



Dietary Leucaena Leaf Meal Pellets Prevent Live Weight Loss in Timor Bali Cattle During Sea Transport

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Abstract | This study was aimed to prevent live weight (LW) loss in the transported beef cattle on sea voyage from Tenau Portland Kupang, Indonesia to the domestic market. Concentrate pellets containing leucaena (*Leucaena leucocephala*) leaf meal was added to the basal diet of maize (*Zea mays*) straw. Twenty eight fattened Timor Bali cattle (*Bibos javanicus*) (LW 250 ± 34.05 kg) were allocated to treatment groups; maize straw as control (K0) or K0 plus pellets at 0.5% LW (K05), 1% LW (K10) or 1.5% LW (K15). The dietary treatment contained crude protein 3.95; 6.18; 7.15 or 7.77 % DM and metabolizable energy 8.40; 9.93; 10.69 or 11.22 MJ/kg DM, respectively. The green basal diet was fed at 4.08 - 4.39% LW following the regular practiced by the trader. The cattle have *ad libitum* access to clean water. This study lasted for 16 days in total: 5 pre-voyage, 7 at sea and 4 post-voyage. Data were analyzed using a General Linear Model. The fixed effect of dietary treatment and LW group were tested at the $p < 0.05$ threshold. The results showed that pellets supplementation increased intakes and in vitro digestibility ($p < 0.05$). Weight gain differences were statistically insignificant ($p > 0.05$) despite numerical trends. In summary Timor Bali cattle on maize straw during sea transport were well fed and indicated to gain weight when the cattle were supplemented with leucaena leaf meal pellets.

Keywords | Cattle, Legume, Protein, Supplement, Pellets, Transport

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INTRODUCTION

Leucaena (*Leucaena leucocephala*) is a tropical tree legume widely used in the ruminant ration for its high crude protein content. The tree in West Timor, Indonesia is part of the agro forestry system which is used not only for soil conservation but also as feedstuff in Timor Bali cattle (*Bibos javanicus*) fattening (Yuksel *et al.*, 1999). The local farmers in Amarasi have used this legume forage up

to 85% fresh weight containing 25.28% crude protein in the cattle ration (Sulistijo and Rosnah, 2022). Lani *et al.* (2015) found that leucaena contains crude protein 19-27% and neutral detergent fibre (NDF) 70.55 – 71.19% causing daily weight gain varied between 170 and 770 g/day. The use of fresh Leucaena forage in cattle ration during sea voyage from East Nusa Tenggara (ENT) to the domestic market, however, was not common practice as the forage spoiled with mould and could not be stored for a long pe-

riod. Instead of using green leucaena forage, inclusion of leucaena leaf meal pellets in the dietary cattle would be a novel feeding strategy for sea transport since that has been successfully applied during on farm Bali cattle fattening (Aoetpah *et al.*, 2024; Mullik *et al.*, 2024).

Recent studies on leucaena leaf processing and its usage in the beef cattle ration has been reported with varied results. Mullik *et al.* (2024) improved rumen molar proportion of glucogenic fatty acids of Bali cattle by way of mixing leucaena leaf meal with chromolaena (*Chromolaena odorata*) leaf meal to form pellets containing crude protein 20% and metabolisable energy 11.4 MJ/kg DM, which then resulted in increased of intake and digestibility. Aoetpah *et al.* (2024) reported that supplemented 56% leucaena leaf meal into a dietary concentrate and fed to Timor Bali cattle on Cipelang (*Pennisetum purpureum* cv. Taiwan) grass as a basal diet increased dry matter intake 3829 g/d, dry matter digestibility 66.89% and average daily gain by 375 g/d. These successful uses of leucaena leaf meal in increasing body weight of cattle during fattening on land might be applied also during sea transport.

Timor Bali cattle production by local farmers in East Nusa Tenggara (ENT) Province was mainly aimed to supply the demand of domestic market. From this area, approximately 64.000 to 70.000 heads of cattle were annually transported to the national market places (Dinas Peternakan Provinsi NTT, 2025), mainly to special area of the capital of Jakarta, Kalimantan or Sulawesi.

The inter island live cattle transport from the farm gates, in the quarantine Portland, during the sea voyage and at the destination area to market place caused a body weight loss of 11.63% live body weight (Aditia and Baihaqi, 2024) worth IDR 48 billion, equivalent USD 2,852,304 annually. This weight loss was resulted from low intake caused by poor quality of hay grass that containing 4.71-5.01% crude protein (Kale Lado and Aoetpah, 2009) or maize straw that fed to the cattle as the only forage. In addition, low intake could be a physiological adaptation of cattle to reduce metabolic heat to balance an increased heat from the environment (Caulfield *et al.*, 2014).

We hypothesized in the present study that supplementing Timor Bali cattle on a basal diet of maize straw with different amounts of dietary pellet concentrate containing leucaena leaf meal would increased nutrient and energy intake and therefore prevented live weight loss during live transport on sea voyage. Therefore, the primary objective of this study was to increase nutrient and energy intake thus to prevent live weight loss in Timor Bali cattle fed maize straw as a basal diet supplemented with varied quantity of dietary pellet concentrate containing leucaena leaf meal during live transport on sea voyage.

EXPERIMENTAL ANIMALS

Research protocols for feeding and handling the experimental animals were approved by the Animal Ethics Committee of the Faculty of Veterinary Medicine of Nusa Cendana University, Kupang Indonesia (reference number 001KEH/SK/VIII/2023). Twenty eight male Timor Bali cattle (*Bibos javanicus*), with an initial average live weight (LW) of 250±34.05 kg and aged 1.5-2.5 yo, belonging to a local collector trader, were selected for this experiment.

EXPERIMENTAL PROCEDURE

A randomized completely block experimental design with four dietary treatments and seven replicates (4 x 7 = 28 experimental units) was utilized. Before the experiment started, the animals were weighed to determine initial body weight, ranked from the lightest to the heaviest and blocked into seven groups. Initial LW differences among groups (Table 4) were statistically adjusted. Twenty eight scrambling papers written ear tag were provided, grouped into seven and placed in seven boxes. From each box which represents block or group, one scrambling paper was randomly drawn and that was the animal that allocated into the treatments. Seven live weight blocks represented the replicates. The dietary treatments were offered for five days at the quarantine Portland of Tenau Kupang (10°10'18" S and 123°31'17"E), seven days during the sea voyage and four days on the holding ground of destination in East Kalimantan (00°32'20"S and 117°16'20"E). The dietary treatments were maize straw only as a basal diet without concentrate pellets as Control (K0) or K0 plus concentrate pellets 0.5% live weight (K05) or 1% live weight (K1) or 1.5% live weight (K15). The nutrient composition of the feedstuff is presented in Table 1.

Maize straw, supplied as a basal diet for cattle on live transport, contains low crude protein, low digestibility, low metabolisable energy and high fibre. Formulated pellets offered contain high crude protein, high digestibility, high metabolisable energy and low fibre.

DIET FORMULATION AND FEEDING REGIMEN

A dietary concentrate was formulated from corn meal, rice bran, leucaena leaf meal, salt and mineral mix to supply crude protein 11.52%. This concentrate then formed into pellets of 0.8 cm diameter in size. The dietary crude protein (CP) concentration for K0 group was 3.95% and those for the treated groups were ranged between 6.18 and 7.77% DM (Table 2).

Samples of the concentrate feed raw materials were obtained at the time of mixing. Approximately 10% of forage offered and refused was collected daily, air dried, placed in sealed plastic bags and stored at room temperature. At the

end of the study, another 10% sample was collected, dried in an oven 60°C, ground to pass through 1 mm sieve and analysed for DM, OM, CP and CF according to AOAC (1990) at the Laboratory of Feed and Nutrition, State Agricultural Polytechnic of Kupang, Indonesia. Crude fiber fractions and in vitro digestibility of dry matter and organic matter for pellets and maize straw was determined at the Laboratory of Feed and Nutrition of Faculty of Animal, Marine, and Fishery Sciences of Nusa Cendana University of Kupang, Indonesia.

Table 1: Chemical composition and *in-vitro* digestibility of feedstuffs fed to the experimental Timor Bali cattle.

Item	Pellets	Maize straw
Dry matter, % fresh weight	92.28	32.73
OM, % of DM	88.56	88.79
CP, % of DM	11.52	3.95
Crude fat, % of DM	2.18	0.25
Crude fibre, % of DM	12.84	24.87
NDF, % of DM	51.77	70.85
ADF, % of DM	17.88	39.05
Hemicellulose, % of DM	33.88	31.81
Cellulose, % of DM	7.81	26.35
Lignin, % of DM	4.93	8.11
Silica, % of DM	0.09	0.99
ME (MJ/kg DM)*	14.24 ^a	8.40 ^b
<i>In vitro</i> DMD, % of DM	64.96	56.63
<i>In vitro</i> OMD, % of DM	63.52	55.73

*values are calculated and quoted from Feedipedia; ^aUnit measurement of metabolisable energy (MJ/kg DM) of pellets was calculated as total percentage dry matter proportion of each individual feed used in pellets multiplied by ME content of the individual feed quoted from feedipedia: metabolisable energy of leucaena leaf meal <https://www.feedipedia.org/node/282>; corn meal <https://www.feedipedia.org/node/715>; rice bran <https://www.feedipedia.org/node/750>; ^bUnit measurement of metabolisable energy (MJ/kg DM) of maize straw was quoted from : <https://www.feedipedia.org/node/16072>; **OM:** organic matter; **DM:** dry matter; **CP:** crude protein; **NDF:** neutral detergent fibre; **ADF:** acid detergent fibre; **ME:** metabolisable energy; **MJ:** Mega joule; **DMD:** dry matter digestibility; **OMD:** organic matter digestibility.

Feeds were offered twice daily in equal quantities; in the morning at 07:00 h and afternoon at 16:00 h. The amount of fresh maize straw offered to cattle according to the regular quantity practiced by the trader which was varied between 4.08 and 4.39% live weight (LW). This basal diet quantity supplied 1.26 % DM of LW, and increased up to 2.42% DM of LW when pellet concentrate was supplemented. Fresh and clean water was freely available at Tenau

Portland of Kupang, during sea voyage and at the holding ground of destination in East Kalimantan.

Table 2: Composition of dry matter, organic matter, crude protein, crude fibre, extract ether and fibre fractions of experimental diets fed to Timor Bali cattle during sea voyage.

Item	Dietary treatments			
	K0	K05	K1	K15
Dry matter (% of fresh wt)	30.70	38.72	43.44	47.55
Dry matter (% LW)	1.26	1.67	2.18	2.42
Pellets : straw ratio (%)	0 :100	26 : 74	39 : 61	48 : 52
Organic matter (% of DM)	91.45	91.50	91.52	91.53
Crude protein (% of DM)	3.95	6.18	7.15	7.77
Crude fibre (% of DM)	24.87	24.87	24.87	24.87
Extract ether (% of DM)	0.25	0.82	1.07	1.22
NDF (% of DM)	70.85	65.23	62.79	61.22
ADF (% of DM)	39.04	32.81	30.10	28.36
Cellulose (% of DM)	26.38	20.91	18.54	17.00
Lignin (% of DM)	8.10	7.17	6.76	6.50
Silica (% of DM)	0.98	0.72	0.60	0.53
Hemicellulose (% of DM)	31.81	32.42	32.68	32.86
Metabolisable energy (MJ/kg DM)	8.40	9.93	10.69	11.22

Wt: weight; **LW:** live weight; **DM:** dry matter; **NDF:** neutral detergent fibre; **ADF:** acid detergent fibre; **MJ:** mega joule.

The parameters measured were feed intake, feed conversion ratio (FCR), in vitro digestibility of dry/organic matter intake and average daily gain. Feed intake was obtained from the difference between the amount of feed offered and that refused within a day. Nutrient intake was obtained from multiplication of nutrients by the amount of feed offered and refused from laboratory analysis on the dry matter basis. Feed conversion ratio was calculated as the ratio between the amounts of feed consumed to the body weight gain. Percentage of laboratory dry/organic matter *in-vitro* digestibility was multiplied by the amount of intake of dry/organic matter then considered as dry/organic matter *in-vitro* digestibility of intake. Average daily gain (g/head. d) was obtained from final live weight minus initial live weight divided by numbers of feeding days.

Addition of concentrate pellets increased dietary concentrations of crude protein, extract ether and metabolisable energy yet decreased those of fibre fractions except hemicelluloses.

STATISTICAL ANALYSIS

The data were analyzed statistically using a univariate general linear model (SPSS 2014; SPSS statistical for

Windows, Version 23.0, IBM Corp., Armonk, NY, USA) see (https://www.ibm.com/support/pages/ibm-spss-statistics-23-documentation). Dietary treatment was the main effect, and body weight group was a covariate because the initial live weights varied greatly. The difference between treatment means was subjected to post hoc Duncan's multiple-range test at the $p < 0.05$ threshold.

Table 3: Intakes of dry matter, crude protein, crude fibre, extract ether, organic matter, fibre fractions, and feed conversion ratio of Timor Bali cattle fed concentrate pellets containing leucaena leaf meal during sea voyage.

Variables	Dietary treatment				sem	p-values	
	K0	K05	K1	K15		D	G
DMI(g/head. d)	2918 ^a	4003 ^b	5005 ^c	5569 ^d	77.66	0.01	0.39
CPI (g/head. d)	117 ^a	242 ^b	348 ^c	432 ^d	8.43	0.01	0.20
CFI (g/head. d)	716 ^a	984 ^b	1223 ^c	1406 ^d	19.42	0.01	0.41
EEI (g/head. d)	7 ^a	31 ^b	50 ^c	66 ^d	1.57	0.01	0.16
OMI (g/head. d)	2665 ^a	3658 ^b	4539 ^c	5206 ^d	71.18	0.01	0.39
NDFI (g/head. d)	2067 ^a	2629 ^b	3140 ^c	3516 ^d	42.02	0.01	0.50
ADFI(g/head. d)	1139 ^a	1334 ^b	1520 ^c	1649 ^d	16.18	0.01	0.63
Cellulose intake (g/head. d)	770 ^a	855 ^b	943 ^c	999 ^d	8.43	0.01	0.62
Lignin intake (g/head. d)	236 ^a	290 ^b	340 ^c	375 ^d	4.16	0.01	0.54
Silica intake (g/head. d)	29 ^a	30 ^b	31 ^c	32 ^c	0.22	0.01	0.17
Hemicellulose intake (g/head. d)	928 ^a	1296 ^b	1620 ^c	1867 ^d	26.19	0.01	0.37
EMI (MJ/kg DM)	8.40 ^a	9.98 ^b	10.72 ^c	11.17 ^d	0.05	0.01	0.09
Total DMI (kg)	47 ^a	64 ^b	79 ^c	91 ^d	1.24	0.01	0.39
Total DMI (%) LW)	1.19 ^a	1.57 ^b	2.06 ^c	2.32 ^d	0.03	0.01	0.01
DMI pellets (%)	0.00 ^a	27.02 ^b	40.43 ^c	45.85 ^d	1.12	0.01	0.36
DMI maize straw (%)	100 ^d	72.98 ^c	59.57 ^b	54.15 ^a	1.12	0.01	0.36
DMI maize straw(g/head. d)	2918 ^a	2921 ^a	2981 ^b	3015 ^b	21.11	0.03	0.04
DMI (g/kg BW)	11.76 ^a	15.54 ^b	20.29 ^c	22.28 ^d	0.47	0.01	0.01
DMI (g/kg BW ^{0.75})	46.58 ^a	62.13 ^b	80.15 ^c	88.95 ^d	1.45	0.01	0.01
FCR (kg/kg)	8.62	5.98	7.15	12.72	2.58	0.31	0.63

p values marked by different superscript in the same row differ significantly ($p < 0.05$) due to dietary treatment; p values marked with no superscript = not significantly different ($p > 0.05$); **D**: diet; **G**: group.

RESULTS

ANIMAL PERFORMANCE

All the experimental Timor Bali cattle were healthy at the quarantine Portland, during sea voyage and at the destination point. The cattle fed concentrate pellets completely eat the feed offered.

FEED INTAKE AND FEED CONVERSION RATIO (FCR)

Intake of dry matter, nutrients, fibre fractions, metabolisable energy, and FCR at the pre-delivery of the transport at Tenau quarantine, on board and post-delivery on the holding ground in Kalimantan is presented in Table 3.

The present study demonstrated that inclusion of leucaena leaf meal in the dietary concentrate pellets increased total intakes of dry matter, nutrients, fibre fractions and metabolisable energy ($p < 0.05$) of Timor Bali cattle on maize straw basal diet. Another finding was that these intake patterns increased accordingly to the additional quantity of the concentrate pellets. A further novel finding is that adding pellet concentrate improved ($p < 0.05$) DMI of maize straw and DMI per kg LW. The results of the experiment found clear support for the use of pellet concentrate for Timor Bali cattle on sea transportation as shown that the percentage dry matter intake pellets increased; while that for maize straw decreased. Different from other responses, the dietary treatment has no effect on feed conversion ratio ($p > 0.05$).

IN-VITRO DIGESTIBILITY AND LIVE WEIGHT CHANGES

In-vitro digestibility of intake and body weight changes of Timor Bali cattle in this experiment is presented in Table 4.

Table 4: *In-vitro* digestibility of feed and body weight changes of Timor Bali cattle fed concentrate pellets containing leucaena leaf meal during sea voyage.

Variables	Dietary treatment				sem	P-values	
	K0	K05	K10	K15		D	G
IVDMD (g)	1652 ^a	2357 ^b	2975 ^c	3448 ^d	49.72	0.01	0.37
IVOMD (g)	1485 ^a	2116 ^b	2670 ^c	3095 ^d	44.66	0.01	0.36
IVDMD (%)	56.63 ^a	59.10 ^b	60.11 ^c	60.66 ^d	0.09	0.01	0.35
IVOMD (%)	55.73 ^a	58.05 ^b	58.99 ^c	59.52 ^d	0.08	0.01	0.36
Initial LW (kg)	249	258	243	248	6.92	0.45	0.01
ADG (g/h. d)	292	355	463	543	160.76	0.69	0.38

p values marked by different superscript in the same row differ significantly ($P < 0.05$) due to dietary treatment; p values marked with no superscript = not significantly different ($P > 0.05$); **D**: diet; **G**: group.

From the results it is clear that of feed intake, digestible feed increased in the gastro intestinal tract, although there

is limitation to this approach where *in-vivo* dry/organic matter digestibility should have been applied. Measure feed digested was increased as the amount of concentrate pellets increased. Average daily gain of the experimental cattle leads to good results, as shown in Table 4 that the ADG increased linearly from 292 to 543 g/head.d accordingly to the pellets supplementation; although the improvement was negligible since there was no significant difference ($p>0.05$).

DISCUSSION

FEED INTAKE, FEED CONVERSION RATIO (FCR) AND METABOLISABLE ENERGY

Timor Bali cattle fed concentrate pellets had higher intake as the percentage of pellets offered increased up to 1.5% live weight. A popular explanation of this intake pattern is that cattle eat pellets to supply the insufficient amount and low quality of maize straw offered as basal diet. Table 2 revealed that dry matter ration offered to cattle during this sea voyage ranged between 1.26 and 2.42% LW containing crude protein 3.95 to 7.77% and metabolisable energy 8.40 to 11.22 MJ/kg DM. To compare, Parakasi (1999), demonstrated that growing beef cattle, live weight between 225 and 315 kg, required dry matter ration from 2.27 to 2.32% live weight containing crude protein 8.6 to 9.4% and metabolisable energy 8.20 to 8.95 MJ/kg DM.

Our finding that the dry matter diet fed to cattle by the trader was lower than required, even pellets was added up to 1% live weight. Addition of pellets up to 1.5% live weight, however, increased DMI exactly to meet the requirement suggested by Parakasi (1999). Pellet consumption in current study is consistent with what has been found in previous study that cattle prefer pellets over ground grains (Sporndly and Asberg, 2006). The present finding is important because there is opportunity to solve body weight lost problem during sea transportation by way of adding dietary pellets.

A limitation of the feeding method in this study was that the supplied ration contained less crude protein than required. Consequently, crude protein intake was 4.00 to 7.58% DM, which was remain lower than that suggested by Parakasi (1999). Despite this limitation, we obtain good results with this simple feeding method where inclusion of leucaena leaf meal and the increasing quantity of pellets enhance crude protein intake. The increasing crude protein intake in this result ties well with previous studies wherein crude protein intake of Thai native cattle increased linearly according to addition of leaf pellet supplementation (Phesatcha *et al.*, 2022). That previous study on Thai native beef cattle also reported an increased microbial population which can be speculated that Timor Bali cattle in the present study have yielded microbial protein.

The finding that FCR in this study was not affected by supplementation of dietary pellets was consistent with what has been reported in the in-land study (Aoetpah *et al.*, 2024). Interestingly, this non-significant difference was also recorded in the ADG. It is unclear whether this was related to a very narrow level of pellets been added. It could be likely due to the limited amount of maize straw offered.

The higher metabolisable energy in pellets was clearly accounted for the higher metabolisable energy intake on cattle. The increasing intake of fibre fractions may have been caused by accumulation of fibre intake from both maize straw and pellets. Additionally, pellet inclusion, which led to enhanced intake of maize straw, could be explained by the role of rumen microorganisms and digestibility. The finding that DMI maize straw increased as the increasing level pellets fed was opposite to the decreasing percentage of maize straw (Table 3). This is because the function of giving these pellets is as a supplementary feed, not as a substitute feed which was resulted in less basal diet refusals. This finding is in line with Klevenhusen *et al.* (2017), who concluded that concentrate quantity altered rumen bacterial communities which would improved feed degradability, enhanced digestibility, and subsequent increased intake.

IN VITRO DIGESTIBILITY AND LIVE WEIGHT CHANGES

The use of in vitro digestibility in this study was a limitation approach, yet the digestibility data was in conjunction with intake and live weight changes. Hogan *et al.* (2007) reviewed that body weight loss during transportation mostly due to excretion of urine and faeces in the first 24 h, salivation and loss of appetite as a result of physiological stress. Urine and faecal odor (Varel, 2002) might also reduced appetite. Fragrant odor and cylindrical form of pellet concentrate in the present study would have enhanced palatability, improved rumen function, supplied crude protein and metabolisable energy, and therefore increased live weight gain. We have verified that using leucaena leaf meal in dietary concentrate produces similar results to those reported by Aoetpah *et al.* (2024) who found that feeding Timor Bali cattle on Cipelang (*Pennisetum purpureum* cv. Taiwan) grass as a basal diet with leucaena leaf meal 1% live weight increased daily weight gain 375 g/d. Compared ADG (292 – 543 g/d) in the present study to those in prior land-based study (Aoetpah *et al.*, 2024), it can be stated that ADG of Bali cattle in sea transport was not truly worse as long as leucaena leaf meal was incorporated in the concentrate pellets and supplemented to maize straw basal diet.

The Control group also gained weight, possibly due to recovery at the destination site. Normal practice by cattle trader offering limited quantity of dry matter feed due to less available room to store straw or hay grass could be solved with feeding pellets. Although others have long

been demonstrated that dietary pellets improved rumen function and digestion (Hogan *et al.*, 2007; Wanapat *et al.*, 2006) and body weight gain, the present study highlighted the use of pellets as a novel feeding practice in sea voyage from Tenau-Kupang Portland Indonesia, although the benefit was non-significant since all groups gained weight. Compared to previous study that Bali cattle on sea transport experienced LW loss 11.63% (Aditia and Baihaqi, 2024), the weight gains of cattle in the present study showed that LW loss was truly prevented.

CONCLUSIONS AND RECOMMENDATIONS

The dietary pellet concentrate containing leucaena leaf meal improved intake and increased a non-significant weight gain of Timor Bali cattle during live transport on sea voyage. Our finding revealed that these cattle on maize straw as a basal diet during sea transport were better fed when the dietary pellets containing leucaena leaf meal supplied.

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NOVELTY STATEMENTS

The novelty of this research lies in the use of pellets for Timor Bali cattle during sea transport from Tenau Portland, Kupang to East Kalimantan, Indonesia. Body weight loss of Bali cattle on sea voyage is prevented using this leucaena leaf meal pellets.

AUTHOR'S CONTRIBUTIONS

Aholiab Aoetpah had the role in designing and generating the concept, running data analyzes and writing the original draft.

Jemseng C Abineno contributed to monitoring and controlling the research.

Ferdi A. I Fallo supervised the research.

Gregorius G Batafor and Musa F. Banunaek conducted the experimental work.

All authors reviewed and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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