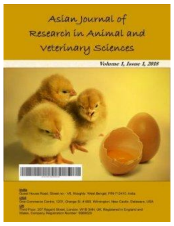

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Effect of Air-Dried Mucuna (*Mucuna pruriens*) Leaf Meal in the Diets of Grower Rabbit Bucks on the Performance, Nutrient Digestibility and Economic Cost of Production

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Authors' contributions

This work was carried out in collaboration among all authors. The authors worked mutually to bring this paper to a successful completion. All authors read and approved the final manuscript.

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ABSTRACT

A twelve week feeding trial was conducted to investigate the effect of air-dried mucuna (*Mucuna pruriens*) leaf meal (MLM) in the diets of grower rabbit bucks. Mucuna leaf meal was included at 0%, 5%, 10%, 15% and 20% for T_1, T_2, T_3, T_4 and T_5 respectively. Thirty grower rabbits bucks were assigned to five experimental dietary treatments denoted T_1, T_2, T_3, T_4 and T_5 respectively in a completely Randomized Design (CRD). Each treatment had six rabbits with each serving as a replicate. Results of performance showed that there were no significant differences in final body weight, daily weight gain, daily feed and protein intake. Protein efficiency ratio and feed conversion ratio were significantly higher at T_1. Nutrient digestibility by rabbit indicates significant different ($p<0.05$) in ether extract (EE), crude fibre (CF), and crude protein (CP). EE and CF were

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significantly higher at T_4, and CP was highest at T_1. There was no significant difference (P>0.05) in NFE across the treatments. There was also no significant difference (P>0.05) for cost per kg gain. Cost of feed consumed, total cost and percentage feed cost were significantly higher (P<0.05) at T_1, T_2, and T_3. Percentage drug cost was significantly better (P<0.05) at T_4 and T_5, percentage cage cost and animal were statistically depressed (P<0.05) at T_1, T_2 and T_3 and highest at T_5. It was concluded that mucuna (*Mucuna pruriens*) leaf meal has potentials as a valuable unconventional leguminous feedstuff. The use of *Mucuna pruriens* leaf meal in the diets of rabbit bucks promoted growth best at 5% and thus carcass yield. Rabbit farmer can incorporate *Mucuna pruriens* leaf meal at 5% for growth performance.

Keywords: Mucuna; rabbit bucks; performance; nutrient digestibility and economic of production.

1. INTRODUCTION

Small-livestock such as rabbits have advantages of fast growth, large litter size, and short generation interval and good quality consumable and non-consumable animal products, but are faced with the challenge of feedstuff availability and affordability. In Nigeria today, the cost of feeding livestock intensively is over 70% [1]. Based on their findings, unconventional feedstuffs could play a vital role in alleviating this enormous challenge posed by intensive feeding in livestock production, because they are mostly cost-free and are readily available.

The cost of feeding rabbits is high, a condition that also prevails for other Nigerian livestock species [2]. Less developed countries, like Nigeria, are facing serious competition between human and livestock (especially, the monogastric animals) for available conventional feedstuffs [3]. This increased competition for available conventional feeds and scarcity of food have both encouraged nutritionists, scientists and agriculturists to research into the use of unconventional feedstuffs that are cheap, readily available and are possible substitute for more expensive protein sources (groundnut cake and soybean meal) and energy sources such as maize [4].

Forages offer a considerable potential as major source of energy, protein, minerals and vitamins for herbivorous animals and are readily available [5]. Forages not only serve as a source of fibre for rabbit, they are essential for normal functioning of the gut health and mobility; caecotrophy and appetite stimulation [6].

Mucuna pruriens, widely known as “velvet bean,” is a vigorous annual climbing legume originally from Southern China and eastern India, where it is at one time widely cultivated as a green crop [7]. It is one of the most popular green crops currently known in the tropics. Velvet beans have great potential as both food and feed as suggested by experiences worldwide. The velvet beans has been traditionally used as a food source by certain ethnic groups in a number of countries. It is cultivated in Asia, America, Africa, and Pacific Islands, where its pods are used as a vegetable for human consumption, and its young leaves are used for animal folder.

Mucuna utilis (velvet bean), a tropics legume, is little known and has a low human preference as an energy/protein source but high preferences in livestock feed [8]. It is comparable to soya bean in terms of amino acid and mineral profile [9]. However, the use of velvet beans as a source of protein for monogastrics is limited by the presence of antinutritional factors like trypsin inhibitors, haemagglutinins, phytic acids, hydrocyanic acid and tannins [10].

Little has been reported on the use of mucuna leaves in the diets of rabbits. Therefore, mucuna leaf meal, a potential feedstuff, could play a vital role in livestock production, hence, its effect on the performance of growing rabbit bucks was investigated in this study.

2. MATERIALS AND METHODS

2.1 Site

The study was conducted at the Rabbitry Unit of the Livestock Teaching and Research Farm, University of Agriculture, Makurdi, Benue State. Makurdi lies between Latitude 7º44’ N and longitude 8º21’E in the Southern Guinea savanna Zone, Benue State. The area has an annual rainfall of 6-7 months in duration (i.e. March – October) and ranging from 508 to 1016 mm with a minimum temperature range of 24.20 +1.4ºC and maximum temperature range of 36.33+3.70ºC, respectively. The relative humidity ranges between 39.50 + 2.20% and 64.00 + 4.80% [11].

2.2 Processing of Mucuna Leaf Meal and Diet Preparation

Mucuna leaves were sourced from within Makurdi metropolis at the back of Rabbitry Unit of the Livestock Teaching and Research Farm, University of Agriculture, Makurdi, Benue State. The leaves were harvested from the wild, such that yellow leaves were discarded, leaving the greenish leaves for use. Harvested leaves were air-dried, turned frequently to enhance uniform drying until the material became crispy. Air-dried mucuna leaves were milled using a roller miller to obtain mucuna leaf meal (MLM) which was subjected to proximate analysis [5] and the proximate composition determined. Five iso-caloric and iso-nitrogenous experimental diets were formulated which contained 0%, 5%, 10%, 15%, and 20% mucuna leaf meal and O%MLM served as the control diet (Table 1).

2.3 Experimental Design

The experimental design was completely randomized design (CRD). Thirty rabbits were grouped into five with each group containing six animals and replicated six times; each animal serving as a replicate. The treatment groups were balanced of their weights and randomly exposed to the five dietary treatments.

2.4 Experimental Animals and Management

Thirty healthy grower rabbit bucks of about four to five (4-5) weeks of age were purchased from farms within Makurdi metropolis for the study. Before the arrival of the rabbits, the cages, feeders and drinkers were properly cleaned and disinfected using izal. On arrival, the rabbits were housed individually in 40 x 60 x 40 cm^3 cages having wire mesh floor, 1m above the ground and acclimatized for 10 days. Standard rabbit husbandry practices including medications, recommended sanitary space measures and other health practices were strictly observed throughout the experimental period [12]. The animals were served feed and water ad-libitum daily for 84 days.

Table 1. Feed composition of grower rabbits diets containing Mucuna Leaf Meal (MLM)

Ingredients	Experimental diets				
	T_1 (0%MLM)	T_2 (5%MLM)	T_3 (10%MLM)	T_4 (15%MLM)	T_5 (20%MLM)
Maize	38	38	37	34	33
Maize offal	12.15	10.15	7.15	8.15	8.15
Brewer dry grain	10	10	10	10	10
Soya bean meal	16	12	12	9	7
Rice offal	19	19	19	19	17
Mucuna leaf meal	0	5	10	15	20
Blood	2	3	3	2	2
Bone ash	2	2	2	2	2
Salt	0.3	0.3	0.3	0.3	0.3
Lysine	0.1	0.1	0.1	0.1	0.1
Methionine	0.2	0.2	0.2	0.2	0.2
Premix	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated	**Analysis (%)**				
Crude protein	17.23	17.25	17.33	17.10	17.29
Crude fibre	13.02	13.17	13.38	13.81	13.45
ME (Kcal/kg)	2560.41	2570.24	2580.00	2567.76	2587.01
Ether extract	2.2	2.30	2.46	2.53	2.66
Calcium	1.2	1.22	1.21	1.20	1.16
Phosphorus	0.8	0.84	0.82	0.80	0.76
Methionine	0.25	0.23	0.22	0.21	0.19
Lysine	1.56	1.21	1.21	1.37	1.32

MLM= mucuna leaf meal, ME= metabolizable energe, T1-5= treatment 1,2,3,4 and 5

Table 2. Proximate composition of experimental diets (Analysed)

Constituents	T_1	T_2	T_3	T_4	T_5
Moisture	11.88	11.97	11.77	10.89	12.00
Ash	9.50	5.42	10.14	17.47	7.79
Ether extract	5.18	5.52	6.39	6.87	6.24
Fibre	12.81	15.01	11.19	20.80	15.41
Protein	16.94	16.39	15.42	18.56	18.23
NFE	43.60	45.69	45.12	25.43	40.34

NFE = Nitrogen Free Extract, T_1= 0% MLM, T_2= 5% MLM, T_3= 10% MLM, T_4= 15% MLM, and T_5= 20% MLM, %= percentage, MLM = Mucuna leaf meal

2.5 Proximate Composition

Proximate composition of mucuna leaf meal, treatment diets as well as feacal samples collected during digestibility trial were determined using the standard methods [13] of Purity Laboratory Jos, Plateau State.

2.6 Fibre Fraction

Fibre fraction of mucuna leaf meal was determined at Animal Nutrition laboratory Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State.

2.7 Growth Performance Indices

Feed intake (FI): a known quantity of feed offered (FO) to each rabbit and the leftover feed (LOF) at the end of every week were weighed and the feed consumed was calculated by difference. That is, FI= FO – LOF.

Body weight gain (BWG): Individual rabbits were weighed at the commencement of the trial, weekly thereafter, and at the end of the feeding trial. Total weight gain was obtained by difference between final live body weight (FW) and initial body weight (IW). That is, FW – IW. Daily weight gain was determined as the total weight gain divided the number of the days the experiment lasted.

Feed Conversion Ratio (FCR): This is a measure of an animal's efficiency in converting feed into desired output. It was calculated as the ratio of feed intake to body weight gain

$$\text{FCR} = \frac{\text{FI}}{\text{BWG}} \quad (1)$$

Protein Intake (PI) was calculated as follows; FI $\times$ % crude protein in feed.

Protein Efficiency Ratio (PER); this expresses numerically the growth promoting value of protein, it involves using the weight of protein intake in a test diet to divide the weight gain by the animal on the test diet. It was calculated as follows;

$$\text{PER} = \frac{\text{BWG}}{\text{PI}} \quad (2)$$

2.8 Digestibility Trial

At the end of the 11th week of the feeding trial, three (3) rabbits, with live weights closed to their treatment average were selected from each treatment and used for the digestibility trial. Faecal collection lasted for five (5) days. During this period, nylon net were tied under individual rabbit cages for daily faecal collection. Before the commencement of faecal collection, the rabbits were deprived of feed for 18 hours to ensure that faecal collection corresponded to the feed offered. The fresh collected faeces were weighed and oven dried at 80^{0}C for 24 hours, the oven-dried faeces per replicate was also weighed. At the end of the digestibility study, collected faeces from each replicate were bulked, thoroughly mixed together and milled. Samples of the milled faeces were stored in air tight containers for proximate analysis. Also sample of feed from each treatment were taken for proximate analysis. Proximate composition was determined as outlined by [13].

Digestibility coefficients were calculated using the following equation by McDonald et al. [14].

$$\text{Apparent digestibility} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} X\ 100 \quad (3)$$

2.9 Economics of Production

The cost of feed ingredients and other services such as transportation and processing (milling of mucuna leaf) were used to get the actual cost of each ingredient during the study. The formulation for each diet was used to determine the cost of feed by multiplying unit cost (N) of each ingredient by its proportion in the diet to determine its cost contribution to the diet. The sum of all the cost contribution from all the ingredients that made up each diet gave the units cost of (N) diet. Value of rabbit per kg multiply by the final weight (kg) were used to get revenue. Benefit per rabbit was gotten by subtracting total cost of production from revenue. Cost benefit ratio was calculated by dividing total cost of production by benefits per rabbit. Feed cost divided by total cost multiplied by one hundred gives percentage feed cost. Percentage drug cost equals to drug cost divided by total cost multiplied by one hundred. Cage cost divided by total cost multiplied by one hundred equals to percentage cage cost and percentage animal cost was determine as cost of animal divided by total cost multiplied by one hundred.

2.10 Statistical Analysis

All the data generated were subjected to the analysis of variance (ANOVA) using Statistical Software (SPSS version 16) and significant differences were separated using its Duncan New Multiple Range Test [15].

3. RESULTS

Table 3 shows proximate composition and fibre fraction of mucuna leaf meal (MLM). The value 11.03 for moisture in this study is lower than 12.50% [16] but similar to 11.37% [17]. The crude protein of 26.09% recorded for MLM was higher than the values of 22.94% [16] but lower than 31.91% by Fathima et al. [17]. The value of 4.91% ether extract in MLM was lower than 8.50% [18] and [16]. Crude fibre (26.54%) obtained is higher than 12.50% and 14.80% [17]. Ash 10.25% obtained in this study was higher than 5.80% recorded by Andrea and Pablo [19]. NFE (21.18%) recorded in this study was lower than 47.51% [20]. From the results and reports, it is noted that differences exist among report with composition and these differences could be attributed to variations in processing method and varieties. However, on average, the best material (MLM) is a fibrous protein source.

3.1 Fibre Fraction of Mucuna Leaf Meal

The fibre fractions are presented in Table 3. Higher cellulose and acid detergent lignin (ADL) lead to low degradation by the microbes. Higher percentages of hemicellulose, neutral detergent fibre (NDF) and acid detergent fibre (ADF) indicates high nutrient degradation by microbes which shows that mucuna leaf meal is saved for rabbit. The value of NDF 49% in this present study is higher than 43% reported by Andrea and Pablo [20], 33% ADF in this research is lower compare to 38% as quoted by Andrea and Pablo [20]. The value for ADL in this work is higher than 7.1% as reported by the earlier author.

Table 3. Proximate composition and fibre fraction of Mucuna Leaf Meal (MLM)

Composition	Percentages (%)
Dry matter	88.97
Ash	10.25
Ether extract	4.91
Crude fibre	26.54
Crude protein	26.09
Nitrogen free extract (NFE)	21.18
Fraction	**%**
Cellulose	22
Hemicellulose	38
Neutral detergent fibre	49
Acid detergent fibre	33
Acid detergent lignin	11

Table 4 contained growth performance of rabbit bucks fed diets containing mucuna leaf meal (MLM). There were no significant differences in the final body weight (FBW), daily weight gain (DWG), daily feed intake (DFI), and protein intake. Animals on T_1 (controlled diet) had the highest FBW (1719.0g) and lowest in T_4 (1459.2 g). The daily weight gain of 11.59-15.04g per rabbit per day were lower than 17.65-18.57 g/day [21] and 18.00-20.00 g [22], but was higher than 4.94-14.80 g/day [23] and 8.70-9.91 g/day [24] who fed rabbits on different levels of groundnut haulms. The average daily weight gain was better at T_1 (0% MLM), T_2 and T_3 but decreased numerically at T_4 and T_5 which had the lowest figures. This implied that mucuna leaf meal had some growth suppressing effect in the diets of rabbits on the weight gain. The quantity of feed consumed per rabbit per day observed in this study was however quite higher than 48.83 – 52.13 g [25], 44.73 to 57.90 g [26] but lower than 77.64 – 87.59 g and 63.89 -82.46 g [27]. Similarities (p>0.05) observed in feed intake suggest that all the diets were palatable and thus accepted by the rabbits as the inclusion of MLM at varying levels did not depressed feed consumption. There were no significant differences (P<0.05) in protein intake and the values ranged from 10.79 to 11.92 g.

Significant differences (P<0.05) occurred in the feed conversion ratio and protein efficiency ratio. The values of feed conversion ratio and protein efficiency ratio obtained in this study showed that the control diet (T_1) was better. The significant difference between the control (T_1), T_4 and T_5 indicate a decline in absorption with the level of mucuna in the body beyond 10%. This has also manifested in the final weight. Though the final weight is statistically seminar on analysis of variance, the trendy decrease in final weight clearly shows that it is not a chance occurrence but diet effect. The mortality rate in T_1 occurred due to injury sustained by the animal and diet effect, we loss two out of six rabbits.

Table 5 showed coefficient digestibility of nutrients by rabbit bucks fed diets containing different levels of mucuna leaf meal (MLM).

There were significant (P<0.05) differences in nutrient digestibility by rabbit. Ether extract and crude fibre varied without pattern while crude protein varied first from 0 to 10%, became elevated at 15% and fell again at 20%. This was almost a trend of declined except 15% which cannot be explained. NFE was not significantly affected meaning that energy utilization was similar across the treatment. The coefficient of digestibility of crude protein which ranged from 71.07%-80.44%, was higher than 63.30 to 76.28% [28] but comparable with 70.56 to 81.31% and 72.25 to 82.88% [29] and [30] respectively. This suggested good availability of crude protein in the diet with MLM up to 20% inclusion levels. High values indicated efficient utilization of protein for tissue accretion while lower values are indications of poor crude protein utilization for tissue synthesis [30]. The crude fibre digestibility was low in T_3 (10.33%) and high in T_4 (56.16%). Coefficient digestibility of crude fibre (10.33%-56.16%) was low compared to values 27.54 to 56.36 21 and 71.00 to 82.29% [29].

Ether extract ranged from 61.71% - 75.37 % and were lower than 71.12% - 78.43% as reported by [30]. High digestibility value of ether extract in this study attests to the rabbit ability to utilize dietary fat [30].

The high digestibility of NFE represents the readily available carbohydrates. This could be an indication that readily available carbohydrates were well utilized by the rabbits across the treatments.

Table 4. Growth performance of rabbit bucks fed diets containing different levels of Mucuna Leaf Meal (MLM)

Parameters	Experimental diets					SEM	P-value
	T_1 (0%MLM)	T_2 (5%MLM)	T_3 (10%MLM)	T_4 (15%MLM)	T_5 (20%MLM)		
Final Weight (g)	1719.0	1645.8	1583.7	1459.2	1467.0	155.51	.062
Total Weight Gain (g)	1263.0	1143.6	1095.8	978.83	983.00	171.95	.083
Daily Weight Gain (g)	15.04	13.05	13.05	11.59	11.73	2.03	.073
Total Feed Intake (g)	5201.50	5737.40	5464.33	5336.67	5364.33	516.94	.590
Daily Feed Intake (g)	62.67	69.13	65.83	64.28	64.63	6.23	.589
Protein Intake (g)	10.79	11.92	11.41	10.99	11.18	1.07	.542
Protein Efficiency Ratio	1.39^a	1.09^b	1.14^b	1.05^b	1.05^b	0.12^*	.023
Feed Conversion Ratio	4.17^b	5.04^{ab}	5.09^{ab}	5.76^a	5.60^a	0.72^*	.023
Mortality Rate (%)	33.3	16.67	0.00	0.00	0.00	_	_

*ab Means on the same row with different superscript are significantly different (P<0.05), SEM= Standard error of mean, *=significant, T_1 = 0% MLM, T_2 = 5% MLM, T_3 = 10% MLM, T_4 = 15% MLM, T_5 = 20% ML*

Table 5. Digestibility of rabbit bucks fed diets containing different levels of Mucuna Leaf Meal (MLM)

Parameters	Experimental diets					SEM	P-value
	T_1	T_2	T_3	T_4	T_5		
Ether extract	67.83^c	63.50^c	73.13^b	75.37^a	61.71^c	5.25^*	.039
Crude Fibre	27.03^b	21.68^b	10.33^b	56.16^a	21.44^b	8.97^*	.001
Crude Protein	80.44^a	72.77^b	71.07^c	78.82^b	71.26^c	4.11^*	.049
NFE	80.23	79.31	80.49	75.66	76.12	5.46	.715

abc Means on the same row with different superscript are significantly different (P<0.05), SEM = Standard error of mean, T_1 = 0% MLM, T_2 = 5% MLM, T_3 = 10% MLM, T_4 = 15% MLM, T_5 = 20% MLM, NFE= nitrogen free extract

Table 6. Economic cost of production of rabbit bucks fed diets containing Mucuna Leaf Meal (MLM)

Parameters	Experimental diets					SEM	P-value
	T_1	T_2	T_3	T_4	T_5		
Cost of weaner rabbit (N)	1300	1300	1300	1300	1300	-	-
Cost per Kg	90.95	86.74	85.05	74.98	70.83	-	-
Cost of feed consumed (N)	473.08	497.66	464.74	400.14	379.96	43.76*	.001
Cost per kg gain	379.23	437.17	432.90	431.51	396.77	55.29	.399
Total cost (N)	1853	1878	1845	1780	17600	43.76*	.001
Revenue (N)	3438	3292	3167	2918	2934	311.02	.062
Benefit per Rabbit (N)	1585	1414	1323	1138	1173	282.09	.125
Cost Benefit ratio	1.190	1.344	1.415	1.667	1.580	1.354	.158
% feed cost	25.397	26.478	25.180	22.363	21.562	1.766*	.000
% Drug cost	8.108	7.992	8.132	8.427	8.527	0.189*	.000
% Cage Cost	1.193	1.720	1.192	1.225	1.258	0.031*	.000
% Animal Cost	66.307	63.921	65.100	67.421	68.200	1.059*	.000

T_1 = 0% MLM, T_2 = 5% MLM, T_3 = 10% MLM, T_4 = 15% MLM, T_5 = 20% MLM, %= percentage, N361= $1

Statistical analysis was run because apart from cost per kg that didn't have replicate and the cost of feed were not analyzed, but the cost of feed consumed varied with each animal and the cost incurred on animal is not the same and it has replicates therefore could be analyzed statistically based on the design which is CRD. Revenue was calculated based on animal's weight (body weight gain) and the weight of the animals varied accordingly and they are replicated too, this is applicable to cost per kg gain, total cost, benefit per rabbit, cost benefit ratio, percentage feed cost, percentage drug cost, percentage cage cost and percentage animal cost, therefore, economics of production can be analyzed statistically.

Table 6 economic of production of rabbit bucks fed different levels of mucuna leaf meal (MLM).

The result of economics of production in this feeding trial showed that cost/kg of the diet was higher in T_1 (₦90.95) and progressively reduced to T_5 (₦70.83) as the level of MLM was increasing in the diets due to the minimal cost of MLM. The cost/kg of the diets, agrees with the findings of [31] who observed that the cost/kg feed was reduced generally with increasing dietary yam peel meal. Cost per kg gain, revenue, benefit per rabbit, and cost benefits ratio. However, the cost of feed consumed, total cost of production, percentage feed cost, percentage drug cost, percentage cage cost and percentage animal cost were significantly different (P<0.05). Cost of feed consumed, total cost of production and percentage feed cost were trendy, they were higher at T_1, T_2 and T_3 and declined at T_4 and T_5, meaning the cost reduced as the test ingredient increased to 15 and 20% respectively and these were in agreement with the report of [31] who worked on Effects of Replacing Maize with Sun-Dried Yam Peel Meal on Growth Performance Carcass Characteristics and Economics of Production of Meat Type Rabbit. The percentage drug cost, percentage cage cost and percentage animal does not follow any particular trend and as such the variations cannot be attributed to the effect of MLM.

The significant differences observed in this study could be attributed to variations in the body weight gain of the animal, disease infestations and different quantities of feed consumed among other things.

4. CONCLUSION

Base on the findings from this study, the following conclusions have been drawn:

> This study has revealed that *Mucna pruriens* leaf meal has potentials as a valuable unconventional leguminous feedstuff.
>
> The use of *Mucuna pruriens* leaf meal in the diets of rabbit bucks promoted growth best at 5% and thus carcass yield.

The economic analysis revealed that with MLM, benefit can be maximized at 20% level of inclusion and also it costs less to produce 1kg live weight of rabbit as level of MLM increased. Based on the results obtained from this study it could be recommended that:

Rabbit farmers can incorporate *Mucuna pruriens* leaf meal at 5% in the diets of rabbit bucks for growth performance.

ETHICAL APPROVAL

As per international standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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