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Original Research

Growth Performance and Carcass Characteristics of Cobb 500 Broiler Chicken Fed Potato Peel Meal as a Partial Substitute of Maize

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Abstract

An investigation was carried out to assess the impact of partially replacing maize with potato peel meal (PPM) on the carcass features and growth performance of Cobb 500 broilers. One hundred and twenty day old chicks were split up into four groups of thirty chicks each. Four starter treatment rations including food with 0%, 5%, 10%, and 15% PPM as a substitute for maize were randomly assigned to these, and they were set up in a CRD with three repetitions. The data collected on growth performance, organ weights, carcass traits, and meat chemical composition were subjected to statistical analysis. The findings showed that there was no discernible variation in the experimental chicks' daily body weight gain or DFI during the beginning period. The groups that received the therapy consisting of 5–15% PPM in place of maize throughout the finisher phase experienced noticeably increased DFI and daily body weight gain. Over the course of the 42-day feeding trial, there was no discernible variation in the average FCR among all the groups. Overall, without having an impact on the birds' ability to grow, their ability to produce carcasses, their organ weights, or the chemical makeup of their meat (C0b 500).

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INTRODUCTION

Poultry farming is costly in poor nations like Ethiopia due to the shortage and high market price of cereal grains and other energy concentrates (Wadhwa and Bakshi, 2013). Madubuike and Ekenyem (2001) and Faniyi (2002) state that 70–80% of the total expenditures associated with producing chickens come from feed costs, a significant amount of which is attributable to the high price of maize on the market. In Ethiopia, maize is a widely consumed staple grain (Yami et al., 2020). The price of maize, chicken, and poultry goods has increased on the market as a result of the conversion of maize to animal feed. Ethiopia is not self-sufficient in cereal grains like maize, which puts it under double pressure. This situation calls for an evaluation of the non-traditional feed sources that are readily available locally and the inclusion of the most promising diets for chicken (EI Boushy & Vanderpoel, 2000).

Solanum tuborsum, or potato peels, are a locally accessible feed resource that can be used to make chicken feed. A significant amount of peel is left over after eating potato leaves in Ethiopia; this is a byproduct. Potato peels are currently produced in small-scale potato chip production companies, hotels, restaurants, and homes. Depending on the method used for peeling, 15–40% of the total tuber is made up of peels (Arapoglou et al., 2010). Peels are a significant environmental problem in urban areas.

Thus, there are negative effects on the environment, human health, and economy when potato peels are used as chicken feed. Sun-dried potato peels, according to Kpanja et al. (2019), provide a moderate amount of nutrients that are adequate to meet the partial nutrient requirements of broilers without impairing their growth performance.

Therefore, it's critical to look for substitutes in which non-traditional feeds, like the peels from potatoes, can be used in place of maize in a chicken's diet. Therefore, the purpose of this study was to assess how the development performance and carcass characteristics of Cobb 500 grill chickens were affected when maize was substituted with potato peel feed.

Materials and Methods

Description of the Experimental Site

350 km south of Addis Ababa, at the Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) Poultry Farm, was the site of the experiment. The location of the experimental site is 1750 metres above sea level, with latitudes of 70˚ 42' 9"N and longitudes of 36˚47' 6"E. The average annual relative humidity is 39.9 and the average annual high temperature is 26.8˚C. The average annual minimum temperature is 11.4˚C. The experimental site saw 1250 mm of yearly rainfall on average (Ebisa et al., 2018).

Preparation of Potato Peel Meal

The Potato Peel Meal (PPM) utilized in this study was obtained from the student cafeteria at JUCAVM, where the peel was mechanically peeled from raw potato tubers using a knife. Fresh peels were collected, washed, and sundried on a plastic sheet as they were peeled off the tuber. These were prepared to go through a 3 mm filter and kept dry and free of rodents until they were required for feeding trials and laboratory testing.

Laboratory Chemical Analysis

For proximate analysis, representative samples of PPM as well as additional feed ingredients (maize, sorghum, soybean, wheat bran, bone, and meat meal) were obtained. Every sample was powdered to fit through a 1 mm filter after being dried in an oven. The Kjeldahl method was used to quantify nitrogen, and N x 6.25 was used to compute crude protein (CP). Using the Pauzenga (1985) formula, the metabolizable energy content of the feed constituents was determined.

$$ME = (37 \times \%CP) + (81.8 \times \%EE) + (33.5 \times \%NFE)$$

Experimental Ration Formulation

The grill treatment diets for starters and finishers, as presented in Table 1, were developed in compliance with the dietary needs (NRC, 1994) of the experimental chicks, taking into account the outcomes of laboratory analytical data. The initial treatment meals were designed to have 21-22% crude protein and 3025–3161 Kcal of metabolizable energy/kg of dry matter. The treatment meals for finishers were designed to include 19–19.5% crude protein and 3106–3217 kcal of ME/kg of DM. Following the National Research Council's recommendations, all treatment diets were similarly supplemented with a vitamin and mineral premix as well as synthetic amino acids (lysine and methionine) (NRC, 1994).

Table 1

Ingredients Proportions of the Starter's and Finisher's Treatment Rations

Ingredients (%)	Starter				Finisher			
	T1	T2	T3	T4	T1	T2	T3	T4
Maize	55	52.25	49.5	46.75	55	52.25	49.5	46.75
Potato Peel Meal	0	2.75	5.75	8.25	0	2.75	5.25	8.25
Sorghum	10	10	10	10	13	13	13	13
Soya bean Meal	25	25	25	25	17	17	17	17
Wheat bran	1.2	1.2	1.2	1.2	6.2	6.2	6.2	6.2
Bone and Meat Meal	6	6	6	6	6	6	6	6
Limestone	1	1	1	1	1	1	1	1
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	1	1	1	1	1	1	1	1
Total	100	100	100	100	100	100	100	100
Composition (%)								
DM	91	90	89.9	89.9	91	90	89.9	89.9
CP	21	21.5	22	22	19	19.5	19.5	19.45
CF	4	4.5	4.8	5.5	6.5	6.9	7.5	7.7
EE	3.79	3.39	3.52	3.38	7	6.5	6.8	6.9
Ash	3.78	3.88	4.43	4.49	3.4	3.38	3.43	3.49
*NFE	58.43	56.43	55.15	54.53	54.7	53	51.67	51.35
**ME/kg DM)	3161	3087.2	3059	3025	3217	3134.7	3112	3106.5
Calcium	1.02	1.02	1.01	1.01	1.01	1.01	1.02	1.03
Phosphorus	0.66	0.64	0.63	0.61	0.67	0.71	0.75	0.78

*T1= Ration containing 0% potato peel meal, T2= Ration containing 5% potato peel meal, T3= Ration containing 10% potato peel meal, T4= Ration containing 15% potato peel meal DM= Dry Matter, CP=Crude Protein, CF= Crude Fiber, EE= Ether Extract, NFE= Nitrogen Free Extract, ME=Metabolizable Energy, *NFE= DM%-(CP+CF+EE+Ash), *ME=37× %CP+81.8×%EE+35.5×%NFE(Pauzenga,1985).*

Management of the Experimental Chicks

Alema commercial poultry farms in Bishoftu provided a total of 120 unsexed day-old Cobb500 broiler chicks. Following their arrival at JUCAVM Poultry Farm, the chicks were weighed individually and split into four groups of thirty each at random. Three groups, each containing ten chicks with similar mean group weights, were created by further subdividing each group. Before the chicks arrived, the experimental pens were properly cleaned, disinfected, well-ventilated, and outfitted with all the equipment required for poultry housing. All the groups were kept in separate 2.5 x 1 m pens and were given round hand feeding and drinkers. On the first, fourteenth, and twenty-first days, the chicks received vaccinations against Gomboro, Newcastle disease, and Marek's disease, respectively. Throughout the trial period, the experimental diets were provided twice a day, at 8:00 p.m. and 16:00 a.m. There was always water available. Lastly, in a fully randomised design with three replicates, the experimental chicks were assigned at random to the experimental beginning treatments (Table 2). After the 21-day feeding study, the chicks were moved to the finisher treatment ration.

Table 2

Allocation of the treatments to the experimental chicks

Treatments*	Replication per treatment	Birds per replication	Total Birds/Trt
Ration containing 0 % of PPM (T1)	3	10	30
Ration containing 5% PPM (T2)	3	10	30
Ration containing 10% PPM (T3)	3	10	30
Ration containing 15% PPM (T4)	3	10	30
Total		120	

Trt= treatment

Data Collection

Production performance data

Before the experiment started, the chicks' initial group body weight was noted for each replicate. Every week, the weight of the subjects was recorded in the morning before meals. At the conclusion of the feeding study, the ultimate body weight was determined. The difference between the feed that was offered and the feed that was left over was used to compute the average weekly feed consumption. The average feed consumed divided by the average body weight gain yielded the feed conversion ratio.

Carcass Characteristics

Following a 42-day feeding trial, two birds were arbitrarily chosen for each replicate. The chosen birds were starved before they were killed. Using a sharp knife, the jugular vein was severed to complete the slaughter procedure. Following evisceration, weights of the organs and hot carcasses were measured and reported in grammes. The proportion of live weight that was subtracted from edible offal (liver, gizzard, and skin) was used to compute the dressing percentage. The carcass was then divided into drumstick, thigh, neck, and back parts, and divided into breast, wing, and back sections. It was then weighed and expressed in grammes. To measure pH, a pH-meter electrode was inserted directly into the Pectoralis major (breast) muscle, two centimetres below the surface. An oven set to 105°C was used to measure the meat's moisture content. The Kjeldahl method was used to calculate the crude protein content (AOAC, 1990). Diethyl ether was used to remove the meat samples in order to assess their fat content (AOAC, 1990). The AOAC (1990) was used to determine the ash content.

Data Analysis

Using the General Linear Model (GLM) and the Statistical Analysis System (SAS, version 9.3), all of the gathered data were investigated using analysis of variance (ANOVA) for completely randomised designs. Duncan's Multiple Range Test (DMRT) was used to compare treatment averages at α=0.05.

The model that was used to analyse the data was this one. $Y_{ij} = \mu + T_i + e_{ij}$

Results and Discussion

Chemical Composition of Potato Peel Meal

Table 3 displays the findings of the chemical examination of potato peel meal (PPM). PPM's metabolic energy content was 2826 kcal/kg less than that of the study's maize, which had a metabolic energy content of 3350 kcal/kg. Research has demonstrated that maize has higher energy content than PPM; this is mostly because of the variations in EE content between the two components. However, the PPM has higher protein content than maize, which may have played a role in the chickens given the PPM showing comparable growth rates. The ME value obtained in this investigation was less than that reported by Ghazalah et al. (2002) for PPM, which was 3200 kcal/kg. In the current investigation, PPM had a crude protein content of 13%; this was greater than the figure reported by Raphael et al. (2017), who reported 11.61% from sun-dried PPM. Furthermore, the current study's measurement of PPM's crude protein content (13%) was greater than that of the majority of cereal grains (8–12%). Simplot (2013) reports that potatoes have a somewhat greater crude protein content than other roots and tubers.

The current study's findings indicate that the crude protein content (13%), which was obtained from PPM, was greater than the crude protein amount found in potato tubers.

In the current investigation, the PPM showed an EE concentration of 0.7%. The PPM utilised in this investigation had a crude fibre level of 5.71%, suggesting that chickens could eat it. This figure is less than the data published by Raphael et al. (2017) and Hassan (2017), who found that the crude fibre concentrations were 8.01% and 10.17% PPM, respectively. The peeling technique, potato variety, and drying duration may all have an impact on the diversity in PPM's chemical makeup.

Table 3

Chemical composition and Calculated ME of maize and PPM used in the study

Constituents (%)	Ingredients	
	Maize	PPM
Moisture	7.50	8
DM	92.50	92
Crude protein	7.00	13
Crude Fiber	2.10	5.71
Ether Extract	4.00	0.7
Ash	1.80	7.63
*Nitrogen Free Extract	77.9	64.96
**Calculated ME (kcal/kg)	3350	2826

*ME= Metabolizable Energy, * Nitrogen Free Extract = DM% - (Crude protein + Crude fiber + Ether extract + Ash) **ME (kcal/kg)= 37× % Crude protein+81.8× %Ether Extract +35.5×%Nitrogen Free Extract (Pauzenga,1985).*

Feed Consumption

Table 4 displays the feed intake data of the experimental chicks fed the beginning treatment meals. The mean daily feed intake during the starter phase did not differ significantly (P > 0.05) amongst any treatment groups, suggesting that PPM might be incorporated in the starter meals to replace 5–15% of the energy in maize. On the other hand, the groups fed the finisher's ration with 5–15% PPM instead of maize energy had considerably (P<0.05) greater mean daily feed intake than the group fed the control finisher's treatment ration based on maize. Based on the average daily feed consumption, the current study's results indicated that PPM might be used to safely replace 5–15% of the maize in the finisher's ration. The groups assigned to treatments containing 5–15% PPM had a greater mean daily feed consumption than the control treatment group, according to the data. This could be because maize tan in PPM has a greater ME content. It has been proposed that the broiler's feed intake and the ME of the ration are related because, in order to meet their energy needs, broilers often eat less high-energy feeds than high-energy feeds. The present findings are consistent with those of Cruz (2016), who observed that grill feed intake rose as cocoyam meal inclusion in the ration increased.

The current study's findings also support those of Badr et al. (2019), who found that feeding the experimental grill with prickly pear peel increased its intake of feed. A partial replacement of maize in broiler diets with yam peel meal resulted in a considerable increase in feed intake (P 0.05), according to Ekenyem et al. (2006). In a similar vein, Blandon et al. (2015) observed that higher levels of banana peel meal inclusion led to an increase in the feed consumption of experimental broilers.

Body weight gain

Table 4 displays the experimental chicks' growth performance. The findings showed that, for all treatment groups, there was no significant difference (P > 0.05) in the mean daily body weight growth during the starting phase. The findings of this study were in contrast to those of Diarra et al. (2012), who found that grill performance was considerably reduced during the beginning phase when 15% of the diet was replaced with yam peel meal instead of maize.

However, there was a significant difference (P<0.05) in the daily body weight gain between the groups fed the control finisher's ration and the groups given the PPM-containing therapy. At the conclusion of the sixth week of the feeding trial, the group fed on the treatment ration containing 0, 5, 10, and 15% of PPM, respectively, achieved the mean final body weight of 2057.53, 2121.59, 2128.54, and 2115.32 g/head (Table 4). Between the groups fed on 5–15% PPM, there was no statistically significant difference (P > 0.05) in the mean end body weight.

The increased feed intake of the animals receiving PPM treatments instead of maize may have contributed to the higher body weight reached by those groups. According to reports, feed intake and body weight grow proportionately (Bogart and Taylor, 1983). The current study's findings concurred with those of Kpanja et al. (2019), who found that grill diets with up to 15% PPM had a beneficial impact on growth performance. Diarra et al. (2012) found that broilers fed up to 15% yam peel diet showed a substantial increase in both live body weight and body weight gains.

The current study's findings are consistent with those of Ekenyem et al. (2006), who found that feeding experimental broilers with yam peel meal increased the animals' live weight. Badr et al. (2019) reported that adding up to 15% of prickly pear peel fruit to the Cobb grill ration improved growth performance.

Feed Conversion Ratio

Table 4 displays the feed conversion ratio of the experimental chicks. The feed conversion ratio did not significantly differ between treatment groups in the starter phase, suggesting that PPM at a rate of 5–15% might substitute maize grain in the starter grill ration in a safe and effective manner without having an adverse effect on the ratio. Likewise, no significant difference (P > 0.05) was found in the mean feed conversion ratio for any of the treatment groups during the finishing period. This suggests that PPM at a rate of 5–15% could replace maize in the finisher's grill ration in a safe and effective manner without having an adverse effect on the feed conversion ratio.

The current study's findings are consistent with those of Ekenyem et al. (2006), who found that feeding Anak 2000 broilers up to 15% yam peel meal instead of maize did not significantly alter the feed conversion ratio (P > 0.05). According to Zhang et al. (2019), there was no discernible variation (P > 0.05) in the feed conversion ratio of Ross 308 broilers that were fed dry heat-processed sweet potato waste in place of maize for the term of feeding. However, the current study's findings run counter to those of Badr et al. (2019), who claimed that increasing the amount of pear peal substituted for maize by up to 15% increased the conversion ratio of Cobb 500 broilers.

Table 4

Effect of Partial Substitution of Maize with PPM on growth Performance of experimental chicks

Parameters	Dietary treatments				
	T1	T2	T3	T4	PV
Table.4 continues…					
Starter phase (1-21 days)	55.8±0.11	55.7±0.11	55.90±0.55	55.93±0.31	0.74
IBW(g)	610.8±4.94	611.75±5.83	612.91±3.89	611.38±1.54	0.98
FBW(g)	29.08±0.23	29.13±0.27	29.18+0.18	29.11±0.07	0.98
DBWG(g)	44.82±0.15	44.61±0.09	44.79±0.27	44.66±0.07	0.78
DFI(g)	1.46±0.01	1.45±0.01	1.45±0.003	1.45±0.003	0.81
FCR					
Finisher phase(22-42 days)					
IBW(g)	610.8±4.94	611.75±5.83	612.91±3.89	611.38±1.54	0.98
FBW(g)	1446.73±18.05[b]	1509.84±19.48[a]	1515.62±6.41[a]	1503.94±7.16[a]	0.03
DBWG(g)	68.89±0.85[b]	71.90±0.92[a]	72.17±0.30[a]	71.61±0.34[a]	0.02
DFI(g)	128.89±1.23[b]	132.85±2.35[ab]	134.76±0.83[a]	133.41±0.55[ab]	0.04
FCR	1.86±0.006	1.84±0.02	1.85±0.003	1.85±0.003	0.54
Entire period(1-42 days)					
FBWG(g)	2057.53±18.54[b]	2121.59±14.33[a]	2128.54±2.51[a]	2115.32±5.79[a]	0.01
TFI(g)	3638.00±26.45[b]	3713.67±47.34[a]	3754.67±15.43[a]	751.33±33.21[a]	0.03
FCR	1.75±0.012	1.75±0.02	1.76±0.006	1.77±0.01	0.71

Carcass and internal organ characteristics

Carcass Characteristics

Table 5 displays the experimental chicks' traits and carcass yield. The findings demonstrated that there were no appreciable variations in carcass yield or carcass features across the treatment groups (P > 0.05). Table 5 further shows that there was no significant difference (P > 0.05) in carcass cut portions between any of the treatment groups. This demonstrated that PPM may, to a certain extent, take the place of maize in a 500-chicken feed. These findings contradict previous research on conventional feeds (Yibrew et al., 2012), which reported that feeding Cobb 500 broilers with mango fruit waste instead of maize enhanced their dressing % when compared to the groups fed a maize-based control treatment. The groups that were given a substitute of 5–15% PPM for maize, on the other hand, exhibited higher numerical values of carcass and carcass cut portions. According to Badr et al. (2016), using up to 15% of prickly pear peel meal in place of yellow maize increased the carcass weight and dressing percentage of Cobb 500 broilers.

Internal organs of the Experimental Chicks

The replacement of potato peel meal for maize grain in Table 6 did not change the internal organ weights (P > 0.05). This is due to the fact that there was no discernible difference (P > 0.05) in internal organs (liver, kidney, heart, and stomach) between any of the therapy groups. This further suggests that the substitution of maize with 5–15% PPM did not have any detrimental effects on the physiological and anatomical functions of the internal organs.

Table 5

Effect of partial substitution of Potato Peal Meal with Maize on Weight of Carcass and Carcass cut parts of Broiler (Mean ± SE) chicken

Parameters	Dietary Treatments				
	T1	T2	T3	T4	PV
Live weight (g)	2123.50 ±5.50	2131.50±13.38	2131.33±26.89	2129.17±28.99	0.99
Carcass (g)	1384.17±2.006	1406.67±9.93	1406.33±17.32	1403.50±21.23	0.61
Dressing percentage (%)	65.18±0.001	66.3±0.001	65.9±0.001	65.9±0.002	0.34
Breast (g)	540.35±0.80	548.50± 3.83	548.66± 6.81	547.833±6.79	0.63
Drumstick with thigh(g)	470.93± 0.742	478.16±3.42	478.16± 5.95	476.83±6.56	0.67
Back	229.058± 0.51	232± 1.59	231.83± 2.83	231.5± 3.06	0.77
Neck	48.44±0.20	49.66±0.49	49.33± 0.66	49.33±0.80	0.50
Wing (g)	97.05±0.26	98.33± 0.61	98.16± 1.10	99±1.48	0.80

The outcome matched that of Guluwa et al. (2014), who found that internal organs such the heart, liver, gizzard, and intestine weight were not adversely affected by sweet orange peel soaking in water. Zhang et al. (2019) also found that internal organs of Ross 308 fed varying amounts of dry heat-processed sweet potato waste instead of maize showed no significant variation (P > 0.05) across any treatment groups. The present findings were consistent with those of Badr et al. (2019), who found no adverse effects on the giblet percentage of Cobb 500 grill chicken with prickly pear peel substituted at a rate of up to 15%.

Table 6

Effect of partial substitution of Potato Peal Meal with Maize on Internal organ of Broiler (Mean±SE)

Parameters	Dietary treatments				
	T1	T2	T3	T4	PV
Gizzard (g)	49.16±0.83	47.5±1.11	45.83±2.006	47.5±2.14	0.63
Liver with bile (g)	40.50± 1.60	40± 1.80	38.33±1.50	38.33±1.05	0.26
Kidney(g)	4.50±0.34	4.5±0.34	4.5±0.34	4.33±0.33	0.98
Heart (g)	9.52± 0.19	9.77± 0.134	9.77± 0.130	9.82± 0.12	0.38

T1= Control, T2= 5% PPM, T3= 10%PPM, T4= 15% PPM, PPM =Potato Peel Meal, PV= Probability Value

Chemical Composition of Meat

One key measure of meat quality characteristics is the pH of breast flesh. The pH values recorded for each treatment group in the current investigation (Table 7) fell within the standard range reported for chicken meat (Castellini et al., 2002). Table 7 displays the findings of the experimental chicks' meat's chemical makeup. The composition of the meat did not significantly change across any of the treatment groups (P>0.05). Every parameter that was taken into consideration showed a numerical value difference between the treatment groups. In terms of numbers, the meat from the groups fed the control treatment had lower levels of DM, CP, and ash content, and greater levels of moisture and EE% than the groups fed the treatment that substituted varied amounts of PPM for maize. The present findings were consistent with those of Badr et al. (2019), who observed that replacing maize with peels from prickly pear plants increased protein and ash content while decreasing EE in comparison to the control group.

Table 7

Effect partial substitution of Potato Peel Meal with Maize on Chemical Composition and pH of broiler breast Meat (Mean±SE)

Parameters	Dietary treatments				
	T1	T2	T3	T4	PV
pH after slaughter	6.39±0.003	6.39±0.006	6.39±0.003	6.48±0.09	0.75
Moisture	72.6±0.59	70.65±1.35	70.48±1.053	69.72±0.99	0.31
DM	27.4±0.59	29.34±1.35	29.51±1.05	30.27±0.99	0.31
CP	19.49±0.74	22.31±1.41	22.56±0.90	23.40±0.95	0.11
EE	4.66±0.08	3.24±0. 002	3.25±0.10	3.24±0.03	0.30
Ash	3.24±0.48	3.78±0.21	3.69±0.05	3.633±0.08	0.54

DM= Dry Matter, CP=Crude Protein, EE=Ether Extract, T1= Control, T2= 5% PPM, T3= 10%PPM, T4= 15% PPM, PPM =Potato Peel Meal, PV= Probability Value

CONCLUSIONS

The study showed that sun-dried PPM could safely be included up to 15% as a substitute for maize in both starter's and finisher's broiler rations without having a negative effect on the growth performance of the experimental chicks. The study also revealed that sun-dried PPM could replace up to 15% of maize in broiler rations without affecting the carcass, organ weights, or meat chemical composition of Cobb 500 broiler chickens. Further research should be conducted in the area of including PPM in the layer's ration for determining egg production performances.

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DATA AVAILABILITY STATEMENT

All data underlying the study results are available from the corresponding author upon reasonable request.

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