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PERFORMANCE AND INTESTINAL MORPHOMETRY OF NAKED NECK BIRDS FED TREE CASSAVA HAY

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Abstract: Tree cassava, a plant native of the caatinga, has been used frequently in the livestock production, especially ruminants. However, the effects of this inclusion in poultry diets is still poorly understood. Basal diet was partially substituted with tree cassava (*Manihot psdeudoglaziovii*) hay in the feeding of naked neck Label Rouge birds reared in semiarid climate. It was evaluated the effects on food intake, weight gain, feed conversion from 33 to 70 days of age (d), relative weight of prime cuts and edible organs at 70d, and the histology of small intestine at 56d. An economic analysis of the use of tree cassava hay was also carried out. Three hundred Label Rouge birds were distributed at 33d into a completely randomized design with three treatments (0, 7 and 14% of tree cassava hay levels) and ten repetitions with ten birds per repetition. There were no differences on feed intake, although tree cassava levels negatively affected weight gain and feed conversion. Relative gizzard weight increased (P<0.05) with higher tree cassava levels. In the duodenum, villus height increased (P<0.01) in birds fed 7% tree cassava hay; crypts were deeper in all segments of birds fed 14% tree cassava hay. Relative gross profit decreased in any scenario simulated with 14% of tree cassava hay. The substitution of tree cassava hay for basal diet at the level of 7% is viable for naked neck Label Rouge birds reared in semiarid climate.

Keywords: alternative feeding; cut yield; economic analysis; free range poultry

DESEMPENHO E MORFOMETRIA INTESTINAL DE AVES CAIPIRAS DE PESCOÇO PELADO ALIMENTADAS COM FENO DE MANIÇOBA

Resumo: A maniçoba, planta nativa da caatinga, vem sendo utilizada com frequência na alimentação de animais de produção, em especial os ruminantes. no entanto, os efeitos da sua inclusão em dietas de aves ainda é pouco conhecida. uma dieta basal foi parcialmente substituída por feno de maniçoba (manihot psdeudoglaziovii) na alimentação de aves pescoço pelado label rouge, criadas em clima semiárido. avaliaram-se os efeitos sobre o consumo de ração, ganho de peso, conversão alimentar de 33 a 70 dias de idade, peso relativo de cortes nobres e órgãos comestíveis a 70 dias de idade e histologia do intestino delgado aos 56 dias. foi realizada uma análise econômica do uso do feno de maniçoba. trezentas aves label rouge foram distribuídas aos 33 dias de idade, em um delineamento inteiramente casualizado, com três tratamentos (0, 7 e 14% de feno de maniçoba) e dez repetições, com dez aves por parcela. não houve diferença estatística significativa no consumo de ração, embora os níveis de maniçoba tenham afetado negativamente o ganho de peso e a conversão alimentar. o peso relativo da moela aumentou (p <0,05) com maiores teores de maniçoba. no duodeno, a altura das vilosidades aumentou (p <0,01) em aves alimentadas com 7% de feno de mandioca; as criptas foram mais profundas em todos os segmentos de aves que receberam 14% de feno de mandioca. a margem bruta relativa diminuiu em qualquer cenário simulado com 14% de feno de mandioca. a substituição do feno de maniçoba pela dieta basal ao nível de 7% é viável para aves caipiras label rouge criadas em clima semiárido.

Palavras-chave: alimentação alternativa, análise econômica, rendimento de cortes, avicultura caipira

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INTRODUCTION

The increasing demand for organic products has stimulated the production of naked neck birds in Brazil. This production system is characterized by rearing management practices that ensure the birds are fed a balanced diet without additives and drugs, but also allow free access to a range area where birds can forage. In this sense, they usually have access to insects and natural vegetation. Utilization of forages as a feedstuff for poultry has gained increasing attention (ABOUELEZZ et al., 2012). Forages contain carotenoids, and vitamins K and E and many nutrient needs may be met through foraging, although pasture is a nutrient source that has not been fully evaluated for poultry (BUCHANAN ET AL., 2007). The nutrients that are provided, together with the physical activity during foraging, result in interesting organoleptic characteristics of the carcass, such as darker and more firm meat, with less fat and differential taste and flavor (TAKAHASHI et al., 2006).

In this sense, the Brazilian semiarid vegetation, so-called “caatinga”, shows great biodiversity of forage resources that represent a relevant potential to the development of agriculture in the Northeastern Brazil (COSTA et al., 2007). Since forage is considered to be a sustainable and natural feed resource (ABOUELEZZ et al., 2012), the use of forage resources adapted to the edafoclimatic conditions of the semiarid may reduce costs with feeding.

Tree cassava is a xerophilous plant found in many parts of the semiarid northeast, which has good palatability and digestibility. The process of hay production results in the volatilization of the cianidric acid present in the composition of tree cassava, which permits its use in animal feeding. Tree cassava hay represents 91% of dry matter, 11% crude protein, 4% ether extract, 58% of neutral detergent fiber and 7% of mineral matter (ARAÚJO et al., 2004).

The use of native forages in bird feeding needs further studies to provide more precise information of effects on performance and gut morphology, besides economical viability. Thus, the objective of the present study was twofold. Firstly, the effects of the substitution of tree cassava hay for mash diet on performance and duodenal histology of naked neck birds reared in semiarid conditions and semi-intensive system were evaluated. Secondly, the economical viability of using this foodstuff was evaluated, in order to provide farmers a local alternative foodstuff to be used in poultry feeding in semiarid conditions.

Thus, the objective of this research was to evaluate the inclusion of tree cassava hay in the feeding of naked-necked birds, raised in a semi-intensive system.

MATERIAL AND METHODS

This study was carried out at the Federal University of Paraíba and the São João do Cariri Field Station, a research field from the same university located in the semiarid region of Paraíba State, in Brazil, between the months of December 2010 and February 2011.

Fertile Naked Neck Label Rouge eggs were obtained from a commercial hatchery and incubated. At hatch, chicks were weighed and vaccinated against Newcastle, fowl pox and infectious bronchitis. In the pre-experimental period, the birds were kept from 1 to 28 days of age (d) in a poultry house under intensive management. At 28 d, 300 birds were distributed according to a completely randomized design into three treatments (0, 7 and 14% of tree cassava hay replacing mash diet), ten repetitions and 10 birds per repetition.

In the experimental period (33-70 d), the birds were placed at 25 m² ranging area with native caatinga vegetation. There was a mansory area with 3.75 m² where the birds were kept during the night and laterals were made of galvanized wire mesh. All ranging areas had a feeder and a drinker. Light was continuous in both pre-experimental and experimental periods, and food and water were provided *ad libitum*.

Corn-soybean meal-based diets were formulated according to the nutritional recommendations for broiler of medium performance (ROSTAGNO et al., 2011) for the phases of 1-28 d, 29 to 56 d and 57 -70 d. After 33 days of age, the basal diet was replaced by 0, 7 and 14% of tree cassava hay according to the treatments. Diet composition is presented in Table 1.

The hay was produced using the aerial part of the plant, which was cut, ground and finally dried for three days. During this period, the material was mixed to assure even drying. The tree cassava hay used contained 16.3% CP, 3,148 kcal ME/kg, 53.81% ADF and 57.63% NDF.

Feed intake (FI), weight gain (WG), feed conversion (FC) and mortality were determined. Mortality was recorded in the experimental period (33 to 70 d). At 70 days of age, thirty-six birds per treatment, eighteen males and eighteen females were taken to the Apprentice Abattoir of the Poultry Facilities of Federal University of Paraiba and fasted for 8 hours before slaughter. The weights of prime cuts (breast, drumsticks and thigh), abdominal fat (AF) and edible organs (liver, gizzard and heart) were recorded and used to calculate the relative weights in relation to the eviscerated carcass (without head and feet).

Table 1 – Composition of experimental diets.

Ingredients, kg	33 to 56 days	57 to 70 days
Corn	65.21	68.26
Soybean meal	29.04	23.91
Bicalcium phosphate	1.61	1.29
Soybean oil	2.15	3.00
Limestone	0.94	0.68
Sodium chloride	0.39	0.35
DL-methionine	0.22	0.10
L-lysine.HCl	0.24	0.10
Vitamin and mineral premix	0.08	0.08
Choline	0.07	0.07
Coccidiostat[2]	0.05	0.05
Antioxidant[3]	0.01	0.01
Inert[4]		2.10
Total	100.0	100.0
Calculated nutritional composition		
Dry matter (%)	87.93	88.11
Crude protein (%)	19.30	17.00
Metabolizable energy (kcal/kg)	3,100	3,150
Crude fiber (%)	2.99	2.75
Lysine (%)	1.05	0.82
Met + Cis (%)	0.75	0.59
Threonine (%)	0.63	0.56
Tryptophan (%)	0.21	0.18
Calcium (%)	0.87	0.68
Available phosphorus(%)	0.41	0.34
Potassium (%)	0.73	0.64
Sodium (%)	0.19	0.18

1Composition: 10.000 IU Vit. A; 2.000 IU Vit.D3; 30 IU Vit.E; 3 mg Vit.K3; 2 mg Vit. B1; 3 mg Vit B6; 12 mg Pantothenic acid; 0,1 g Biotin; 1 mg Folic acid; 50 mg Nicotinic acid; 0,015 mg Vit. B12 ; 0,25 mg Selenium, 106 mg Manganese; 100 mg Iron; 20 mg Copper; 2 mg Cobalt; 2 mg Iodine and excipient qsp 1000g; 2 Coccidiostatic; 3Antioxidant; 4Sand.

Three samples with approximately 2 cm were taken at 56 days of age from the medial region of duodenum, jejunum and ileum of four males per treatment (randomly chosen) and routinely processed for histology. Tissue was fixed in Bouin's solution, dehydrated, cleared and infiltrated with paraffin wax. After embedding, cuts with 5 µm of thickness were sectioned and mounted on glass microscope slides to be stained with hematoxylin and eosin. The cuts were observed under 10 X magnification using a light microscope (Nikon E-100 equipped with a digital camera) and photos were taken. Villus height and crypt depth were determined using the software Image J (Abramoff et al., 2004); villus height was measured from the top of the villus to the villus-crypt junction. The crypts were measured from the villus-crypt junction until the baseline. Ten vertically oriented villi and ten crypts were measured per sample, with a total of 40 readings per variable for each treatment.

Relative gross profit (RGP) was calculated considering only variable costs of feeding, since fixed costs were the same for all treatments (Equation 1). The data of final body weight and poultry meat prices were used to calculate income, and the data of feed intake and feeding costs were used to calculate the gross profit. Gross profit of each treatment was then used to calculate the relative gross profit (RGP) in relation to the standard diet (control group) in different market scenarios, which enables us to indicate (or not) the use of tree cassava hay in chicken feeding. Therefore, feeding costs (per kilogram of diet) were calculated using three different prices of tree cassava hay (US$ 0.03, 0.05 and 0.07/kg), and constant prices of other feed ingredients, except for corn and soybean meal, as described below. These values were then crossed with different prices of poultry meat (whole bird, from US$ 1.75 to 2.50/kg).

Ingredient prices (US$/kg) used to calculate a low-cost standard diet (LC) were corn, 0.40; soybean meal, 0.50; soybean oil, 1.60; bicalcium phosphate, 0.68; limestone, 0.08; sodium chloride, 0.10; DL-methionine, 4.00; L-lysine.HCl, 3.50; choline chloride, 2.25; anticoccidial drug, 15.50; antioxidant, 4.25; vitamin and mineral premix, 2.75. The high-cost standard diet was calculated using the average prices of corn and soybean meal in the region (US$ 0.52/kg and 0.68, respectively).

(Equation 1)

$$RGP = \frac{(BWTreat\ x\ KG\$) - (FITreat\ x\ US\$Treat)}{(BWCon\ x\ KG\$) - (FICon\ x\ US\$Con)}$$

In which:

RGP = Relative Gross Profit;

BWTreat =Mean bodyweight at each tree cassava hay level, in kg/bird;

KG$ = Price of bird kilogram, in US$/kg;

FITreat = Mean feed intake in the evaluated treatment, in kg/bird;

$US\$_{Treat}$ = Price of food at each tree cassava hay level, in US$/kg;

BWCon =Mean body weight of birds in the control treatment (no hay), in kg/bird;

FICon =Mean feed intake in the control treatment (no tree cassava hay), in kg/bird;

$US\$_{Con}$ = Price of food in the control treatment, in US$/kg.

Statistical analyses were carried out using SAEG (2007) and the variables that showed statistical differences for the F test were compared by Tukey test at 5% probability.

RESULTS AND DISCUSSION

There were no differences (P>0.05) on feed intake from 33 to 70 d, whereas body weight gain decreased and feed conversion were impaired (P<0.01) when 14% of tree cassava hay was used. On the other hand, birds fed with 7% tree cassava hay showed similar performance results when compared with the control treatment (Table 2).

Table 2–Body weight gain (BWG, kg), feed intake (FI, kg), feed conversion (FC, kg/kg) and relative weight (%) of heart and gizzard of naked neck birds fed three levels of tree cassava hay in replacement of the diet from 33 to 70 days of age. Each value represents 10 repetitions.

Tree cassava hay (%)	BWG (kg)	FI (kg)	FC (kg/kg)	Heart (% carcass)	Gizzard (% carcass)
0	1.87 A	4.99 a	2.69 B	0.73 A	2.61 C
7	1.77 A	4.99 a	2.83 B	0.70 AB	3.20 B
14	1.53 B	5.05 a	3.31 A	0.64 C	3.55 A
RMSE	0,47	1,30	0,74	0,16	0,68

Means followed by similar letters in the column are similar by Tukey's test (P<0.05).

The usage of alternative feedstuffs is an important issue in semiarid Northeastern Brazil, a region with unevenly distributed rain throughout the year. Small scale farmers in the region rely on poultry production as one of the sustaining mainstay of economy, and any consistent alternative to reduce feeding costs are welcome. Native forages have been proposed as a means of minimizing food scarcity in periods of prolonged drought in animal feeding, not only for ruminants, but also for non-ruminant species.

Impaired performance in birds fed 14% of tree cassava hay in the present study can be explained by the lower energy levels and increased fiber in the diet. Although fiber is important to intestinal health, nutrient digestion and also behavior of birds probably due to its effect on intestinal transit and physical stimulation of intestine development (CHOCT, 2009), the higher levels apparently impaired performance. It is known that fiber affects feed intake (MADAR; THORNE, 1987), and consequently impairs nutrient absorption in the small intestine. Plant cell wall is typically composed by cellulose, non-amilaceous polysaccharides (NAP), pectin and lignin. NAP portion in plants is associated with antinutritional factors that can decrease nutrient digestibility in chickens (CHOCT et al., 1996; LEESON; SUMMERS, 2001), which might explain the lower performance of birds fed with the higher tree cassava level. In a previous study, Paraíso Pedrês birds fed three different tree cassava hay levels (0, 10 and 20%, GIVISIEZ et al., 2010) have shown impaired performance.

Besides, Jacob (2007) reported decreased body weight gain in birds fed 5, 10 or 20% of Illinois bundle flower in the diet due to reduced feed intake, at least in part. On the other hand, Costa et al. (2007)

have evaluated the effects of four substitution levels of tree cassava hay replacing corn-soybean meal based diet (0, 5, 10 and 15%) for naked neck birds and reported increased feed intake and similar performance, different from our findings.

Although poultry may obtain small amounts of energy and utilize amino acids such as methionine, threonine and lysine from pasture forage (BUCHANAN et al., 2007), the inclusion of vegetation must not be excessive because of performance impairment. Fiber associated with plant feedstuffs can exert considerable influence on small and large intestinal functioning by virtue of its solubility in water and physical characteristics (MORAN Jr., 2006).

Relative organ weights were similar for drumsticks, thigh, breast, abdominal fat and liver (P>0.05, data not shown). Gizzard relative weight increased and relative heart weight decreased with increasing levels of tree cassava hay (P<0.01, Table 2).

The increased fiber content that results from the substitution of tree cassava hay for mash diet probably caused hypertrophy of gizzard muscle, and therefore higher relative weight of this organ. Gonzáles-Alvarado et al. (2007) evaluated the effects of increasing dietary fiber for birds by including soybean and oat hulls and reported increased weights of the gastrointestinal tract, gizzard and ceca, but lower small intestine weight. The authors suggest that higher gizzard weight is expected when greater mechanic stimulus is present, such as more digesta is present within the organ. Increased dietary fiber results in longer retaining time in order to decrease the size of particles and improve digestion and absorption in the small intestine.

Furthermore, a heavier and more muscular gizzard apparently is closely related with better utilization of nutrients (CHOCT, 2009). Indeed, the consumption of 4% of feed as wood shavings in laying hens resulted in a 50% heavier gizzard and significant improvement (from 97 to 99%) in the digestibility of starch in the ileum, which was probably due to more amylase being secreted (HETLAND et al., 2003). Gonzales-Alvarado et al. (2007) reported decreased pH of digesta present in gizzard, suggesting that chloridric acid production in proventriculus was increased. Although the chicken digestive system has limited capacity of utilize high fiber materials, it has been reported that chickens consuming forage retain microbes in the ceca that digest fiber and that the ceca become enlarged compared to those of chickens not consuming forage (ABOUELEZZ et al., 2012).

Data presented in Table 3 refer to histology results in the three segments of the small intestine (duodenum, jejunum and ileum) of 56-day-old birds fed 0, 7 and 14% of tree cassava hay in replacement of standard diet.

Table 3 – Intestinal morphometry of the small intestine (duodenum, jejunum and ileum) of nacked neck birds, fed diets containing or not tree cassava hay.

Intestinal segment	***Treatment***			
Duodenum	***0%***	***7%***	***14%***	***RMSE***
Villus height (μm)	1406.25 b	1466.55 a	1401.92 b	70,86
Crypt depth (μm)	73.50 c	116.39 b	155.53 a	8,88
Villus:crypt ratio ($\mu m.\mu m^{-1}$)	19.02 a	12.49 b	9.26 c	1,05
Jejunum				
Villus height (μm)	796.66 a	757.74 b	804.10 a	54,38
Crypt depth (μm)	103.35 b	147.89 a	149.03 a	9,44
Villus:crypt ratio ($\mu m.\mu m^{-1}$)	7.71 a	5.08 b	5.38 b	0,61
Ileum				
Villus height (μm)	577.94 b	607.34 a	617.44 a	50,93
Crypt depth (μm)	94.55 c	122.39 b	128.48 a	8,36
Villus:crypt ratio ($\mu m.\mu m^{-1}$)	6.06 a	4.81 b	4.76 b	0,53

Means followed by different letters in the same rows are different by Tukey's test ($P < 0.05$).

Villus height was higher (P<0.05) in the duodenum of birds fed 7% tree cassava hay and crypt depth was higher (P<0.05) when 14% tree cassava hay was used compared with the other treatments. Villus:crypt ratio (V:C ratio) was greater (P<0.05) in the treatment with no tree cassava hay substitution compared with the other treatments.

Fresh tree cassava cannot be used because it produces the lethal cianidric acid within the animal body and many farmers demonstrate prejudice against its use. Hay production causes volatilization of the antinutritional component and this was corroborated by the low mortality rates during the experimental period (data not shown). It is known that villi rapidly and continuously respond to lumen conditions (MORAN Jr., 2006). Nevertheless, the effects of tree cassava hay on histology of the small intestine have not been assessed yet, only the effects of other high fiber feedstuffs, such as leucaena hay for broiler chickens (OLIVEIRA et al., 2000).

Villus height was smaller (P<0.05) in the jejunum of birds from the treatment with 7% tree cassava hay, and crypt depth was smaller in the treatment with no tree cassava hay. Villus:crypt ratio was higher (P<0.05) in the treatment with birds fed 0% tree cassava hay. In the ileum, villus height and crypt depth were significantly smaller in the treatment with no tree cassava. Nevertheless, villus:crypt ratio was greater ($P<0.05$) in the same treatment.

In the jejunum, differently from our results, Oliveira et al. (2000) have reported significantly higher villi in broilers fed 6% of *Leucaena leucocephala* hay or *Leucaena cunningane* hay at 21 and 42 days of age when compared with birds fed the standard diet. On the other hand, ileum results were similar to Oliveira et al. (2000), who reported deeper crypts in birds fed leucaena hay.

The number and size of villi depend on the number of cells it comprises. More cells indicate higher villi and, as a consequence, increased absorption area. Efficient absorption only occurs if there is functional integrity of villus cells. Deeper crypts indicate that more cells are being replaced. The treatment with 14% of tree cassava hay presented deeper crypts in all segments of the small intestine, indicating that maintenance of mucosa was possible only due to greater activity of crypts. According to Maiorka et al. (2002), intestinal mucosa has the greater turnover rate of all organic tissues. Cell turnover is affected by many factors, such as ulcer lesions, non specific enteritis and mechanical lesions or lesions caused by intestinal pathogens. Decreased turnover rate affects the morpho-functional characteristics of the mucosa and affect, consequently, the absorption efficiency.

The intestinal mucosa development is controlled by the processes of cell extrusion and proliferation. If extrusion rate is increased, there is reduction of villus height and, consequently, cell proliferation is increased and crypts become deeper (UNI et al., 1998). Although the intestinal mucosa presents great recovery ability, the dietary components should be cautiously chosen in order to avoid great damage. The greater recovery needs result in increased energy costs that must be deviated from other production functions, probably resulting in impairment of production performance traits (XU et al., 2003). This happens because villi can increase or decrease their length to alter surface area and optimize cost of maintenance for recovery relative to productive advantage (MORAN Jr., 2006). Maiorka et al. (2002), dietary components may negatively affect the mucosa development. In the present study, it was seen that increasing dietary fiber resulted in lower villus height probably caused by increased desquamation of the epithelium, which impairs the process of mucosa recovery (MAIORKA et al., 2003).

Thus, depending on the level of aggression caused by the diet, the ability of recovery can be not enough and mucosa damage may become irreversible. The consequence is lowered absorption capacity of the gastrointestinal tract and impaired performance. Possibly, tree cassava levels used in the present study did not result in severe mucosa damage and regeneration was similar. Thus, due to greater crypt depth in birds fed 7 or 14% of tree cassava hay, villus:crypt ratio was decreased in all segments.

It was not expected, though, that higher villi were present in ileum when 14% of tree cassava hay was used. Moran Jr. (2006) suggested that fiber increase in feed formulation with decreased plane of nutrition results in enhanced motility and luminal throughput with lengthening of villi, which is dependent on the resulting viscosity inside the gut. Deeper crypts were also seen in the treatment with 14% of tree cassava hay. According to Choct (2009), the crypt is the villus factory and a large crypt indicates rapid tissue turnover and high demand for new tissue and, consequently, high demand for energy and protein for maintenance. This probably has also contributed to the lower performance results.

Finally, performance may also have been compromised by the high mean temperature and mean relative humidity recorded during the experiment, which were 34.4ºC and 82.1%, respectively. Heat stress results in decreased feed intake in order to minimize metabolic heat produced during digestion. Besides, part of the energy is deviated to heat dissipation and the less energy becomes available for production and growth. Naked neck birds are considered more resistant to heat stress, and this was one of the reasons for choosing this type of birds to be reared under the semiarid conditions. Nevertheless, panting has been observed (data not shown), indicating that the birds have triggered physiological mechanisms to cope with heat stress.

The Relative Gross Profit (RGP) decreased in any scenario of prices when 14% of tree cassava hay was used (Table 4).

Table 4 – Relative Gross Profit (RGP) of the treatments with different levels of tree cassava hay considering diverse hay and bird prices and feed costs (LC and HC, low and high costs, respectively).

Tree cassava hay (%)	Hay price (US$/kg)	Bird price (US$/kg BW)					
		1.73		2.22		2.72	
		LC	HC	LC	HC	LC	HC
7	0.03	98	100	97	98	97	98
14		88	89	88	89	88	88
7	0.05	98	100	97	98	97	97
14		88	88	88	88	88	88
7	0.07	98	99	97	98	97	97
14		87	88	88	88	88	88

LC=Low-cost diet; HC=High-cost diet.

Nevertheless, the use of 7% of tree cassava hay was economically viable when the diet has high cost (HC), if the price of bird kilogram was not higher than US$ 1.75 and tree cassava hay price was US$ 0.05 or less.

Alternative feedstuffs are intended to decrease feeding costs, and thus a simple economic analysis was carried out. The Relative Gross Profit allows the producer to assess if the included feedstuff is really providing profit or at least preventing losses. Our results have shown that tree cassava hay, a feedstuff not commonly used for poultry but with great potential because of the great availability in the semiarid Northeastern Brazil, is a viable choice when it substitutes 7% of the standard corn-soybean meal based diet and two conditions are present, that is, high price of feedstuffs (HC diets) or low market price of the live bird. Costa et al. (2007) have reported that even 10% of tree cassava hay can substitute mash diet in naked neck birds rearing when the same conditions are present.

CONCLUSION

Further studies should evaluate cecal microbiota, digestibility of diets and the mucosa functionality, including transport of nutrients, since performance impairment may have resulted not only by worse histology and smaller absorption area, but also decreased absorption ability.

It is viable to use 7% of tree cassava hay in substitution for the standard mash diet for Naked Neck birds when diet costs are high and bird market price is low.

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