Gut morphology, meat yield and sensory properties of laying hens fed water hyacinth [*Eichhornia crassipes* (Mart.) Solms-Laubach] meal diets supplemented with Maxigrain® enzyme

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Abstract

In an experiment to determine the effect of feeding varying levels of Water Hyacinth Meal (WHM) supplemented with and without exogenous enzymes (Maxigrain®) on the gut morphology, meat yield and sensory properties of laying hens, a total of 216 laying hens aged 24 weeks and 4 weeks in lay were used. Six experimental diets were formulated based on the Completely Randomized Design model using a 2 x 3 factorial arrangement made up of two levels of enzyme (No enzyme, With enzyme) and three dietary inclusion levels of WHM (0, 10 and 20 %). At the end of the feeding trial, two birds per replicate were randomly selected, kept off feed for 12 hours, slaughtered, defeathered, eviscerated and dressed. The meat of the breast and thigh of each replicate sample were then selected for sensory evaluation. All parameters were expressed as percentage of live weight. Results showed that there were no significant (p>0.05) differences in live weight (LW), slaughter weight (SW), defeathered weight (DW), eviscerated weight (EWT) and dressed weight (DW) between birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; and between birds fed the varying dietary inclusion levels of WHM (0, 10 and 20 %). Also, there were no significant (p>0.05) differences in the weight of the head, neck, breast, back, thigh, drumsticks, wings and shanks between the birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; and between the birds fed the varying dietary inclusion levels of WHM (0, 10 and 20 %). Of all the internal organs assessed, only the gizzard weight was significantly (p<0.05) higher for the non-enzyme-supplemented diets than for the enzyme-supplemented diets. There were no significant (p>0.05) differences in appearance, flavour, juiciness, tenderness and overall acceptability between the meat of birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; but the meat of birds fed 10 and 20 % dietary inclusion levels of WHM had significantly (p<0.05) higher scores for tenderness and general acceptability than the meat of birds fed the 0 % dietary inclusion level of WHM. Hence, WHM can be included up to 20 % in layer diets for optimal meat yield, gut morphology and sensory properties.

Key words: Gut morphology, water hyacinth, laying hens, exogenous enzymes.

Introduction

Water hyacinth [*Eichhornia crassipes* (Martius) Solms-Laubach], a free floating aquatic weed species with broad leaves, beautiful, purple or lilac-blue, lily-like lavender flowers (Gopal, 1987) is regarded as the world's most noxious and invasive aquatic weed species because of its prolific growth. Numerous international conferences, workshops and symposia had been held on its physical, chemical, biological and integrated control, yet with complete control still elusive (Julien, 2000). It is a menace and a national and international problem causing great damage to agriculture, fisheries, transportation and navigation; and also causing great damage to the aquatic population, tourism and the environment. However, recent research study have shown that water hyacinth meal (WHM) can be a valuable feed resource for poultry; for optimum growth performance and nutrient utilization; it can be included up to 10 % in the diets of pullet chicks (replacing 50 % of wheat offal), without the addition of any exogenous enzymes (Malik *et al*., 2013). Malik *et al*. (2014) also determined that WHM can be included up to 15 % in the diet of pullet chicks (replacing 75 % wheat offal) without any detrimental effects on their carcass characteristics and haematological profile. However, the problem of water hyacinth utilization in the diets of poultry is its high fibre content (between 15 and 22 %), hence the need for exogenous enzyme supplementation to degrade its non-starch polysaccharides. Each gramme of Maxigrain® contains 10, 000 IU cellulase, 200 IU β-glucanase, 10, 000 IU xylanase and 2, 500 FTU phytase; and it has been used by different researchers to improve the nutrient digestibility and utilization of various fibrous feedstuffs (Alu, 2012; Ademola *et al*., 2012a; Ademola *et al*., 2012b).

The rearing of egg-type chickens has been proved to be a more profitable aspect of poultry production than the rearing of broiler birds as layer birds have been estimated to contribute 65-75 % of the total poultry population in Nigeria (Munira *et al*., 2006). A modern-day egg-laying hen is capable of producing close to 300 eggs in a normal one-year laying cycle and can be sexually matured from 16-18 weeks of age; aside from the residual meat obtained as spent layer at the end of the laying cycle (Coon, 2002). After completing their laying cycles, the meat of laying hens becomes tough due to increased collagen content as compared to broiler. According to Guan *et al.* (2013), the meat of spent layers have larger muscle fibres which are associated with meat toughening due to the large amount of connective tissues in muscles; and this increases with age. Sale of spent layers is an important source of income to the poultry farmer and can contribute meaningfully to the animal protein intake in Nigeria which is estimated at 4.5 g *per capita per day* (caput) - which is below the FAO minimum level of 35 g per caput (Ezike and Nwoye, 2004). Besides, the meat of spent layer is highly relished among the local populace because of its tougher meat which they generally prefer to the soft and tender meat of conventional broiler chicken. Hence, the objective of this research study was to evaluate the gut morphology, meat yield and sensory properties of laying hens fed diets containing varying levels of water hyacinth meal supplemented with exogenous enzymes (Maxigrain®).

Materials and Methods

Preparation of water hyacinth meal

Water hyacinth meal (WHM) was prepared using the procedure of Malik *et al*. (2013). Whole growing plants of water hyacinth (including leaf, stem and roots) were collected from River Niger in Lokoja, Kogi State. The green plants were harvested freshly from the river surface in the month of March (at the height of the dry season) by hand and using canoe; and sun-dried for five to seven days at the river bank until they were properly dried. They were then packaged in polythene sacks and transported to Minna for further processing. At the Animal Production Laboratory of the Federal University of Technology, Minna, the sundried plants were separated from foreign materials and debris and oven dried at 80^{0}C for about 24 hours to a moisture content of less than 10 %. The dried plants were then milled with an attrition mill and sieved using a 2 mm sieve. The fine-grained, powdered products obtained were then stored in plastic containers with lid until needed. The proximate composition of WHM is shown in Table 1 while its fibre composition is shown in Table 2.

The experimental diets

Six experimental diets were prepared for the birds. They were Diet 1 (Control Diet with 0 % dietary inclusion level of WHM, with no Maxigrain® enzyme added), Diet 2 (Layers' diet with 10 % dietary inclusion level of WHM, with no Maxigrain® enzyme added), Diet 3 (Layers' diet with 20 % dietary inclusion level of WHM, with no Maxigrain® enzyme added), Diet 4 (Control Diet with 0 % dietary inclusion level of WHM, with Maxigrain® enzyme added), Diet 5 (Layers' diet with 10 % dietary inclusion level of WHM, with Maxigrain® enzyme added) and Diet 6 (Layers' diet with 20 % dietary inclusion level of WHM, with Maxigrain® enzyme added).

Table 1: Proximate composition of water hyacinth meal

Parameter	% composition
Dry matter	94.9
Crude protein	14.41
Crude fibre	21.33
Ether extract	3.00
Ash	23.11
Nitrogen free extract	33.05

Table 2: Crude fibre composition of water hyacinth meal

Fibre component	% Composition
Neutral detergent fibre (NDF)	63.54
Acid detergent fibre (ADF)	37.46
Cellulose	24.60
Hemicellulose	26.08
Lignin (ADL)	12.86

Maxigrain® was a commercial grade enzyme purchased from ANIMAL CARE, Kaduna, at the rate of ? 400 per sachet (100 g) and added as a non-nutritive additive at the rate of 100 g per tonne of feed. The other feed ingredients used were purchased from the Central Market, Minna and from other commercial feed ingredients depot within Minna metropolis. Table 3 shows the gross composition of the experimental diets (on % basis).

Experimental animals and their management

A total of 216 laying hens aged 24 weeks and about 4 weeks in lay were used for this study; and were randomly divided into six treatments made up of three replicates per treatment and 12 birds per replicate. They were managed intensively in the battery cages and fed the experimental diets *ad libitum* for 12 weeks.

Determination of Gut Morphology and Meat Yield

At the end of the feeding trial (when the birds were 36 weeks' old), two birds per replicate, making a total of six birds per treatment, were randomly selected and kept off feed for 12 hours. Their live weights were recorded, after which they were slaughtered. Slaughtering, evisceration and

Table 3: **Composition of the experimental diets for laying hens**

	Without enzyme			With enzyme**		
WO replacement	**0%**	**50%**	**100%**	**0%**	**50%**	**100%**
Ingredients (%)	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**
Maize	43.00	43.00	43.00	43.00	43.00	43.00
Groundnut cake	21.00	21.00	21.00	21.00	21.00	21.00
Fish meal (65 % CP)	2.00	2.00	2.00	2.00	2.00	2.00
Wheat offal (WO)	**20.00**	**10.00**	**0.00**	**20.00**	**10.00**	**0.00**
WHM	**0.00**	**10.00**	**20.00**	**0.00**	**10.00**	**20.00**
Palm oil	1.00	1.00	1.00	1.00	1.00	1.00
Bone meal	3.50	3.50	3.50	3.50	3.50	3.50
Limestone	8.00	8.00	8.00	8.00	8.00	8.00
Lysine	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50	0.50	0.50
*Premix (Layer)	0.25	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated values						
Crude protein (%)	17.99	17.65	17.31	17.99	17.65	17.31
Metabolizable energy (Kcal/kg)	2520	2533	2546	2520	2533	2546
Crude fibre (%)	3.99	5.07	6.15	3.99	5.07	6.15
Lysine (%)	1.64	1.64	1.64	1.64	1.64	1.64
Methionine (%)	0.77	0.77	0.77	0.77	0.77	0.77
Calcium (%)	4.30	4.30	4.30	4.30	4.30	4.30
Phosphorus (%)	1.02	1.02	1.02	1.02	1.02	1.02

*Each 2.5 kg of the Premix contains 8,500,000 IU vitamin A; 1,500,000 IU vitamin D_3; 10,000 mg vitamin E; 1,000 mg vitamin K_3; 1,500 mg vitamin B_1; 4,500 mg vitamin B_2; 15,000 mg niacin (B_3); 4,500 mg pantothenic acid (B_5); 5,000 mg vitamin B_6; 15 mg vitamin B_{12}; 600 mg folic acid; 500 mg biotin H2; 175,000 mg choline chloride; 200 mg Cobalt (Co); 3,000 mg copper (Cu); 1,000 mg iodine (I); 40,000 mg manganese (Mn); 200 seleniun (Se); 30,000 mg Zinc (Zn); and 1,250 mg antioxidant.
WHM = Water hyacinth meal WO = Wheat offal
**Maxigrain® enzyme was added at the rate of 0.10 g/kg of the diet as a feed additive

dressing were carried out using the standard procedure of Jones (1984). The bled carcasses were weighed and then dipped in scalding water (60 ^{0}C) for one minute. They were then defeathered, singed and eviscerated. After dissection, the internal organs and abdominal fat of the carcasses were carefully removed. The weights of the primal cut-up-parts (head, neck, shank, back, thigh, breast and drumsticks) as well as the weights of the internal organs (heart, liver, gizzard, kidney and intestines) were taken and recorded.

Determination of Sensory Properties

The meat of the breast and thigh of each replicate sample were selected for sensory evaluation. The selected parts were boiled in water for about 30 minutes, until well cooked, with salt added to taste. Samples, made up of equal bite size from each treatment (about 20 g), were coded and randomly allocated to 20 selected panelists. Each sample was evaluated independently; with each panelist made to rinse his or her mouth with water after tasting each sample. Sensory evaluation was carried out on appearance (colour), flavour, juiciness, tenderness (texture) and overall acceptability of the meat of each replicate using a nine-point Hedonic Scale (Peryam, 1998). The score was arranged in a descending order; with the maximum score 9 given to the "like extremely" while the lowest score 1 was for the "dislike extremely".

Chemical Analysis

The proximate composition of WHM and the experimental diets were determined using the procedures of AOAC (1990). Fibre composition of WHM was determined using the procedure of Van Soest *et al*. (1998).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS, 2000, Version 6, SAS Institute, Cary, NC, USA) based on the Completely Randomized Design model following a 2 x 3 factorial arrangement (2 levels of enzyme and 3 levels of WHM). Where treatment or interaction means were significant, they were separated using the Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

WHM has a high fibre (21.33 %), low protein (14.41 %) and high ash (23.11 %) content. The NDF and ADF values of 63.54 and 37.46 obtained for WHM in this study compares favourably with the values of 62.3 and 29.0 respectively obtained by Dung (2001) for whole shoot water hyacinth collected from the river in the Mekong Delta of Vietnam. For the experimental diets for laying hens, CP ranged from 17.31 % (Diet 3 and Diet 6) to 17.99 % (Diet 1 and Diet 4). These values more than satisfy the minimum 16 % CP recommended for laying hens in the tropics by Olomu (2011) and 16.5 % CP recommended for laying hens in the tropics by Aduku (1993).

Among the laying hens, there were no significant ($p>0.05$) differences in live weight (LW); as well as bled weight (SW), plucked weight (DW), eviscerated weight (EWT) and dressed weight (DW) expressed as % of LW (Table 4), between birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; and between birds fed the varying dietary inclusion levels of WHM (0, 10 and 20 %). These results are in agreement with the findings of Biswas *et al*. (1999) that carcass yield had no significant ($p>0.05$) difference among enzyme-treated and non-treated diets for broilers. Also, there were no significant ($p>0.05$) differences in the weight of the head, neck, breast, back, thigh, drumsticks, wings and shanks between the birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation (Table 5); and between the birds fed the varying dietary inclusion levels of WHM (0, 10 and 20 %).This result is in agreement with the findings of Omojola and Adeshehinwa (2007) who observed that the weight of the breast, back, wing, thigh and the drumstick of broilers were not affected significantly ($p>0.05$) by the exogenous enzyme inclusion in the diet. Apart from the head and the neck that were significantly ($p<0.05$) affected by enzyme inclusion, the weight of the other organs were not affected by the treatments. Of all the internal organs assessed, only the weight of the gizzard showed significant ($p<0.05$) differences between the birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; with the gizzard weight being significantly ($p<0.05$) higher for the non-enzyme-supplemented diets than for the enzyme-supplemented diets (Table 6). This result is comparable to the report of Aderemi *et al.* (2006) who determined the effect of feeding enzyme-supplemented cassava root sievate (CRS) on egg quality, gut morphology and performance of egg type chickens. The authors found that the gizzard weight of layers both fed unsupplemented and supplemented high fibre CRS was significantly ($p<0.05$) increased. According to the authors, high fibre elicited gizzard hypertrophy in layers because greater grinding action was required on the more fibrous diets; hence the increase in the gizzard weight.

Table 4: **Main effects of exogenous enzymes supplementation and feeding graded levels of water hyacinth meal on the meat yield of laying hens**

Treatment	Live weight (g)	Bled weight (% of LW)	Plucked weight (% of LW)	Eviscerated weight (% of LW)	Dressed weight (% of LW)
ENZYME (E)					
0	1550.00	97.33	90.59	71.16	64.81
1	1565.22	97.76	90.39	72.04	66.14
SEM	84.48	0.73	0.89	1.17	0.93
LOS (0.05)	NS	NS	NS	NS	NS
HYACINTH (H)					
0%	1561.70	97.07	90.39	72.28	65.94
10%	1602.00	97.87	90.49	71.68	65.51
20%	1509.20	97.70	90.59	70.86	64.97
SEM	103.47	0.89	1.08	1.43	1.14
LOS (0.05)	NS	NS	NS	NS	NS
INTERACTION					
E X H	NS	NS	NS	NS	NS

Means in the same column with no superscripts were not significantly ($p>0.05$) different
SEM = Standard error of the means LOS = Level of significance
NS = not significantly different ($p>0.05$) LW = Live weight

There were no significant ($p>0.05$) differences in appearance, flavour, juiciness, tenderness and overall acceptability between the meat of birds fed diets supplemented with exogenous enzymes and those without exogenous enzyme supplementation; but the meat of birds fed 10 and 20 % dietary inclusion level of WHM had significantly ($p<0.05$) higher scores for tenderness and general acceptability than the meat of birds fed the 0 % dietary inclusion level of WHM (Table 8). This result is comparable to the findings of Omojola and Adeshehinwa (2007) when they determined the carcass and sensory characteristics of the meat of broiler chickens fed diets supplemented with graded levels of Roxazyme G®. The flavour, tenderness and juiciness scores of the meat of birds fed the enzyme supplemented diets were significantly ($p<0.05$) higher than those fed the Control Diet (with no enzyme supplementation); while the colour, texture and the overall acceptability were not significantly ($p<0.05$) affected by the inclusion of the enzyme in the diet. Tenderness is regarded as the most important sensory attribute affecting meat acceptability (Omojola and Adeshehinwa, 2007). It varies with the muscle age and depends on changes in the proportion and types of tissue supporting the muscle fibre (Lawrie, 1998). In this Study, the taste panelists rated the meat of birds fed the 10 and 20 % dietary inclusion level of WHM better than the meat of birds fed the 0 % dietary inclusion level of WHM in terms of tenderness and general acceptability. What this means is that the higher dietary inclusion level of WHM in the diet of laying hens produced tenderer meat that is more acceptable to consumers.

Table 5: Main effects of exogenous enzymes supplementation and feeding graded levels of water hyacinth meal on the weight of cut-up-parts (expressed as % of live weight) of laying hens

Treatment	Head (%)	Neck (%)	Breast (%)	Back (%)	Thigh (%)	Drumsticks (%)	Wings (%)	Shanks (%)
ENZYME (E)								
0	3.02	4.83	14.13	16.59	11.52	8.38	7.91	3.20
1	2.93	4.95	14.52	17.49	11.67	8.46	7.81	3.11
SEM	0.14	0.31	0.60	0.48	0.20	0.19	0.27	0.11
LOS (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
HYACINTH (H)								
0%	3.01	4.73	15.19	16.75	11.54	8.23	8.07	3.03
10%	3.00	5.09	13.71	17.57	11.67	8.51	7.81	3.17
20%	2.92	4.84	14.08	16.79	11.58	8.53	7.70	3.26
SEM	0.18	0.37	0.73	0.59	0.24	0.24	0.34	0.13
LOS (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
INTERACTION								
E X H	NS	NS	NS	NS	NS	NS	NS	NS

Means in the same column with no superscripts were not significantly (p>0.05) different
SEM = Standard error of the means LOS = Level of significance NS = not significantly different

Table 6: Main effects of ex ogenous enzymes supplementation and feeding graded levels of water hyacinth meal on the gut morphology of laying hens

Treatment	Heart (%)	Liver (%)	Kidney (%)	Gizzard (%)	Intestine (%)	Abdominal fat (%)	Cardiac fat (%)
ENZYME (E)							
0	0.48	1.69	0.11	2.20^{a}	4.93	2.10	0.00
1	0.51	1.83	0.11	1.84^{b}	4.75	2.32	0.00
SEM	0.03	0.12	0.01	0.09	0.31	0.52	0.00
LOS (0.05)	NS	NS	NS	*	NS	NS	NS
HYACINTH (H)							
0%	0.52	1.63	0.10	2.00	4.69	2.48	0.00
10%	0.49	1.72	0.11	2.10	4.71	1.80	0.00
20%	0.47	1.94	0.11	1.97	5.12	2.35	0.00
SEM	0.04	0.15	0.01	0.11	0.37	0.64	0.00
LOS (0.05)	NS	NS	NS	NS	NS	NS	NS
INTERACTION							
E X H	NS	NS	NS	*	NS	NS	NS

$^{a\,b\,c}$ Means in the same column with different superscripts were significantly (p<0.05) different
SEM = Standard error of the means LOS = Level of significance NS = not significantly different (p>0.05)

Table 7: Interaction effects of exogenous enzymes supplementation and feeding graded levels of water hyacinth meal on the weight of the gizzard (expressed as % of live weight) of laying hens

Treatment	Weight of gizzard (expressed as % of live weight)
Diet 1	2.00^{b}
Diet 2	2.24^{ab}
Diet 3	2.35^{a}
Diet 4	1.99^{b}
Diet 5	1.96^{b}
Diet 6	1.58^{c}
SEM	0.17
LOS (0.05)	*

$^{a\,b\,c}$ Means in the same column with different superscripts were significantly (p<0.05) different
Diet 1 = 0 % WHM; no Maxigrain® enzyme added Diet 4 = 0 % WHM; Maxigrain® enzyme added
Diet 2 = 10 % WHM; no Maxigrain® enzyme added Diet 5 = 10 % WHM; Maxigrain® enzyme added
Diet 3 = 20 % WHM; no Maxigrain® enzyme added Diet 6 = 20 % WHM; Maxigrain® enzyme added
WHM = Water hyacinth meal LOS = Level of significance SEM = Standard error of the mean

Table 8:**Main effects of exogenous enzymes supplementation and feeding graded levels of water hyacinth meal on the sensory properties of the meat of laying hens**

Treatment	Appearance	Flavour	Juiciness	Tenderness	General Acceptability
ENZYME (E)					
0	7.5	8.0	7.6	6.8	7.9
1	7.5	8.1	7.6	6.8	7.9
SEM	0.05	0.08	0.04	0.08	0.08
LOS (0.05)	NS	NS	NS	NS	NS
HYACINTH (H)					
0%	7.5	8.1	7.5	6.5^{b}	7.8^{b}
10%	7.6	8.0	7.6	7.0^{a}	8.0^{a}
20%	7.5	8.0	7.6	6.9^{a}	7.9^{ab}
SEM	0.07	0.10	0.05	0.10	0.09
LOS (0.05)	NS	NS	NS	*	*
INTERACTION					
E X H	NS	NS	NS	NS	NS

$^{a\ b\ c}$ Means in the same column with different superscripts were significantly (p<0.05) different

SEM = Standard error of the means LOS = Level of significance NS = not significantly different

Conclusion and Recommendation

It is concluded that WHM can be included up to 20 % in layer diets with no detrimental effect on meat yield, gut morphology and sensory properties of laying hens. Hence, it is recommended to feed millers, animal nutritionists and poultry farmers to include WHM up to 20 % in the diets of laying hens for optimal carcass characteristics, gut morphology and sensory properties.

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