Effect of substituting maize in the grower diet with ground *Prosopis juliflora* pods on performance of indigenous chicken in Kenya

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Abstract

Ninety-six KARLO improved chicken (KIC) aged 8 weeks were used to study the effect of replacing the maize component in commercial grower feed with *Prosopis juliflora* pods on growth performance. A commercial grower feed, without ground *Prosopis juliflora* pods GPJP, was used as the control diet. The experimental diets were formulated by replacing maize in the diet with GPJP at 0% (PJP-0), 10% (PJP-10), 20% (PJP-20) and 30 % (PJP-30). A Completely Randomized Design (CRD) was used with the four dietary treatments that were iso-nitrogenous and iso-caloric. Feed intake and live weight gains were monitored for eleven weeks and used to calculate feed conversion ratio (FCR). Two birds from each pen were slaughtered to measure different parts carcass weights.

Results indicate that PJP-10 and PJP-30 decreased feed intake as compared to PJP-0 in pullets, while in cockerels, PJP-30 decreased feed intake as compared to treatments PJP-0 and PJP-10. All treatments had similar findings on live weight gains in pullets. However,PJP-30 had lower live weight gains than PJP-0 in cockerels. PJP-30 had lower final live weight (FLW) in pullets and cockerels however PJP-20 in cockerels gave similar results as PJP-30. In cockerels, PJP-30 had lower values for live weight change (LWC) as compared to PJP-0 and PJP-10. Cockerels receiving PJP-30 had lowest yields for dressed cold weight (DCW) eviscerated weight (EW) and breast weight (BW) as compared to yields from the other treatments with PJP-0 and PJP-10 having similar weights for DCW and EW while in BW the first three levels of GPJP inclusion had similar weights. In pullets, the first three levels of GPJP had similar BW yield but PJP-30 yielded lower BW than PJP-0. All treatments had similar effects on Leg W in pullets. These results indicate there is GPJP potential as a poultry feed ingredient to reduce the burden of overreliance on cereals.

Key words: *cacarcass weight, daily gain, feed conversion efficiency, feed intake, improved chicken, Kenya, maize*

Introduction

Poultry production is constrained by many factors, feed being the major challenge (Meseret et al 2011a; Kingori et al 2010). The main source of energy in poultry ration is cereals (AL-Marzooqi et al 2015) with maize being the most commonly used grain in Kenya for poultry feeding. On the other hand, the staple food for Kenyans is maize grains which is consumed as grains or ground to make maize flour thus creating competition between man and poultry resulting in exorbitant feed prices (Yusuf et al 2016). With the increasing human population, diminishing land dedicated for grain production and climate changes that are becoming increasingly unfavourable for maize production, there is need to look in other viable and sustainable feed alternatives for the poultry industry. The increasing population coupled with growth in the economy will see an increasing in consumption of animal related protein sources.

Since feed as an input accounts for approximately 60-80% of the total cost of poultry production (Mukhtar 2012), there is need to ensure that birds continue producing without being affected by this constraint. This can be made possible by embracing the use of non-conventional feedstuffs like *Prosopis juliflora* pods that remains largely underutilized (Sawe et al 1997). Prosopis has been harnessed and used in feeding various animals. Wanjohi et al (2017), Yusuf et al (2016), AL-Marzooqi et al (2015), Odero-Waitituh (2015) and Meseret et al (2011a) have incorporated *Prosopis juliflora* pods in broiler diets with positive results. Meseret et al (2011b) reported good performance in layers while Haščík et al (2011) reported improved sensory attributes in broiler meat when fed on *Prosopis juliflora* pods. Wanjohi et al (2017), reported a 20 % replacement of the complete KIC diets had positive effect. This study was therefore important in establishing the potential of prosopis as a replacement for maize in KIC diets.

Materials and methods

Study site

The on-station feeding trials for KIC was conducted at KALRO Non-Ruminant Institute (NRI) at Naivasha. NRI is 100 km west of Nairobi at an altitude of 1900 m a.s.l. The station has a bimodal rainfall pattern with an annual mean of 620mm. The average day and night temperature are 26°C and 8°C respectively and a relative humidity range between 60 and 75 %. The natural vegetation is predominantly star grass (*Cynodon plectostachyus*) with scattered tall Acacia trees (*Acacia xanthophloea*).). Soil is volcanic in origin, alkaline (p H 7.4), dark, sodic and deep. (Herrero et al 2010).

Dietary treatments

Four dietary treatments consisting of a control with 0% GPJP (PJP-0) and three other diets formulated by replacing the maize portion in the commercial grower diet with GPJP at 10%(PJP-10), 20% (PJP-20) and 30 % (PJP-30) as presented in Table 1.

Experimental design

A complete randomized design (CRD) was used with 24 growers per treatment (12 pullets and 12 cockerels). The diets were randomly allocated to the KIC. Free access to feed and clean water was allowed throughout the experimental period

All the 96 KIC growers were offered the respective treatments and daily feed intake (feed offered minus feed remains from 7am to 6pm) recorded. The refusals were weighed each morning before the fresh feed was offered. Weekly feed conversion ratio was calculated as the ratio of feed intake per bird to the body weight gain per bird (average daily feed conversion ratio per week). Average live weight gain for each experimental unit was represented by the average change in pen weight for a given period of time. Weight gain of the growers was monitored by weighing the birds weekly at 0900 hours (before morning) feeding from the10th to 20 th week of age.

The birds were assigned to the four treatments in a completely randomized design (CRD). Each treatment had four pullets and four cockerels replicated three times

Carcass evaluation

On the 20th week, two birds per pen were randomly selected and fasted for 12 hours with free access to drinking water. They were then weighed and sacrificed and the carcass dissected into various cuts. Carcass measurements included pre-slaughter live weights, cold dressed weight, prime cuts (breast, back, legs (drumstick and thigh) and wing weights. The dressing percentage was calculated as a ratio of carcass weight to pre-slaughter live weight.

Chemical analyses

Feeds samples were dried and ground to pass through a 1mm screen using a Wiley mill. The samples were then analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash while calcium and phosphorus were analyzed by atomic absorption spectrophotometry using the methods of AOAC (1990). Gross energy was determined using a bomb calorimeter.

Statistical analyses

Data were analyzed using Statistical Analysis Software (SAS 2002) using General Linear Model of Analysis of Variance-GLM (ANOVA) to determine the difference between the treatment means at 5% significance level. Means differences were separated by Tukey’s test.

Results

The experimental diets formulated for KIC and were iso-caloric and iso-nitrogenous, around 13.00MJ/Kg on average and 23% CP respectively (Table 1) with crude fiber increasing as the level of GPJP increased and as the level of maize decreased from PJP-0 to PJP-30.

Table 1. Experimental diets composition

Ration composition	Treatments			
	PJP-0	PJP-10	PJP-20	PJP-30
GPJP	0.00	6.40	12.80	19.20
Maize	64.00	57.60	51.20	44.80
Fish meal	7.50	7.50	7.50	7.50
Soy bean	24.50	24.50	24.50	24.50
Vegetable oil	2.5	2.5	2.5	2.5
DCP	0.65	0.65	0.65	0.65
Iodized salt	0.5	0.5	0.5	0.5
Vitamin premix*	0.35	0.35	0.35	0.35
Total	100.00	100.00	100.00	100.00
Chemical composition				
DM (%)	89.40	89.80	90.90	90.60
CP (% DM)	23.04	23.39	23.43	22.97
EE (% DM)	8.61	8.13	7.81	7.06
CF (% DM)	4.59	5.36	5.59	6.54
Ash (% DM)	7.80	8.10	8.20	8.25
NFE (% DM)	45.36	44.70	45.63	45.67
Ca (% DM)	1.01	0.97	0.99	0.96
P (% DM)	0.45	0.46	0.44	0.49
ME (MJ/Kg DM)	13.69	13.47	13.41	13.06

PJP-0= diet containing 0% GPJP; PJP-10 = diet containing 10% GPJP substituting maize; PJP-20 = diet containing 20% GPJP substituting maize; PJP-30 = diet containing 30% GPJP substituting maize; GPJP = ground prosopis juliflora pods; DCP-dicalcium phosphate; CP-crude protein; ME-metabolizable energy; CF- crude fibre.

**Vitamin premix to provide the following per kg of diet: Vitamin A, 10,000 IU; Vitamin D_3, 2000 IU, Vitamin E, 5 mg; Vitamin K, 2 mg; Riboflavin, 4.2 mg; Nicotinic acid, 20 mg; Vitamin B_{12}, 0.01mg; Pantothenic acid, 5 mg; Folic acid, 0.5 mg; Choline, 3 mg; Mg, 56 mg; Fe, 20 mg; Cu, 10 mg; Zn, 50 mg; Co, 125 mg; Iodine, 0.08 mg.*

Feed intake, daily gain and feed conversion ratio

Substituting maize with GPJP had negative effect on feed intake ($Y = -0.85x^2 + 2.55x + 86.1$, $R^2 = 0.99$) in cockerels and ($Y = -0.33x^2 + 0.42x + 64.7$, $R^2 = 0.29$) in pullets and combined sexes (Table 2 and Figure 1). The same negative effects were also observed in daily weight gain ($Y = -0.875x^2 + 2.77x + 18.7$, $R^2 = 0.99$) in cockerels and combined KIC but in pullets there was no effect of substituting maize with GPJP ($Y = -0.383x^2 + 1.49x + 10.6$, $R^2 = 0.63$) in pullets (Table 2 and Figure 2). Substitution of maize with GPJP had no FCR effect in pullets ($Y = 0.313x^2 - 1.48x + 8.56$, $R^2 = 0.67$), cockerels ($Y = 0.538x^2 - 1.99x + 6.64$, $R^2 = 0.95$) and grouped KIC (Table 2, Figure 3).

Table 2. Productive performance of KIC

Parameters	Treatments				SEM	*p*
	PJP-0	PJP-10	PJP-20	PJP-30		

Feed intake (g/day)	Pullets	65.66^{a}	61.2^{b}	65.9^{ab}	60.1^{b}	1.08	0.041
	Cockerels	87.85^{a}	87.5^{a}	86.4^{ab}	82.6^{b}	1.36	0.027
	Mean	76.73 ^{a}	74.3^{a}	74.7^{a}	71.4^{b}	0.88	0.023
Daily gain (g/day)	Pullets	11.95^{a}	11.4^{a}	12.23^{a}	10.2^{a}	0.52	0.069
	Cockerels	20.54^{a}	20.9^{a}	18.9^{ab}	15.8^{b}	0.66	0.034
	Mean	16.26^{a}	16.1 ^{a}	15.5^{a}	12.9^{b}	0.43	0.044
FCR	Pullets	7.29^{a}	7.16^{a}	6.63^{a}	7.75^{a}	0.51	0.078
(g feed/g	Cockerels	5.08^{a}	5.08^{a}	5.19^{a}	7.34^{a}	0.71	0.059
weight gain)	Mean	6.16^{a}	6.08^{a}	5.95^{a}	7.57^{a}	0.45	0.064
FLW (Kg/bird)	Pullets	1.59^{a}	1.56^{a}	1.59^{a}	1.47^{b}	24.41	0.042
	Cockerels	2.33^{a}	2.33^{a}	2.28^{ab}	2.15^{b}	38.9	0.039
	Mean	1.96^{a}	1.95^{a}	1.93^{a}	1.81^{b}	25.1	0.042
LWC (Kg/bird)	Pullets	0.915^{a}	0.885^{a}	0.918^{a}	0.801^{a}	23.7	0.065
	Cockerels	1.52^{a}	1.52^{a}	1.47^{ab}	1.34^{b}	34.7	0.038
	Mean	1.22^{a}	1.21^{a}	1.19^{a}	1.07^{b}	25.1	0.024

^{abc} *means with different superscripts differ significantly (P<0.05) within a row; P = pullet; C = cockerel, E= both pullet and cockerel combined;* ***PJP-0*** *= GPJP replacing 0% of maize;* ***PJP-10*** *= GPJP replacing 10% of maize;* ***PJP-20*** *= diet GPJP replacing 20% of maize;* ***PJP-30****= GPJP replacing 30% of maize; GPJP = ground Prosopis juliflora pods*

Figure 1. Effect of varying levels of Prosopis pods on feed intake

Figure 2. Effect

Figure 3. Effect of varying levels of Prosopis pods on feed conversion ratio

Final live weight changes

Final live weight and live weight change declined with increase in the proportion of prosopis pods substituting maize in the diet throughout the experimental period. (Table 2).

Carcass yield evaluation

As the level of maize substitution with GPJP increased, DCW, EW and Breast yields reduced in both cockerels and pullets and in leg yield for cockerels. However, substitution of maize with GPJP had similar effects in wing yields in both cockerels and pullets and in leg yield in pullets.

Table 3. Carcass performance of KIC receiving different levels of *Prosopis Juliflora* pods in their diets

KIC	Parameters	Treatment				SEM	*p*
		PJP-0	PJP-10	PJP-20	PJP-30		
Cockerel	PSW (Kg)	2.24	2.23	2.25	2.26	0.31	
	DCW (Kg)	2.03^{a}	1.99^{a}	1.99^{b}	1.98^{c}	0.01	0.027
	DP (%)	90.6	89.6	89.1	88.71	0.47	
	EW (Kg)	1.91^{a}	1.88^{a}	1.86^{b}	1.851^{c}	0.01	0.021
	EP (%)	84.9	84.1	82.02	82.9	0.56	
	Breast W (g)	308^{a}	303^{a}	319^{ab}	307^{b}	0.07	0.042
	Breast P (%)	13.8	13.5	14.2	13.7	0.33	
	Leg W (g)	540^{a}	558^{a}	522^{b}	536^{b}	0.08	0.019
	Leg P (%)	24.2	24.9	23.3	23.9	0.37	
	Wing P (%)	9.76 ^{a}	9.32 ^{a}	9.13 ^{a}	8.82 ^{a}	0.35	0.063
Pullet	PSW (Kg)	1.47	147	1.46	1.46	0.22	
	DCW (Kg)	1.320^{a}	1.318^{b}	1.302^{b}	1.29^{c}	8.32	0.006
	DP (%)	89.8	89.8	88.6	88.3	0.56	
	EW (Kg)	1.21^{a}	1.23^{ab}	1.19^{bc}	1.21^{c}	11.11	0.004
	EP (%)	82.3	83.9	81.6	81.8	0.77	
	Breast W (g)	244^{a}	240^{ab}	237^{ab}	228^{b}	6.02	0.025
	Breast P (%)	16.4	16.3	16.1	15.5	0.42	
	Leg W (g)	288^{a}	306^{a}	306^{a}	313^{a}	7.77	0.067
	Leg P (%)	19.7	20.7	20.8	21.3	0.515	
	Wing P (%)	9.87^{a}	9.72^{a}	8.91^{a}	8.88^{a}	0.38	0.059

^{abcd} means for same sex with different superscripts differ significantly (P<0.05) within a row; PSW = pre-slaughter weight; DCW = dressed carcass weight; DP = dressing percentage; EW = eviscerated weight; EP = eviscerated percentage; W = weight; P = percentage; T_1 = diet containing 0% GPJP of maize component; T_2 = diet containing 10% GPJP of maize component; T_3 = diet containing 30% GPJP of maize component; T_4 = diet containing 30% GPJP of maize component; GPJP = ground Prosopis juliflora pods

Discussion

Some studies have involved replacement of the whole diet with *Prosopis juliflora* pods such as Meseret et al (2011a) using broilers. However, few studies such as Odero-Waitituh et al (2016), Choudhary et al (2005) and Al-Beitawi et al (2010) have replaced maize component in the formulation with GPJP in broiler diets. The current study replaced maize at three levels, 10, 20, and 30 % with control being the commercial diet containing 0% of GPJP.

Feed intake, daily gain, FCR and final live weight

The results indicate that substitution of higher levels of maize with GPJP depressed feed intake (FI) in KIC. Similar study by Wanjohi et al (2017) reported a similar trend of diets negatively affecting feed intake when GPJP replaced whole diet at 30%. Further, results of FI are in agreement with the findings by Odero-Waitituh (2016) and Vanker et al (1998) who reported that 10% inclusion levels and AL-Beitawi et al (2010) who reported that up to 20% inclusion level of GPJP does not reduce the FI in broiler chicks. The inclusion levels in this study and studies by Odero-Waitituh, (2016) and AL-Beitawi et al (2010), are similar and the CF of about 6% on average in study by Meseret et al (2011a). This indicates that the GPJP at level of about 20 % provides the birds with nutrients profile that does not adversely affect their performance. This means that the feed also has a relatively lower CF and reduced effect of anti-nutritive factors making the birds to have a better feed intake.

Weight gain results indicate pullets were not affected by inclusion of any level of GPJP while in cockerels, 30% of *Prosopis juliflora* pods lowered daily gain as compared to lower levels. These results are similar to of a study involving replacement of the whole diet in KIC cockerels (Wanjohi et al 2017), but in pullets all levels of GPJP inclusion had similar weight gains. Although the high levels of GPJP had relatively same feed intake as compared to the lower levels, it indicates that the nutrients are fairly available for the KIC since the amount of GPJP is lower per unit of feed in this study as compared to substituting the whole diet (Wanjohi et al 2017).

The results follow a similar trend observed in FI. The findings could be explained by the fact that pullets have lower capacity for DM intake as compared to cockerels due to the capacity of the digestive tract making the effects of GPJP intake less pronounced in pullets than cockerels. There is similarity in results for FLW in the present study and when GPJP replaced complete diets in both pullets and cockerels, where 30% GPJP reduced FLW (Wanjohi et al 2017) but different from AL-Beitawi et al (2010) who reported the FLW was optimum at a level of 20% prosopis pods inclusion. This points to the fact that IC are not affected by relatively higher levels of CF and tannins as compared to broilers by giving better results at higher percentage of prosopis than what Odero-Waitituh et al (2016) and Meseret et al (2011a), reported. This could be due to the fact that the KIC have better fibre utilization due to their slower growth that make nutrient digestibility better than broilers that have faster growth rates (Pauwels et al 2015). The reduced daily gain in cockerels and FLW in both cockerels and pullets receiving 30 % GPJP substituting maize could be due to high fibre content that reduces feed intake and eventually lowers growth. Similar results have been reported by Al-Marzooqi et al (2015) on the use of prosopis with or without enzymes in broilers. Results for the entire experimental period do not show any difference in FCR in pullets, cockerels and grouped chicken. Study by Wanjohi et al 2017 when GPJP replacing complete diets indicate that 30% GPJP had the highest FCR in pullets and grouped birds are not in agreement with the findings of this study but apart from results of cockerels. Meseret et al (2011a) replaced the whole diet with GPJP and the results during the finisher phase are similar to the finding of this current study. Results of study by Odero-Waitituh (2015) also found no difference in broilers' FCR when maize was replaced at the same levels as this study. However, AL-Beitawi et al (2010) reported that 20% of prosopis pods have the best FCR. This can be attributed to the fact that the amount of prosopis juliflora pods did not affect the availability of nutrients. This could be due to the low amount of prosopis in the diet as compared to study where complete diet was replaced by GPJP (Wanjohi et al 2017) at the same levels as in this study thereby resulting to lower level of CF anti-nutritive factors in the diets.

In the present study**, c**ockerels receiving 30% GPJP had the lowest yields for DCW, EW and BW as compared to yields from the other treatments with 10% and 20% GPJP10% and 20% GPJP had similar yield but 30% GPJP had lower yield than 10% GPJP for DCW and EW in pullets. For BW, the first three treatments had same BW yield but 30% yielded lower BW than 10%. All treatments had similar effects on Leg W. These findings are not congruent to findings of Odero-Waitituh (2015), Meseret et al (2011a), AL-Beitawi et al (2010) and Yusuf et al (2008) who reported that at 30% inclusion level in broilers rations there was no impact in dressing percentage.

Conclusion

- *Prosopis juliflora* pods are a viable alternative to be used in the poultry diets.
- The pods can be used to reduce the competition for grains that are used as human food and other industrial uses.
- The use of the pods can reduce the feeding cost, maintain the biological performance of the chicken as well as improving the livelihoods for the communities living in the arid and semi-arid regions where the prosopis pods are easily found.

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