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Evaluation of the nutritional value of soaked-boiled-fermented Java plum (*Syzygium cumini)* seed meal for poultry

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Chemical analysis, apparent metabolizable energy (ME_n), and one feeding trial were conducted to evaluate the nutritional value of Java plum seeds (JPS) that had been subjected to a combination of soaking, boiling, and fermentation (SBF). Five broiler starter diets were formulated with the processed Java plum seed meal (JPSM) comprising 0, 80, 160, 240, and 320 g/kg of the diet. The JPS before and after processing contained 910±5.30 and 888±6.10 g DM; 44.2±0.940 and 48.1±1.02 g CP; 886±9.90 and 888±6.54 g NFE; and 13.2± 0.165 and 13.3±0.154 MJ calculated metabolizable energy; 24.4±1.33 and 9.17±0.940 g tannins per kg, respectively. The ME_n value of the processed JPSM was 14.7±0.973 MJ/kg. Feed intake (FI), weight gain (WG), and feed efficiency (FCR) of broiler chicks decreased (R^2 > 0.850) with increasing JPSM in the diet. At 80 and 320 g/kg inclusion, FI, WG, and FCR were depressed by 16.0 and 34.1%, 20.2 and 42.5%, and 4.90 and 12.5%, respectively. Liver, heart, and pancreas weights relative to body weight were not significantly (P > 0.05) affected. However, caecum, gizzard, and intestine weights increased (R^2 > 0.800), while the heart weight decreased (R^2 = 0.772) with increasing JPSM in the diet. At 80 and 320 g/kg JPSM inclusion, weights of caecum, intestine, and gizzard increased by 48.5 and 68.2%, 18.8 and 43.5%, and 9.55 and 19.2%, respectively. Inclusion of JPSM in chick diets adversely (P < 0.05) affected nitrogen retention (NR), nitrogen digestibility (ND), dry matter digestibility (DMD), and excreta water content (EWC). At 320 g/kg JPSM inclusion, NR, ND, DMD, and EWC were depressed by 30.8, 12.6, 0.42, and 2.45%, respectively. No mortality was recorded at 320 g/kg JPSM inclusion. The SBF did not improve the nutritional value of JPS for poultry production.

Key words: Anti-nutrients, broiler performance, nutrient utilization, organ weights, processing.

INTRODUCTION

The Java plum seeds (JPS) are produced by Java plum (JP) tree, belonging to Myrtaceae plant family (Kurt,

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Figure 1. The structure of Java plum fruit and seeds.

2005). The JPS are enclosed in a dark, red-purple, ovaloid fruit (Figure 1). The seeds are mainly dispersed by birds and mammals (Whitinger, 2004). In Uganda, the seeds are dispersed mainly by birds, which eat the fruit pulp and discard the seeds at variable distances from the source (Ndyomugyenyi, 2008). The seedlings from fallen seeds grow naturally under mother trees and thorny bushes, if available in the area, are good cover for the young seedlings (Chhotu et al., 2003). The seeds and leaves of JP are popular livestock feeds in some areas of India (Pankaj, 2003). The JP tree is utilized by humans as food and medicine, and the ripe JP fruit is eaten as a preserve (Okuto and Ouma, 2009; Hutchinson, 2003). The JP fruit pulp is very juicy with a sweet to stringent flavour in poorer varieties and is used to make jelly, jam, squash, wine, and vinegar (Pankaj, 2003). Pods are often fermented to make beer (Chhotu et al., 2003). The seeds were reported to possess anti-inflammatory, anti-arthritic, anti-pyretic, carminative, and astringent properties (Duane et al., 2004; Hutchinson, 2003).

In Uganda, the JPS are unused feed resource and are readily available for livestock feeding. Currently, the JP fruits are mainly eaten by children who climb trees for fun and collect the fruits, which they enjoy eating. However, the JPS left after using the pulp are of little importance and are always discarded as waste (Ndyomugyenyi et al., 2008). The JPS can be widely produced in Uganda, because JP trees thrive very well in a variety of soils including loam, marl, and sandy soils (Morton, 1987). The seeds are a potential energy source, because they are rich in carbohydrates (Pankaj, 2003). Compared to maize with a starch component of 68% (Ewing, 1997), JPS contain 41% starch (Morton, 1987). However, JPS have an advantage of being less costly and less competed for than maize. If the treated JPS meals would replace a larger proportion of maize meal, not only feed costs could reduce, but also competition between humans and livestock for maize.

Despite the availability of JPS, little work has been conducted to include the seeds in poultry diets. An attempt to include Java plum seed meal (JPSM; when JPS were boiled for 50 minutes) in broiler chick diets caused retarded growth of the chicks due to the presence of anti-nutrients (Ndyomugyenyi et al., 2008). Therefore, the ability to include JPS in poultry diets could depend on the processing techniques that eliminate anti-nutrients from the seeds. Although some anti-nutrients in JPS were identified (Ndyomugyenyi, 2008), little effort has been made to eliminate them. In addition, little work has been done to include the adequately processed JPSM in poultry diets. Therefore, this study was conducted to evaluate the nutritional value of soaked-boiled-fermented Java plum seed meal in broiler chick diets.

MATERIALS AND METHODS

Source, processing and chemical analysis of JPS

The JPS were obtained from Wakiso district (00°24ˈN 32°29ˈE), Uganda. The seeds were sun-dried and stored in gunny bags on wooden stands until used. The sun-dried seeds were soaked in water at room temperature for 12 h, drained and rinsed once with fresh water, boiled in water at 100°C for 2 h, cooled under shade for 12 h, mixed with fresh water (1 kg of seeds in 65 ml of water), placed in gunny bags, well covered, allowed to ferment for one

Table 1. Composition of broiler starter diets used in the feeding trial (g/kg air-dry basis) (UNGA Farm Care (East Africa) Limited with technical assistance from Frank Wright Limited, part of BASSF Group).

Diets	**1**	**2**	**3**	**4**	**5**
Processed Java plum seeds	0.00	80.0	160	240	320
Maize	550	470	390	310	230
Fishmeal (55 g/kg CP)	100	100	100	100	100
Soybean (full fat; roasted)	310	310	310	310	310
DL-Methionine	5.00	5.00	5.00	5.00	5.00
Lake shells	5.00	5.00	5.00	5.00	5.00
Bone ash	20.0	20.0	20.0	20.0	20.0
Salt	5.00	5.00	5.00	5.00	5.00
Vitamin-trace mineral premix[1]	5.00	5.00	5.00	5.00	5.00
Total (10^3 g)	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Composition of diets (g/kg unless otherwise stated)					
Dry matter	883	885	886	888	889
Metabolizable energy (MJ/kg)	13.4	13.4	13.3	13.2	13.2
Crude protein	216	212	209	205	202
Lysine	13.3	13.1	13.0	12.8	12.6
Methionine	9.48	9.32	9.16	9.00	8.84
Methionine + Cysteine	12.5	12.2	11.9	11.7	11.4
Crude fat	88.0	85.8	83.2	80.7	78.1
Crude fibre	30.0	31.0	31.6	32.6	33.7
Calcium	12.1	12.4	12.6	12.9	13.2
Phosphorus	8.38	8.17	7.97	7.76	7.56
Condensed tannins	0.00	0.734	1.47	2.20	2.93

[1]Premix provided per kg diet: Vitamin A 15,000 I. U., Vitamin D_3 3,000 I. U., Vitamin E 15 I.U., B_{12} 0.013 mg, Vitamin K 4 mg, Riboflavin 10 mg, Folic acid 2 mg, Nicotinic acid 44 mg, Pantothenic acid 13 mg, Biotin 0.064 mg, Vitamin B_1 2.2 mg, Vitamin B6 5.5 mg, Choline Chloride 350 mg, Copper 6.25 mg, Iodine 1.5 mg, Zinc 62.5 mg, Manganese 62.5 mg, Selenium 0.1 mg, BHT (Antioxidant) 100 mg, Zinc Bacitracin 10 mg.

week and then sun-dried. Proximate and mineral compositions were determined using procedures of AOAC (1990). Tannins were determined using modified Vanillin assay method (Price et al., 1978).

Determination of metabolizable energy (ME) of JPS

Metabolizable energy (ME), calculated from chemical composition

The ME of raw and processed JPBM was estimated using the following formula developed by ARC (1977): ME (kcal/kg) = 4.31 x g.dCP + 9.28 x g.dEE + 4.14 x g.dNFE. Digestibility coefficient (d) estimates of 90% for CP, 90% for EE, and 80% for NFE were assumed. In the calculation of ME, it was also assumed feedstuffs did not contain anti-nutritional factors. According to Moughan et al. (2000), in feedstuffs that do not have anti-nutritional factors, digestibility coefficients are numerically the same.

Apparent metabolizable energy (ME_n)

The ME_n of processed JPSM was determined using a modified conventional 4-day total collection procedure of Bourdillon et al. (1990). The ME_n value was corrected to zero nitrogen balance using a factor of 8.22 times the nitrogen retained in the body (Hill and Anderson, 1958). The ME_n per gram feed dry matter = EI - EO - 8.22 N, where EI = Feed intake × Gross energy of feed; EO = Faecal output × Gross energy of faecal; 8.22 = Combustible energy value of uric acid per gram of nitrogen; N = Nitrogen per gram feed - Nitrogen per gram faecal.

Growth assays

One feeding trial that lasted three weeks was conducted to assess the responses of 150 broiler chicks fed varying levels of the soaked, boiled, and fermented (SBF) JPSM. Day-old, Ross strain broiler chicks were randomly distributed into fifteen weld-meshed cages each measuring 1.0 m^2. Five diets were formulated with processed JPSM at dietary levels of 0, 80, 160, 240, and 320 g/kg. Energy supplement was maize while protein supplements were fish meal and full fat roasted soybean meal. The control diet was formulated to meet the nutritional requirements as recommended by NRC (1984). Heat was provided using charcoal via clay pots and 24 h lighting was ensured using kerosene lanterns. The composition of the diets is shown in Table 1.

Determination of nutrient utilization parameters

The excreta (3 samples per treatment) were collected at the

Table 2. Composition of raw and processed JPSM (g/kg DM).

Composition	Raw JPSM	Processed JPSM	Maize
Dry matter	910±5.30	888±6.10	864±4.70
Crude protein	44.2±0.940	48.1±1.02	99.6±3.32
Ether extract	4.00±0.110	4.34±0.0910	40.5±1.24
Crude fibre	34.4±1.20	37.9±1.40	22.6±1.21
Ash	21.7±0.600	8.81±0.200	15.1±0.5
Nitrogen free extract	886±9.90	888±6.54	708±4.52
Sodium	4.30±0.0310	3.30±0.0220	-
Calcium	4.81±0.0420	4.21±0.0250	0.50±0.01
Phosphorus	0.88±0.0110	0.45±0.0130	3.20±0.21
Potassium	8.95±0.930	4.38±0.720	-
Condensed tannins[1]	24.4±1.33	9.17±0.940	-
Calculated metabolizable energy, MJ/kg	13.2± 0.165	13.3±0.154	14.4±0.07
Apparent metabolizable energy, MJ/kg	-	14.7±0.973	14·5±0.046*

[1]Catechin Equivalent. *Cilliers et al. (1994).

end of the feeding trial. The samples were stored in a freezer at 10°C to prevent decomposition or fermentation. The frozen excreta were thawed at room temperature, pooled and homogenized in a blender. The samples of the test feed and fresh excreta were taken for the determination of nitrogen and dry matter using standard procedure of AOAC (1990). The nutrient utilization parameters were calculated using the following formulae:

Nitrogen retention (g) = Nitrogen in the feed - Nitrogen in the excreta

Nitrogen digestibility (g/kg) = Nitrogen in the feed - Nitrogen in the excreta/Nitrogen in the feed × 1000

Dry matter digestibility (g/kg) = Dry matter of the feed – Dry matter of the excreta/Dry matter of the feed × 1000

Excreta water content (g/kg) = Weight of fresh excreta - Oven weight of excreta/Weight of fresh excreta × 1000

Data collection

Body weights of chicks were taken at the start of experiment and at the end of each week for three weeks. All the feed provided was weighed and feed intake (FI) was determined weekly for each replicate. The weekly body weight gain (WG) and FI measurements were used to compute feed efficiency (FCR). Mortality was recorded as it occurred. At the end of the experiment, three chicks from each replicate group were slaughtered to determine organ weights relative to body weight. Cervical dislocation was used to quickly separate the spinal cord from the brain, hence providing a fast and painless death of the birds.

Experimental design and statistical analysis

A Completely Randomized Design was used with three replicates. Each replicate contained ten broiler chicks. Data obtained were analyzed using General Linear Model (GLM) procedures of Statistical Analysis System (SAS, 2001) and regression analysis. Means were separated using Least Significant Difference (LSD) at 5% significant level.

RESULTS AND DISCUSSION

Nutrient composition of JPSM

The nutrient composition of raw and processed JPSM is shown in Table 2. The composition of maize is also included for comparison purposes. The dry matter (DM) and calculated ME of raw and processed JPS were comparable to those of maize. The ME_n of the processed JPS was also comparable to that of maize (Cilliers et al., 1994). However, NFE of raw and processed JPS was higher than that of maize. The NFE of raw and processed JPSM was also higher than the 752 g/kg reported by Ndyomugyenyi et al. (2008). Processing increased CP and NFE contents of JPSM by 8.11 and 0.230%, respectively. The CP of raw JPSM was lower than the 63 to 85 g/kg reported by Morton (1987).

Despite the ME_n of the processed JPSM being lower than that of common energy sources such as cassava meal (14.9 MJ/kg) and wheat (15.1 MJ/kg) (Ewing, 1997), it is still within an acceptable range for use as energy feedstuff. Additionally, the seeds are readily available; face little competition between humans and livestock. Condensed tannins reduced by 62.4% after processing JPS indicating that processing by soaking-boiling-fermentation was not effective in removing tannins from the seeds.

Growth assays

FI, WG, and FCR of broiler chicks decreased (R^2 > 0.850) with increasing JPSM in the diets (Figure 2). At 80 and 320 g/kg inclusion, FI, WG and FCR were depressed by 16.0 and 34.1%, 20.2 and 42.5%, and 4.90 and 12.5%, respectively. Liver, heart, and pancreas

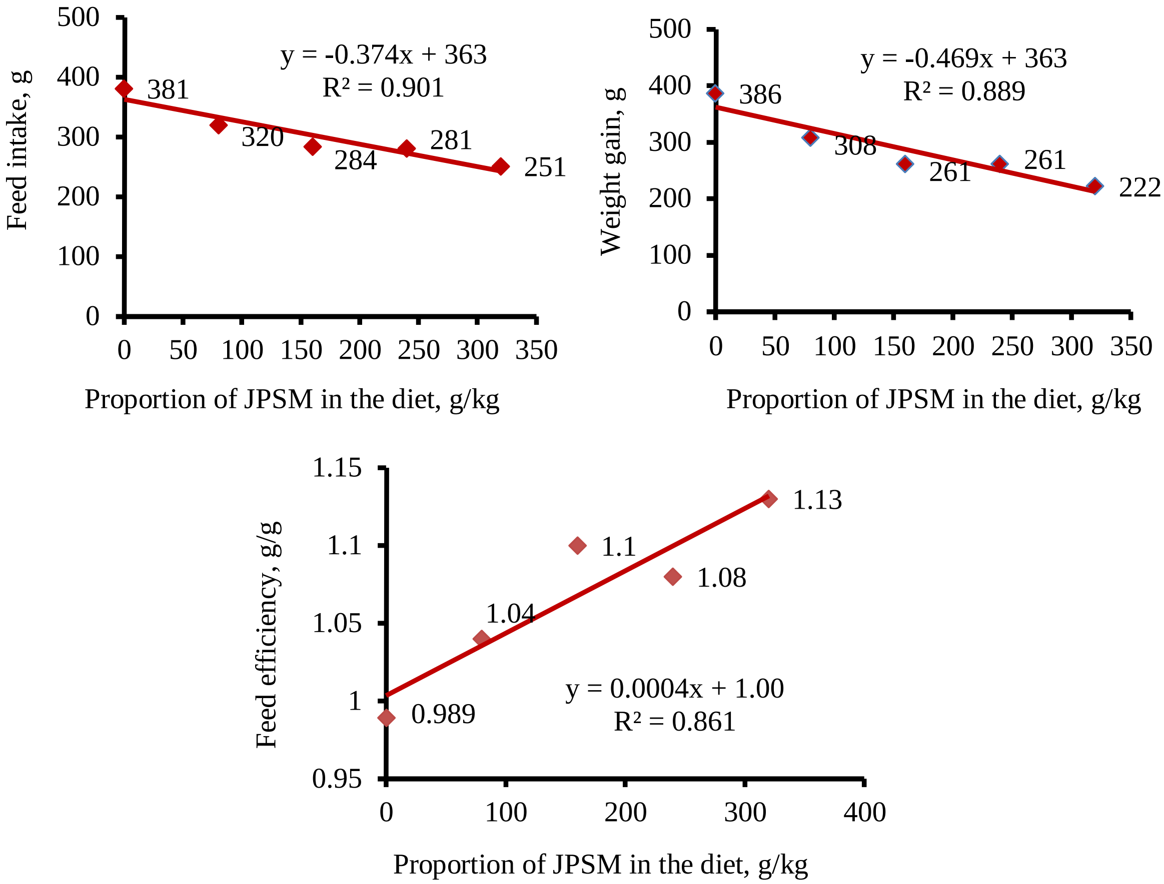

Figure 2. Performance of broiler chicks (0 to 3 weeks) fed graded levels of processed JPSM.

Table 3. Effect of feeding graded levels of processed JPSM on organ weights, nutrient utilization and mortality of broiler chicks (0-3 weeks of age).

Organ weights, g/kg	Processed JPSM inclusion levels (g/kg)						
	0	80	160	240	320	LSD	P
Liver	35.7	32.1	34.6	32.7	33.0	3.65	0.235
Heart	9.18^{a}	9.60^{a}	9.19^{a}	7.93^{ab}	6.81^{b}	1.99	0.0560
Pancreas	7.67^{a}	6.66^{ab}	5.07^{b}	6.12^{ab}	7.64^{a}	1.88	0.0549
Nutrient utilization, g/kg unless otherwise stated							
Nitrogen retention, g	2.21^{a}	2.20^{a}	1.96^{b}	1.91^{b}	1.53^{c}	1.82	<0.0001
Nitrogen digestibility	602^{a}	614^{a}	576^{a}	576^{a}	526^{b}	37.8	0.0039
DM digestibility	711^{a}	690^{abc}	688^{bc}	678^{c}	708^{ab}	20.7	0.0244
Excreta water content	652^{a}	636^{ab}	627^{bc}	615^{c}	636^{ab}	18.9	0.0173
Mortality and cost/kg gain							
Mortality, %	3.33	6.67	6.67	3.33	0.00	-	-
Cost per kg gain (10^3), Ugx[1]	2.06	2.18	2.31	2.28	2.39	-	-

[abcd]Means with different superscripts are significantly different (P < 0.05). [1]JPS are locally available; will be obtained at low cost or no cost; Ugx (Uganda shillings)

weights relative to body weight were not significantly (P > 0.05) affected by JPSM inclusion (Table 3). However, caecum, gizzard, and intestine weights increased (R^2 > 0.800), while the heart weight decreased (R^2 = 0.772) with increasing JPSM in the diets (Figure 3). At 80 and 320 g/kg JPSM inclusion,

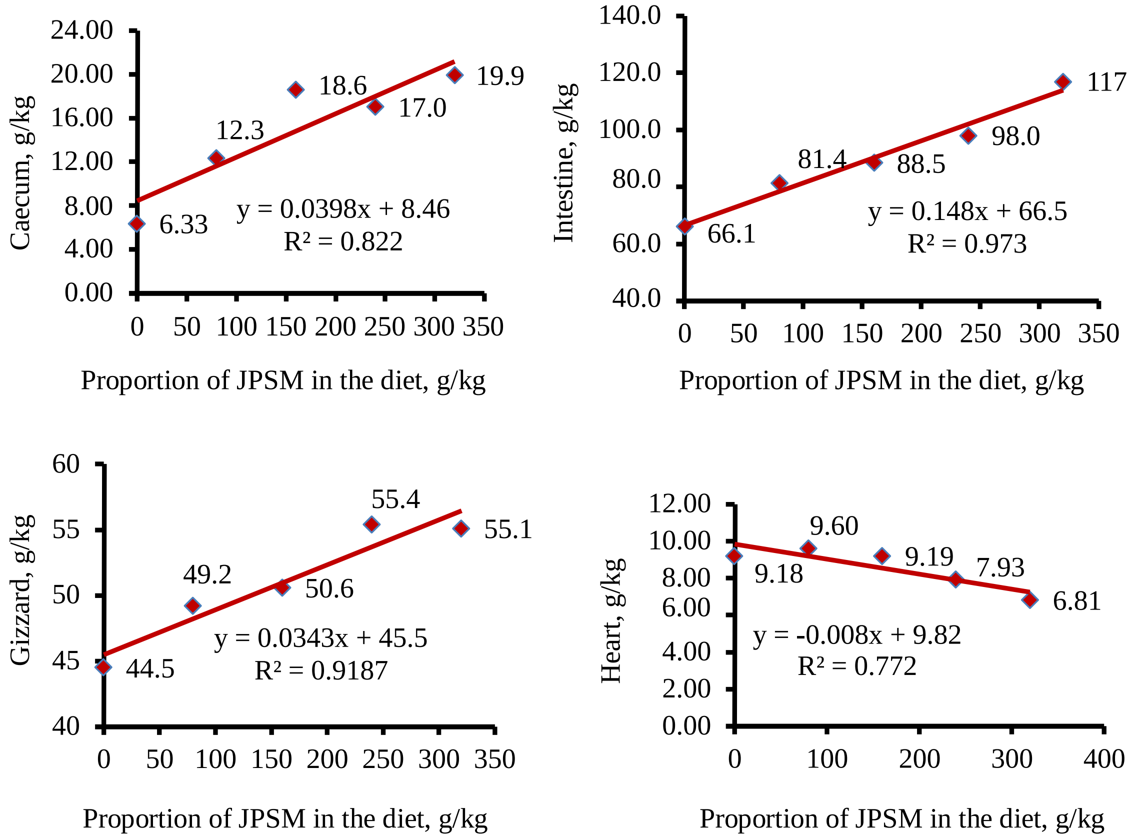

Figure 3. Organ weights of three-week broiler chicks fed graded levels of processed J PSM.

weights of caecum, intestine, and gizzard increased by 48.5 and 68.2%, 18.8 and 43.5%, and 9.55 and 19.2%, respectively. Inclusion of JPSM in chick diets adversely ($P < 0.05$) affected nitrogen retention (NR), nitrogen digestibility (ND), dry matter digestibility (DMD), and excreta water content (EWC) (Table 3). At 320 g/kg JPSM inclusion, NR, ND, DMD, and EWC were depressed by 30.8, 12.6, 0.42, and 2.45%, respectively. No mortality was recorded at 320 g/kg JPSM inclusion. The cost per kg gain of birds increased with increasing JPSM in the diets. The cost increased by 5.5 and 13.8% at 80 and 320 g/kg inclusion, respectively.

The decrease in WG with increasing level of SBF JPSM in the starter diets could be attributed to low FI (Figure 4) and poor nutrient utilization by the birds (Table 3). The low FI was probably due to astringency of JPSM. Tannins were reported to be responsible for the astringent taste and low FI of feedstuffs (Hagerman, 2002; Brown, 2001; Reed, 1995; Van Soest, 1994). According to Hagerman (2002), tannins reduce FI by decreasing palatability and negatively affecting digestion. In the current study, 37.6% tannins remained in JPS after processing (Table 2). Tannins in JPSM could have also caused poor nutrient utilization, hence growth depression of chicks. Tannins form complexes with carbohydrates (Mahmood et al., 2006) and combine with proteins (Teguia and Beynen, 2005; Van Soest, 1994) in the digestive tract thereby negatively affecting their digestibility. Studies on the effect of sorghum tannins on broiler performance (Kyarisiima, 2002; Okot and Mujabi, 2001) also showed that tannins were responsible for growth depression. However, growth depression in the present study could not entirely be attributed to tannins, because tannin content in the chick diets ranged from 0.734 to 2.93 g/kg catechin equivalent (Table 1). Brown (2001) reported that levels of over 5.0 g/kg tannins in poultry diets cause growth depression. Other anti-nutrients reported in JPS such as saponins, alkaloids, phytic acid, oxalates, and triterpenes (Zdunczy et al., 1997) could have also played a role in depressing FI and growth of the chicks. Saponins were reported to significantly affect growth, FI and reproduction of animals (Francis et al., 2002). Saponins also impair digestion of protein and uptake of vitamins and minerals in the gut (Francis et al., 2002). Phytic acid is known to affect protein and lipid utilization (Kumar et al., 2010), because it inhibits enzymes (such as pepsin, amylases, and trypsin) needed to digest food (Coulibaly et al., 2011; Ramakrishna et al., 2006). Oxalates combine with proteins to form complexes that

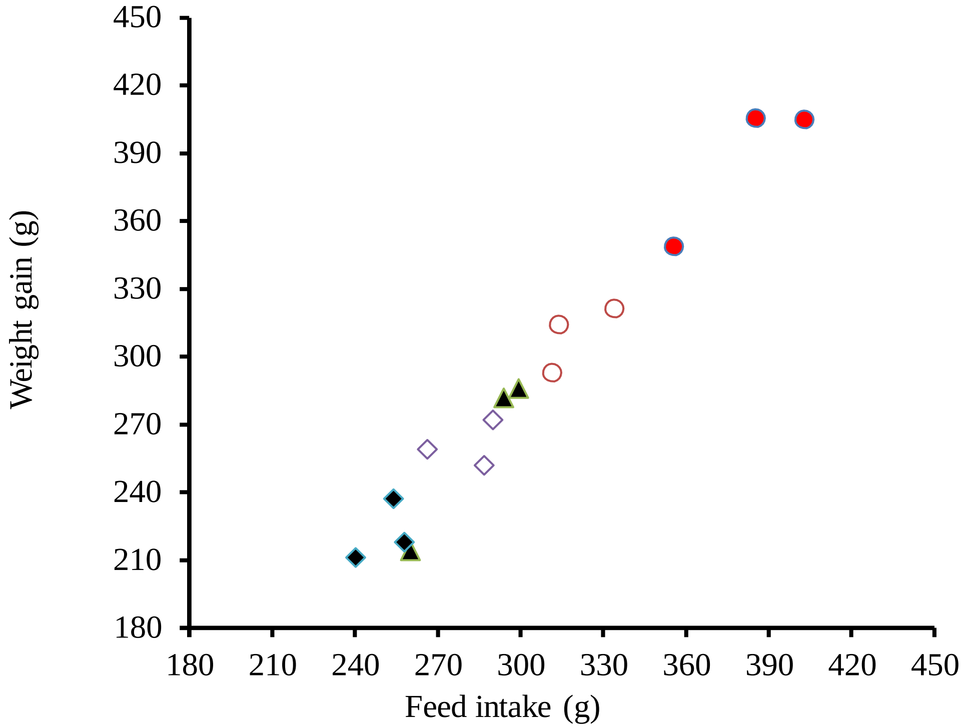

Figure 4. Weight gain versus feed intake of chicks fed on control (●), 80 (○), 160(▲), 240 (◇) and 320 g/kg (◆) processed JPS diets.

inhibit peptic digestion (Akande et al., 2010). The FCR of chicks decreased with increasing levels JPSM meal in the diet probably, because of anti-nutritional factors, such as alkaloids and tannins in meal and the effects of continued consumption of these anti-nutritional factors.

No mortality of chicks was recorded at the highest level of JPSM inclusion (320 g/kg) suggesting that lethal effects of JPSM (Ndyomugyenyi et al., 2008) were minimized by SBF treatment. The cost per kg gain of birds increased with increasing JPSM in the diets, because the seeds were obtained from peri-urban areas at a cost (harvesting and transport costs). However, the seeds are readily available in rural areas and will eventually be obtained at low or no cost. The liver, heart and pancreas weights relative to body weight were not significantly affected suggesting healthy chicks. Gizzard weight increased with JPSM inclusion probably, because of JPSM texture which facilitated the increased rate of contraction of the gizzard. The increase in gizzard weight was also reported when whole maize was used for poultry feeding (Engberg et al., 2004; Gabriel et al., 2007; Lu et al., 2011; Roche, 1981). Increment in caeca weight at higher levels of JPSM could be due to stress exerted on these organs as they attempted to extract nutrients from nutrient-impoverished diets due to the presence of anti-nutrients. The avian caecum is a multi-purpose organ whose functioning can be efficient and very important to a bird's physiology especially during stress periods (Clench and Mathias, 1995). Clench and Mathias (1995) reported that caecal lengths and masses increased when birds were fed on poorer and more fibrous diets. The reason for increment in intestine weight at higher levels of JPSM could not be readily established in the present study.

Conclusions

Including soaked-boiled-fermented Java plum seed meal in diets depressed the performance of broiler chicks. Soaking-boiling-fermentation treatment is not an effective method to improve the nutritional value of Java plum seeds for poultry. Maize remains a better energy source in poultry diets.

Conflict of Interests

The authors have not declared any conflict of interests.

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