimental design and feeding

The experiment was carried out over 84 days, preceded by 14 days of adaptation. Twenty-four weaned dwarf sheep were weighed and placed in 4 groups of 6 animals each. Animals were housed in individual pens, 1 m x 1 m, with a feeding and water trough. The average weight of the animals at the beginning of the trial was 11.04±1.98 kg, 11.05±1.82 kg, 11.09±1.83 kg, and 11.06±197 kg, respectively, for the four groups. Hence, the average weight of the sheep in each group was similar at the beginning of the study.

The animals foraged daily from 08:30 h to 12:00 h and from 16:00 h to 18:00 h in the natural grassland. The first group was the control group, which received no supplements. The second group was supplemented with concentrate (pelleted feed) based on local feedstuffs, the third group received this concentrate feed and multi-nutritional lick stone based on local feedstuffs, and the last group was supplemented with multi-nutritional lick stone only. The natural pasture was abundant and composed of *Panicum maximum* C1, *local Panicum maximum, and Tridax proc*ess; once the sheep returned from the pasture, they were led to their individual box. Water was offered to all animals at all times without limitation (ad libitum). The ingredients used to make the concentrate feed were oyster shells, common salt, orange peel, rice bran, wheat bran, palm kernel meal, and cassava meal. The nutritional composition of the supplements made is shown in Table 1.

Chemical composition of the feed supplements

The chemical composition of the feed indicates its nutritional value. Hence, to know the chemical composition of the concentrate and lick stone used in this study as the supplements, the AOAC (Horwitz and Latimer 2005) procedure was used to determine their composition in terms of dry matter (DM) (#930.15), phosphorus (P) (#946.06), calcium (Ca) (#978.05), magnesium (Mg) (#2006.03), organic matter (OM) (#942.05), ash (#942.05), and total nitrogen (TN) (#990.03) values (Table 1).

Data and statistical analysis

The data collected on each sheep included daily feed supplement intake and body weight. These data were used to calculate average feed intake, feed conversion ratio, average daily gain, feed cost, and economic feed efficiency. Parameters were compared using analysis of variance when the data followed a normal distribution and the Kruskal Wallis test if the normality assumption was not met. The Student-Newman-Keuls (SNK) post-hoc test was performed in cases of significance ($P<0.05$); all these analyses were performed in R software version 4.2.1 (R Core Team 2022). The standard deviations of the means were calculated and added to them, and the differences were considered significant if $P<0.05$.

RESULTS AND DISCUSSION

Chemical composition of the feed supplement

Table 1 reveals that the concentrate feed contains greater amounts of organic matter and phosphorus than the multi-nutritional lick stone. The multi-nutritional lick stone has shown a good balance in organic matter, ash, total nitrogen, calcium, and magnesium. The dry matter of both supplements reveals that they were more concentrated in nutrients, in contrast to fodder. The feed supplements used were multi-nutritional lick stones and concentrate feed based on local feedstuffs. An analysis of the chemical composition revealed that the lick stone had a good balance of nutrients except for phosphorus. This difference might be explained by the lack of dicalcium phosphate or feedstuffs such as cassava peel and palm kernel meal in the lick stone, in contrast to the concentrate. Because the aim was to make the lick stones based essentially on local feedstuffs, adding commercial ingredients like dicalcium phosphate was avoided. This imbalance was not observed in the concentrate feed because of the ingredients of dicalcium phosphate, cassava peels, palm kernel meal, and orange peels. Cassava peels have been proven to be a source of phosphorus (Khalil 2022). As the ratio of phosphorus to calcium should be 1.0:1.7 because the two minerals provide bone with the necessary strength for the main activities of the sheep, such as grazing and walking (Ternouth & Coates 1997; Karn 2001), it is compulsory to find local feedstuffs rich in phosphorus that can correct this imbalance. The concentrate feed had a good nutrient balance but was less rich than the lick stone except for phosphorus and organic matter. The concentrate used lacks sources of minerals and protein such as charred bone meal, quicklime, cement, and urea, and the lesser use of oyster shells and common salt, which are a good source of minerals. The high incorporation of ingredients such as cassava peels, rice bran, and orange peel raised the organic matter composition of the concentrate feed relative to the lick stone. Compared to the feed supplements described by the studies of Babatoundé et al. (2016) and Montcho et al. (2016) and the nutritional requirements set by Noziere et al. (2018) and NRC (2007), the feed supplements used in the present study have good potential to fill the nutritional gaps of African dwarf sheep.

Feed supplement intake

Table 2 reveals the amount of the average daily feed supplement taken by the sheep of each group. The multi-nutritional lick stones were taken in lesser amounts in the presence of the concentrate feed than when served alone. Combining concentrate feed and lick stone raised the overall feed intake relative to the groups that received only one of the two supplements.

For animals, feed is essential for production and the different functions of the organism. Its quality and quantity are the primary determinants of livestock's growth performance and economic return. Throughout the study, the feed intake of sheep given the multi-nutritional lick stone was lower than that of sheep given concentrate feed because the lick stone is more compact and was made to be licked instead of eaten like concentrate feed. Even when some sheep tried to eat chunks of lick stone, its solidity did not allow them to take in a great quantity. Apart from that, the composition of the lick stone was such that even a small quantity was more concentrated in nutrients needed by the sheep. Also, the group of sheep that had both lick stone and concentrate feed increased their ingestion of concentrate feed slightly; this confirms the result of Zhao et al. (2022), who reported that the lick stones could improve the feed intake because of their ability to improve the digestibility of the diet and the passage of roughage through the gastrointestinal tract. The 18.44±4.61 g/d of lick stone intake revealed by this study is in the range of 13.3 g/d to 500 g/d reported by Zhao et al (2022). The lick stone was taken in somewhat greater amounts when served alone than combined with concentrate feed. This finding confirms the ability of animals to adjust their feed ingestion according to their nutritional need (Clauss et al. 2007; Forbes 2007). The lick stone intake (18.44±4.61 g/d) of the group fed only with lick stone was lower than the 75 g to 110 g/d reported by Yahya et al. (2022). It might be due to the average initial body weight (35 kg) of Yankasa rams used by those authors instead of dwarf sheep used in this study, which had 11.06 kg as the initial average body weight. The quantity of concentrate feed intake was close to that reported by Montcho et al. (2016), who used a multi-nutritional block for African dwarf sheep. African dwarf sheep seem to appreciate the concentrated feed in the rainy season and the multi-nutritional block in the dry season (Dokui et al. 2022).

Table 1. Chemical composition of feed supplements (% dry matter basis, unless otherwise stated)

Item	DM	OM	Ash	TN	P (g/kg)	Ca (g/kg)	Mg (g/kg)
LS	87.81	31.91	68.09	40.62	0.007	96.05	75.81
CF	86.58	78.27	21.73	17.5	8.99	54.031	14.11

LS= Multi-nutritional lick stone, CF= Concentrate feed, DM= Dry matter, OM= Organic matter, TN= Total nitrogen

Table 2. Feed supplement intake (g)

Item	CF	CF + LS			LS	P-value
		CF	LS	CF + LS		
FI_1	174.42±46.25^b	192.47±34.07^{bc}	14.33±2.79^a	218.82±17.81^c	21.26±3.62^a	<0.001
FI_2	249.79±30.87^b	267.94±19.31^b	21.87±6.53^a	274.85±16.98^b	17.55±4.36^a	<0.001
FI_3	236.16±23.68^b	237.12±54.60^b	10.20±1.57^a	254.57±46.83^b	16.51±9.34^a	<0.001
FI	220.12±31.89^b	232.51±25.93^b	15.47±2.79^a	249.41±25.93^b	18.44±4.61^a	<0.001

FI_1= Feed intake in the first month, FI_2= Feed intake in the second month, FI_3= Feed intake in the third month, FI= feed intake over the 84-day period, CF= concentrate feed, LS= multi-nutritional lick stone based on local feedstuffs, P= probability

Feed conversion ratio

Table 3 shows the amount of each feed supplement needed to produce a unit of body weight. It shows that more concentrated feed than the lick stone was needed to produce one unit of body weight. Combining concentrate feed and lick stone increased the feed supplement needed to produce one unit of body weight.

The feed conversion ratio permitted us to measure each feed supplement's potential to increase the sheep's body weight. The multi-nutritional lick stone showed better potential to improve the body weight gain of African dwarf sheep than the concentrate feed. The chemical analysis confirms the good balance of nutrients in the lick stone. The fact that the sheep fed with concentrate feed in combination with lick stone have the best feed intake but not the best feed conversion ratio proves that the concentrate feed was less convertible to body weight than the lick stone. The feed conversion ratio (6.55 to 13.63) of the concentrate reported by a previous study (Amuda and Okunlola 2020) was better than the 56.80±12.59 of the concentrate revealed by this study; this is due to the significant utilization of feedstuffs such as rice bran and cassava peels, which can limit the digestibility of the concentrate and, thus, the availability of the nutrients (NRC 2007; Noziere et al. 2018). The feed conversion ratio (9.38±0.94) of the multi-nutritional lick stone based on local feedstuffs was better than (13.2 to 38.8) reported by Hatungimana & Ndolisha (2015); this might be justified by the great use of ingredients like *Penisetum purpureum* and *Leucaena leucocephala* which are not mostly used in the lick stone.

Average daily gain

The average daily gain observed was due to the effect of forage intake and the feed supplement for those supplemented. However, it was solely due to forage intake for the non-supplemented group. The impact of supplementation needs to be evaluated.

Table 4 shows how the body weight of the sheep changed during the trial period. The table shows that the sheep fed with concentrate feed grew faster than the non-supplemented sheep, especially after the first month. The combination of concentrate feed and multi-nutritional lick stone did not significantly affect the growth of African dwarf sheep during the rainy season. Overall, the non-supplemented gained 50.54%, 30.04%, and 7.23% less weight than those supplemented with concentrate feed, combination concentrate feed-lick stone and lick stone alone.

Their average daily weight gain measures animals' growth speed. For the African dwarf sheep used in this study, the average daily gain enables us to determine the effect of each treatment on the growth performance of the sheep. The concentrate feed exhibited the potential to increase daily body weight growth faster than no supplementation. This finding is backed up by the fact that the sheep's intake of concentrated feed was greater than their intake of lick stones. The concentrate feed's composition in terms of fiber sources such as rice bran, cassava peel, and orange peels makes it a feed better suited for ruminants. Gallo et al. (2019) confirmed that a minimum of 15% nitrogen detergent fiber (NDF) is required in the feed of ruminants to improve their ruminal activity and growth performance. The concentrate feed seems more fit for this purpose than the lick stone, a source of minerals more than fiber. The average daily gain across all groups (44.96 g/day to 63.21 g/day) revealed by this study is less than 90.48 g/day reported by Amuda and Okunlola (2020). As the body weight gain is greatly determined by breed and the initial body weight, the initial average body weight of the sheep in this study (11.06 kg) was well under the 15 kg weight of the sheep used by those authors, which may explain that difference. The average daily gain across all groups (44.96 g/day to 63.21 g/day) revealed by this study was close to the gains (28.6 g/day to 57.1 g/day) reported by Aye & Adegun (2010).

Feed supplement cost and Economic feed efficiency

Table 5 reveals that both the concentrate feed alone and the concentrate feed in combination with the lick stone required a greater cost than the lick stone served alone to produce a kilogram of body weight. The lick

Table 3. Feed conversion ratio (g of feed/g of body weight)

Item	CF	CF+LS	LS	*p-value*
FCR_1	41.33±17.47[b]	110.72±25.00[c]	5.76±1.27[a]	<0.001
FCR_2	76.49±17.63[b]	104.73±18.51[c]	13.74±1.44[a]	<0.001
FCR_3	52.58±9.52[b]	90.81±9.68[c]	8.65±1.27[a]	<0.001
FCR	56.80±12.59[b]	102.09±15.00[c]	9.38±0.94[a]	<0.001

FCR_1= Feed conversion ratio for the first month, FCR_2= Feed conversion ratio for the second month, FCR_3= Feed conversion ratio for the third month, FCR= Feed conversion ratio over the 84-day period, CF= Concentrate feed, LS= Multi-nutritional lick stone base on local feedstuffs

Table 4. Average daily gain (g/day)

Item	NS	CF	CF+LS	LS	*p-value*
ADG_1	57.96 ± 10.56	63.91 ± 14.45	70.29 ± 23.78	58.33 ± 9.88	0.499
ADG_2	24.79 ± 5.80[a]	53.33 ± 19.83[b]	40.15 ± 9.09[ab]	27.22 ± 10.08[ab]	0.002
ADG_3	43.04 ± 8.65[a]	72.38 ± 12.25[b]	53.14 ± 12.25[ab]	49.34 ± 20.46[ab]	0.024
ADG	41.93 ± 6.68[a]	63.21 ± 12.67[b]	54.53 ± 8.37[ab]	44.96 ± 9.88[ab]	0.004
BWG (kg)	3.52 ± 0.56[a]	5.31 ± 1.06[b]	4.58 ± 0.70[ab]	3.78 ± 0.83[ab]	0.004

ADG_1= Average daily gain in the first month, ADG_2= Average daily gain in the second month, ADG_3= Average daily gain in the third month, ADG= Average daily gain over the 84-day period, BWG= Body weight gain over the 84-day period, CF= Concentrate feed, LS= Multi-nutritional lick stone base on local feedstuffs

Table 5. Feed supplement cost (money invested in feed supplement/kg of body weight gain)

Item	CF	CF + LS	LS	*p*-value
FC_1	200.34 ± 84.67[ab]	274.81 ± 181.38[b]	64.47 ± 16.32[a]	0.020
FC_2	391.11 ± 66.51[b]	615.08 ± 211.53[c]	108.05 ± 21.83[a]	<0.001
FC_3	294.87 ± 65.93[b]	550.14 ± 138.89[c]	49.55 ± 9.13[a]	<0.001
FC	295.44 ± 62.63[b]	480.01 ± 122.43[c]	74.02 ± 10.37[a]	<0.001

FC_1= Feed cost during the first month, FC_2= Feed cost during the second month, FC_3= Feed cost during the third month, FC= Feed cost over the 84-day period

stone required less cost to produce a unit of body weight than the other options.

Overall, the price of one kg of all feed supplements was under the average one kilogram of body weight. All the feed supplements used in this study can provide the breeders with a good economic return; this confirms the fact that the local feedstuffs have nutritional potential and should be explored to reduce the feed cost of the dwarf sheep to improve the economic return for breeders (Dokui et al. 2022). However, the lick stone was more affordable, whereas the combination with concentrate was less affordable for the breeders. Besides the feed conversion ratio influencing the feed cost, the lick stone had the best feed conversion ratio.

Table 6 shows the amount of money gained for one unit of money invested in feeding. The analysis of those values in each group revealed that the lick stone allowed the best economic return. The combination of concentrate feed and lick stone didn't significantly affect the economic return of African dwarf sheep during the rainy season relative to providing no supplement, whereas the lick stone alone did have a significant effect.

Adopting a new feed that is not economically viable is impossible. To prevent this, in animal feed and nutrition, the economic return of every new feed developed is evaluated using economic feed efficiency (EFE); this allows us to determine the amount of money gained or wasted for one unit of money invested in the feed. It enables researchers to know if the economic return has resulted from the efficacy of the feed as measured by the body weight gained. This study has revealed that the lick stone alone provided the best economic return compared to the concentrate feed, the concentrate combined with the lick stone, or no supplement. The fact that the EFE of the lick stone was the best confirmed that the nutrients in the lick stone were more convertible, as shown by the feed conversion ratio. It leads the lick stone to be more advantageous for the sheep, leading to this result. It is a waste of money to give combined concentrate feed and lick stone for African dwarf sheep during the rainy season because that is not economically sustainable. The fact that the lick stone allowed the best economic return might be explained by the fact that during the rainy season, in

Table 6. Economic feed efficiency (money gained / money invested in feed supplement)

Item	CF	CF+LS	LS	*p*-value
EFE_1	8.94±4.17[a]	7.62±4.17[a]	26.01±6.52[b]	<0.001
EFE_2	4.87±2.05[a]	2.95±0.87[a]	23.32±2.78[b]	<0.001
EFE_3	6.83±2.38[a]	4.34±0.61[a]	36.14±7.14[b]	<0.001
EFE	6.88±2.40[a]	4.97±1.14[a]	28.49±2.53[b]	<0.001

EFE_1= Economic feed efficiency in the first month, EFE_2= Economic feed efficiency in the second month, ECE_3= Economic feed efficiency in the third month, EFE= Economic feed efficiency over the 84-day period, CF= Concentrate feed, LS= Multi-nutritional lick stone base on local feedstuffs, *p*= probability

contraction to the dry season, fodder is available but has a deficiency in protein and minerals like calcium and magnesium (Azando et al. 2022; Olomonchi et al. 2022). The EFE (4.97±1.14) revealed by this study was better than (-0.28 to 0.14) reported by the study by Inweh et al. (2021) for West African dwarf goats. That might be justified by the chemical composition of the feed in this study, which is better balanced than theirs. The fact that the growth performance of goats is sometimes lower than sheep's might also contribute to this difference between the EFEs (Bosso et al. 2007).

CONCLUSION

The aim of this study was to make different feed supplements and determine which one was better for the growth and economic performance of African dwarf sheep during the rainy season. The results have proved that the multi-nutritional lick stone based on local feedstuffs can increase feed intake. The lick stone was better converted to the body weight than the concentrate feed. Concentrate feed allowed for better growth performance than non-supplemented sheep, but it is not economically viable. The multi-nutritional lick stone based on local feedstuffs has allowed the best economic return. It is a waste of money to combine feed concentrate and lick stone for the African dwarf sheep in the rainy season because that decreases the economic return. The multi-nutritional lick stone based on local feedstuffs is economically viable for African dwarf sheep during the rainy season in Benin. As the climate conditions of the West African countries are close to each other, this study shall help the remaining countries to choose wisely the type of feed supplement they should use during the rainy season.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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