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Research Article
Effects of *Mangifera indica* (Mango) Leaf Powder on Growth Characteristics, Biomarkers of Oxidative Stress and Toxicity in *Gallus gallus* Domesticus (Brahma) Hens

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Abstract
Background and Objective: Due to undesirable consequences of synthetic antibiotics in animal farming and ban on their use, it is imperative to find readily available alternatives that are accessible and non-harmful to the environment. This study aimed to evaluate growth performance, biomarkers of oxidative stress and toxicity in Brahma hens fed *Mangifera indica* (mango) leaf powder. **Materials and Methods:** A total of 48 Brahma hens, (45 days old), with an average weight of 400 g were divided into 4 groups of 12, according to their body weights. Hens in group 1 (control) were fed a diet without mango leaves powder *ad libitum* throughout the experiment, while hens in groups 1, 2 and 3 received a control diet supplemented with 0.25, 0.5 and 0.75% *M. indica* leaves powder, respectively. **Results:** The addition of *M. indica* leaves powder to diet did not significantly increase ($p>0.05$) feed intake, weight gain and mean daily gain compared to control birds. Meanwhile, hens fed the diet containing mango leaf powder had significantly ($p<0.05$) higher live body weight compared to the control group. Relative liver weight and abdominal fat weights were significantly ($p<0.05$) lower in mango leaf powder-fed birds compared to controls while the liver size difference was not significant. Only superoxide dismutase and aspartate aminotransferase activities were decreased significantly ($p<0.05$) compared to control. **Conclusion:** *Mangifera indica* leaf powder can be used to improve the growth of Brahma hens, especially the diet supplemented with 0.5% showed the best growth rate.

Key words: : Brahma hen, growth performance, leaves of *Mangifera indica*, oxidative stress, toxicity

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Due to lack of space for rearing large livestock, especially in densely populated areas, the development of poultry farming in general and family poultry in particular seems to be an essential solution to meet the growing demand for animal-derived protein[1]. Poultry farming is a fast way to increase meat production. It performs important socio-economic and socio-cultural roles. More than 35 million people work in the intensive and extensive systems of the nation[2]. In Cameroon, the extensive system is considered traditional or rural and is dominated by the local chicken breeds, which account for more than 80% of the country's total population[3]. This system will continue to play a very important role as a source of protein and income in rural environment where almost 80% of the population lives[4], thus to increase the animal production, it is necessary to take into account the improvement of this breed. Hens of local breed grow slowly, and despite their numbers, they contribute only 10% of the Gross Domestic Product (GDP) and provide 20 eggs and 50% of the 3600 g of meat consumed per year per inhabitant in Cameroon[2,5].

Unfortunately, due to intrinsic and environmental factors (poor feed and water quality, temperature fluctuations, high stocking densities on farms), bird performance is declining. Breeders are turning towards the use of chemicals such as antibiotics and hormones to improve growth and reproductive performance and combat against oxidative stress[6]. However, in addition to their high cost, these products cause microbial resistance over time and their chemical residues are found in consumer products made from these animals[7,8]. Consequently, many countries have banned the use of antibiotics and synthetic hormones as growth promoters in animal husbandry[9]. As a result of the ban, animal health suffered and production was reduced, which hindered economic viability of farms[10]. In order to find solutions of these problems, researchers have turned to readily available alternatives to antibiotics and synthetic hormones, which do not harm the environment and can be readily accessed by all breeders. Therefore, plant-based products such as those of *Mangifera indica* (commonly called mango tree) with anti-inflammatory, anti-bacterial, anti-parasitic, anti-fungal, anti-mutagenic, antioxidant, hepato-protective and stimulatory properties are becoming increasingly popular[11-13].

Mangifera indica leaf powder contains flavonoids, tannins, sugars, mucilages, steroids, cardiotonic glycosides, and leucoanthocyanins[14].

The multiple compounds and properties of mango leaves make them suitable for use in animal production for fighting stress and promoting growth. Based on this idea, the present study was initiated to better understand the effects of medicinal plants on oxidative stress, growth performance and toxicity index of rural hens.

MATERIALS AND METHODS

Ethical consideration: The experimental procedures used in this study were approved by the Ethical committee of the Department of Animal Science of Dschang University (ECDAS-UDs 23/02/2015/UDs/FASA/DSAES) and was in conformity with the internationally accepted standard ethical guide lines for laboratory animal use and care as described in the European Community guidelines; EEC Directive86/609/EEC, of the 24th November 1986.

Animal material: A total of 48 Brahma hens (16 males and 32 females) (45 days old), with an average weight of 400±15 were used in this study. Each hen was marked with a ring having its number.

Housing and feeding: The hens were housed in a galvanized metal mesh cages equipped with drinkers and feeders. The birds were reared at a natural daytime rhythm (12/12) throughout the trial period.

The ingredients used in the rations were purchased from the dealers of agricultural by-products in the city of Dschang. Table 1 shows the percentage compositions and chemical characteristics of the experimental rations used in Brahma hen.

Table 1: Percentage compositions and chemical characteristics of the experimental rations used in Brahma hen

Ingredients (%)	Starter phase (1-12 weeks)	Grower phase (13-20 weeks)
Maize	48.00	45.00
Wheat bran	2.50	0.00
Wheat middings	14.00	22.00
Cotton seed cake	8.00	6.00
Soya bean meal	15.00	13.00
Fish meal	6.00	3.00
Bone meal	0.00	1.50
Shell powder	1.50	1.00
Broiler concentrate 5%*	5.00	5.00
Palm oil	0.00	3.50
Total	100.00	100.00
Calculated chemical composition		
Crude proteine (%)	23.20	20.70
Metabolizable energy (kcal kg^{-1})	2913.00	3013.00
Calcium (%)	1.48	1.51
Phosphorus (%)	0.69	0.73
Lysine (%)	1.29	1.10
Methionine (%)	0.43	0.40
ME/CP	125.00	145.00

*Broiler concentrate 5%, Crude protein: 40%, Metabolizable energy: 2078 kcal kg^{-1}, Calcium: 8%, Available phosphorus: 2.05%, Lysine: 3.30%, Methionine: 2.40%, ME: Metabolizable energy and CP: Crude protein

Sanitary protection: The building and all the cages were pre-disinfected with a solution of bleach and cresyl (0.5 L of bleach and 0.5 L of cresyl for 20 L of water) sprayed in all corners of the building and allowed to air dry for a period of two weeks before the introduction of the animals. The premises and equipment were cleaned daily. Water, soap and a sponge were used to wash feeders and drinkers daily.

Plant material: Fresh matured leaves of *M. indica* were collected from the same tree at the Dschang University. They were dried in the shade at a temperature of 25°C. After drying, the leaves were crushed and ground into powder with the use of a grinding mill. The powder thus obtained was stored in opaque bottles until use.

Phytochemical tests were performed to confirm the presence or absence of certain bioactive components of *Mangifiera indica* powder. Constituents like flavonoids, phenols, tannins, steroids, terpenes, alkaloids and saponins were studies. The results of phytochemical tests of mango leaves powder are presented in Table 2.

Experimental design: A total of 48 were distributed in a completely randomized design with 4 groups of 12 birds. Hens were treated for 60 days and an adaptation period was 7 days. The treatment groups were:

- **Group 1 (control):** Formulated diet without *M. indica* powder
- **Group 2:** Formulated diet + 0.25% *M. indica* powder
- **Group 3:** Formulated diet +0.50% *M. indica* powder
- **Group 4:** Formulated diet + 0.75% *M. indica* powder

Feed consumption: Based on the difference between the quantity of feed served and the refusals, the feed consumption (FC) was calculated:

$$\text{Feed consumption (FC)} = Qs\text{-}Qr$$

Qs = Quantity served (g)
Qr = Remaining quantity (g)

Evolution of live weight (LW): The change in weight was obtained by weighing the young animals weekly between 6-8 a.m. throughout the experimental period. The weighing was done using an electronic scale with a capacity of 7000 g and a precision of 1 g.

Weight gain (WG): The weight gain was calculated using the difference between the weight of the week considered and the weight of the previous week.

$$\text{Weight gain (WG)} = W_n\text{-}W_{n-1}$$

W_n = Weight per week in consideration (g)
W_{n-1} = Weight in the previous week (g)

Average daily gain (ADG): Weight gain during a period was divided by its duration to calculate the average daily gain (ADG).

$$\text{Average daily gain (ADG)} = \frac{\text{Weight gain (g)}}{\text{Duration (d)}}$$

Assessment of relative weight and volume of organs: When the birds were slaughtered, their liver, heart, gizzard and fat were removed, stripped of fatty tissue and then weighed using a scale of 160 g capacity and an accuracy of 10^{-3} g body weight. The relative weight of the different organs was then determined using the following formula:

$$\text{Relative weight (\%)} = \frac{\text{Organ weight}}{\text{Animal weight}} \times 100$$

Liver volume was determined by the method of water displacement in a milliliter using a graduated cylinder. As the graduated cylinder is filled with water to a known initial level, the difference between the volume obtained when the organ is immersed corresponds to the volume of the organ itself.

Histology of organs: Realization and observation of histological sections of the kidney and liver were carried out according to speci c protocols in the Anatomo-pathology Laboratory of Banjoun Evangelic University. The same collected kidney section was immediately fixed in 10% formalin and processed for studies of histopathology. Then 4 µm thick sections were cut and stained with the hematoxylin and eosin procedure, and examined microscopically. At least 20 microscopic elds (20X)/slide were examined and evaluated for each slide.

Oxidative stress markers Oxidative stress indicators such as: Malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidases (GPx) were analyzed according to the methods described respectively by Oyedemi *et al.*[15] and modified by Kodjio *et al.*[16], Dimo *et al.*[17], Sajeeth *et al.*[18] and Habbu *et al.*[19].

Biochemical analyses

Hepatotoxicity markers: As soon as the birds were slaughtered, blood was collected and placed in test tubes without anticoagulant, then centrifuged at 3000 rpm for 15 min. The serum was collected, aliquoted and stored at -20°C for dosing. Aspartate-amino transferase (AST) and alanine amino-transferase (ALT) assays were evaluated by the enzymatic analysis method based on the protocol listed in the instructions for the CHRONOLAB® commercial kit.

Nephrotoxicity markers:

- Blood creatinine was measured by the colorimetric or kinetic method according to the instructions for the CHRONOLAB® commercial kit
- Urea was measured by the Urease-GLDH method using the CHRONOLAB® commercial kit

Statistical analysis: One-way analysis of variance (ANOVA) was performed to test the effects of different doses of *Mangifiera indica* powder on the traits studied. Duncan's test was used to separate the means when there were significant differences. The Pearson correlation coefficient made it possible to establish the relationships between the different parameters. The results are expressed as Mean±standard deviation. The significance limit was set at 5% and SPSS 22.0 software was used for data analysis.

RESULTS

Effects of *M. indica* leaves powder on growth characteristics of Brahma hens: Table 3 summarizes the effects of dietary *M. indica* leaf powder on cumulative feed intake, final live weight, body weight gain, average daily gain, feed conversion and feed efficiency of the Brahma hen. Results showed that *M. indica* leaves powder had no significant effect ($p<0.05$) on the feed consumption of the test groups compared to the control group. Whatever the concentration; the final live weights of birds fed diet supplemented with *M. indica* leaves powder were comparable, but significantly ($p<0.05$) higher than those of the control group. Likewise, whatever the percentage; no significant effect ($p>0.05$) was observed on consumption index and cumulative feed efficiency compared to the hens of the control group.

Effects of dietary *M. indica* leaf powder on relative organ weight, liver volume and gut density of the Brahma hen: Table 4 shows the effects of *M. indica* leaf powder on relative body weight, organ volume and abdominal fat in Brahma hens. Whatever the concentration; dietary supplementation of *M. indica* leaf powder, reduced the relative weight of the liver of the hens compared to the control. However, this decrease was only significant ($p<0.05$) with the inclusion level of 0.5%. The relative weight of gizzard and heart was not significantly influenced by the supplementation of *M. indica* leaf powder in the diet. Nevertheless, a decrease in the values of these characteristics was noted in all the hens fed diet supplemented with *M. indica* leaf powder. Relative abdominal fat weights in birds fed diet supplemented with *M. indica* leaf powder were comparable but significantly ($p<0.05$) lower than those of the control groups. On the other hand, the volume of the liver of hens fed diet supplemented with the leaf powder of *M. indica* were comparable but significantly ($p<0.05$) higher than those of the control group. Supplementation of *M. indica* leaf powder at 0.5 and 0.75% in the diet induced comparable but significantly ($p<0.05$) higher intestine densities than those of the control group.

Effects of *M. indica* leaf powder on markers of oxidative stress of Brahma hens: Table 5 highlights the effects of *M. Indica* powder on oxidative stress markers in Brahma hens.

Table 2: Phytochemical constituent of *Mangifiera indica* leaves powder

Tests	Component	Quantity
Shinoda	Flavonoides	++
	Tanin	+
Ferric chloride	Phenols	++
Dragendorff	Alcaloides	-
Foam index	Saponines	++
Liberman-buchard	Steroids	++
	Terpenoides	-

-: Absent, +: Low and ++: High

Table 3: Effects of *Mangifera indica* leaf powder in the diet on growth characteristics in Brahma hen

	M. indica powder concentration in ration (%)				
Growth characteristics	Control 0	0.25	0.5	0.75	p-value
Feed consumption (g)	4692.5±258.57	4837.61±80.25	4791.58±39.92	4724.12±208.05	0.19
Live weight	1261.50±94.37[b]	1472.00±62.17[a]	1577.50±109.76[a]	1505.00±55.37[a]	0.00
Weight gain (g)	998.25±280.2	1085.64±163.13	1019.92±347.85	1079.18±250.40	0.83
Daily weight gain (g)	16 .64±4.67	18.09±2.72	17.00±5.80	17.99±4.17	0.83
Consumption index	5.60±3.76	4.54±0.63	6.54±6.83	4.62±1.17	0.60
Feed efficiency	0.21±0.06	0.22±0.03	0.21±0.07	0.23±0.05	0.87

[a,b]Values affected with the same letter in the same line are not significantly different ($p>0.05$) and p: Probability

Table 4: Effects of *M. Indica* leaf powder in diet on organ volume in Brahma hens

	M. indica powder concentration in ration (%)				
Organ	Control 0	0.25	0.5	0.75	p-value
RW of liver	2.01±0.17[a]	1.83±0.23[ab]	1.76±0.07[b]	1.87±0,13[ab]	0.08
RW of gizzard	2.43±0.23	2.23±0.16	2.17±0.34	2.25±0.28	0.33
RW of fat	3.72±1.09[a]	1.72±0.63[b]	2.38±0.90[b]	1.70±0.42[b]	0.01
RW of heart	0.49±0.05	0.42±0.12	0.45±0.03	0.48±0.04	0.22
Liver volume	23.50±2.10[b]	26.83±1.60[a]	26.67±1.63[a]	26.50±1.29[a]	0.01
Density of intestine	0.32±0.04[b]	0.35±0.04a[b]	0.38±0.04[a]	0.38±0.05[a]	0.05

[a,b]Values affected with the same letter in the same line are not signi cantle different (p>0.05), p: probability and RW: Relative weight

Table 5: Effects of *M. indica* leaf powder in feed on oxidative stress characteristics in Brahma hens

	M. indica powder concentration in ration (%)				
Oxidative stress characteristics	Control 0	0.25	0.5	0.75	p-value
SOD	3.96±0.75[a]	3.11±0.54[b]	2.49±0.77[b]	2.61±0.66[b]	0.01
CAT	0.81±0.16	0.76±0.10	0.74±0.10	0.81±0.14	0.70
GPx	0.01±0.001	0.01±0.005	0.01±0.005	0.01±0.003	0.65
MDA	0.64±0.05	0.60±0.08	0.62±0.03	0.61±0.03	0.61

[a,b]Values affected with the same letter in the same line are not signi cantle different (p>0.05). SOD: Super oxide dismutase, CAT: Catalase, GPx: Glutathione peroxidase, MDA: Malondialdéhyde and p: Probability

Table 6: Correlation between the different characteristics in Brahma hen

Characteristic	FC	LW	WG	ADWG	RW liver	SOD	CAT	GPx	MDA	ALT
LW	0.62	1								
WG	0.50	0.48	1							
ADWG	0.50	0.48	-1.00**	1						
RW liver	-0.77	-0.96*	-0.39	-0.39	1					
SOD	-0.68	-0.99**	-0.58	-0.58	0.95*	1				
CAT	-0.67	-0.99**	-0.55	-0.55	0.96*	0.99**	1			
GPx	-0.66	-0.99**	-0.49	-0.49	0.97*	0.99**	0.99**	1		
MDA	-0.64	-1.00**	-0.49	-0.49	0.97*	0.99**	0.99**	1.00**	1	
ALT	-0.91	-0.88	-0.64	-0.64	0.93	0.92	0.91	0.90	0.89	1
AST	-0.03	-0.65	-0.69	-0.69	0.43	0.67	0.66	0.62	0.64	0.42

*Correlation is significant at 0.05, **Correlation is significant at 0.01, ALT: Alamin aminotransferase, AST: Aspartate aminotransferase, SOD: Super oxide dismutase, CAT: Catalase, GPx: Glutathione peroxidase, MDA: Malondialdéhyde, RW: Relative weight, WG: Weight gain, ADWG: Average daily weight gain, LW: Live weight and FC: Feed consumption

Superoxide dismutase activities at different concentrations of the *M. indica* powder were comparable but significantly ($p<0.05$) lower than those of the control birds. The serum activities of catalase and glutathione peroxidase, as well as the level of malondialdehyde recorded in birds fed diets supplemented with *M. indica* leaf powder remained comparable to the values recorded for the control group. However, *M. indica* leaf powder, regardless of its concentration in the feed, induced a non-significant decrease ($p<0.05$) in the malondialdehyde levels in the blood. Relative liver weight was positively and significantly correlated with SOD level ($r = +0.95$, $p<0.05$) and serum catalase activity ($r = +0.96$, $p<0.05$) and serum GPx activity ($r = +0.97$, $p<0.05$). In addition, negative and non-significant correlations were recorded between malondialdehyde level and weight gain ($r = -0.49$, $p< 0.05$) and feed consumption ($r = -0.64$, $p> 0.05$). On the other hand, negative and significant correlations were recorded between the level of malondialdehyde and live weight ($r = -1.00$, $p<0.01$) (Table 6).

Effects of *M. indica* leaf powder in feed on markers of toxicity in Brahma hens: The effects of *M. indica* leaf powder on toxicity markers are shown in Table 7.

This reveals that regardless of the percentage, ALT and AST activities decreased non-significantly ($p>0.05$) in hens fed diet supplemented with *M. indica* leaf powder compared to the control group. The activities of these enzymes were lowest in hens receiving 0.25% *M. indica* leaf powder in the feed. Relative liver weight was positively and non-significantly correlated with ALAT and AST activities ($r = +0.93$, $p>0.05$) and ($r = +0.43$, $p>0.05$), respectively as indicated in Table 6.

The different concentrations of *M. indica* leaf powder reduced the serum creatinine level in comparison with the control birds. However, this decrease was only significant ($p<0.05$) in hens fed diet supplemented with *M. indica* leaf powder at doses of 0.5 and 0.75%. However, the supplementation of the *M. indica* leaf powder, whatever the rate, had no significant effect ($p>0.05$) on the serum level of urea compared to the controls.

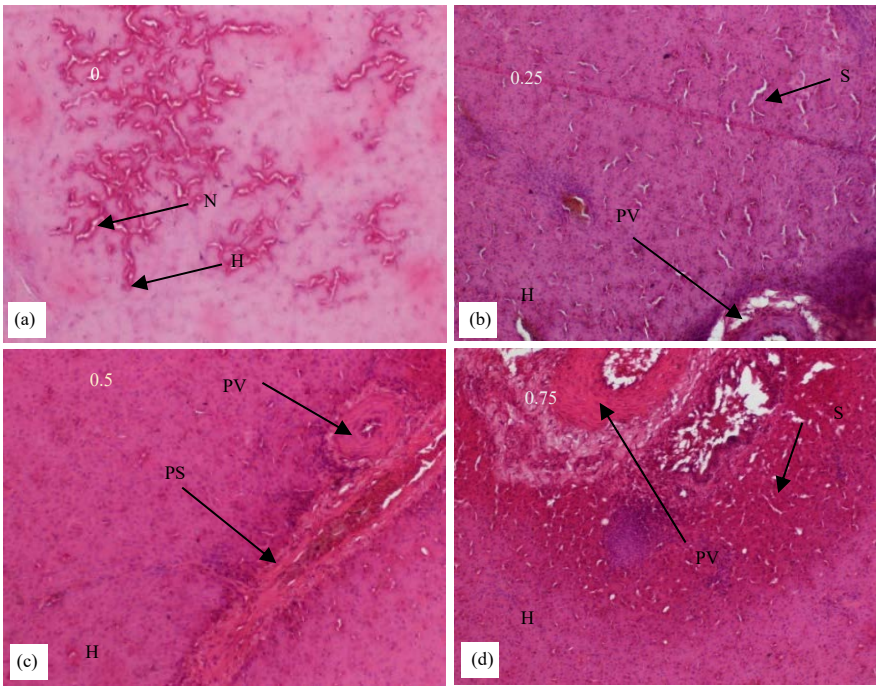

Fig. 1(a-d): Effects of *Mangifera indica* leaf powder in feed on liver histology in Brahma hen
0 (control), 0.25, 0.5 and 0.75: Doses of *Mangifera indica* leaf powder (g), PS: Portal space, H: Hepatocyte, N: Necrosis, S: Sinusoid and PV: Portal vein

Effects of *M. indica* leaf powder in feed on liver histology in the Brahma hen: Figure 1 illustrates the effects of *M. indica* leaf powder on liver histology in the Brahma hen. The liver of the hens of the control group showed slight alterations, infiltrations and degeneration of the hepatocytes. Supplementation of *M. indica* leaf powder improved the histological structure of the liver. However, this improvement was more evident in hens that received 0.5% of the powder in the ration.

Effects of *M. indica* leaf powder on kidney histology in the Brahma hen: The effects of *M. indica* leaf powder on kidney histology in the Brahma hen are presented in Fig. 2. The kidney of the hens of the control group showed slight alterations and tubular infiltrations. Supplementation of *M. indica* leaf powder in the diet improved the histological structure of the kidney; although this improvement was more evident in hens that received 0.75% of the powder in the ration.

DISCUSSION

The results showed that the *M. indica* leaf powder, whatever its concentration considered in the feed, led to a non-significant increase in feed intake in Brahma hens. These results contradict with the findings of Bello[20], who reported that the incorporation of *M. oleifera* leaf powder at the rate of 16 and 24% in the feed of local hens induced a significant decrease in the feed intake compared to control birds. The difference between the results of these two studies may be related to the plant used, the rate of supplementation in feed, the duration of the treatment and the managerial conditions. The increase in feed consumption observed in the present study could be due to the palatability of the feed or stimulation of the appetite centers caused by certain compounds found in the mango leaves (flavonoids, phenols and carotenoids). According to Yang *et al.*[21], these molecules will improve the taste, flavor, smell and thus the palatability of the feed. Supplementation of *M. indica* powder in the feed of hen, regardless of the concentration, induced a significant increase in live weight compared to the control. This result might be due to the increase in feed consumption. Indeed, optimal consumption would boost the bioavailability of nutrients required for the growth and development of cells in animal tissue. A positive correlation was also noted between live weight and feed consumption, suggesting a variation in the same direction of the two variables.

In the present investigation, a non-significant increase in live weight gain and average daily gain were recorded in Brahma hens fed diet supplemented with *M. indica* leaf powder. This could be due to the availability of nutrients necessary for constructive reactions of the body. In addition, there is evidence that tannins, alkaloids, saponins, flavonoids

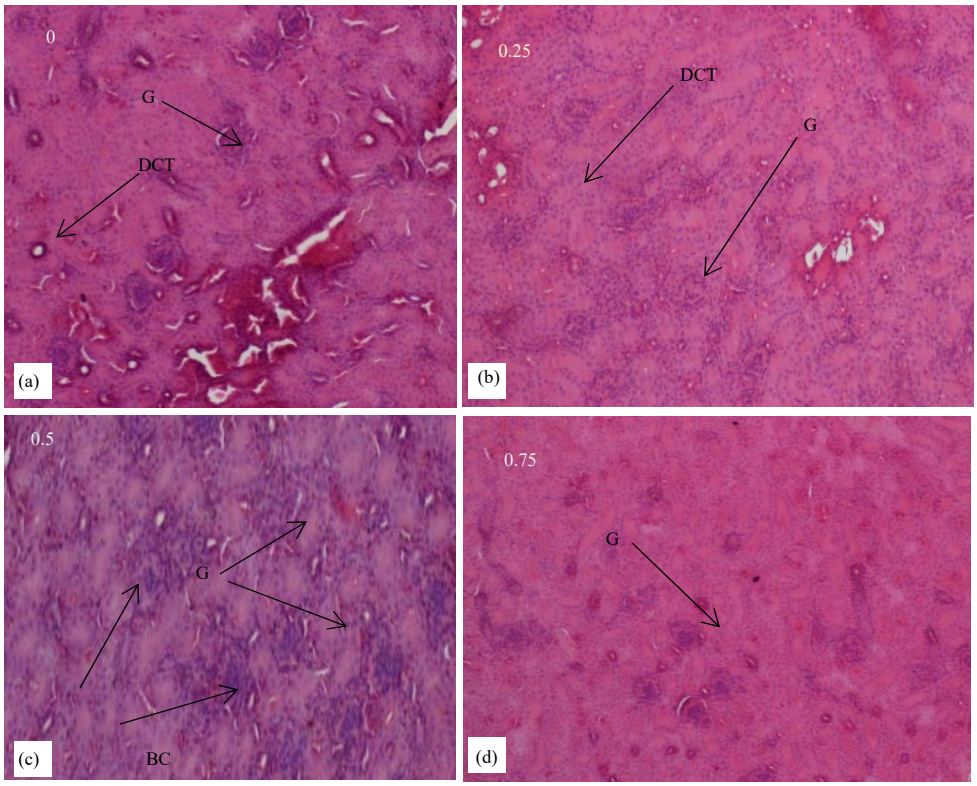

Fig. 2(a-d): Effects of *Mangifera indica* leaf powder in feed on kidney histology of Brahma hen
0 (control), 0.25, 0.5 and 0.75: Doses of *Mangifera indica* leaf powder (g), G: glomerulus, BC: Bowman's capsule and DCT: Distal convoluted tube

Table 7: Effects of *M. indica* leaf powder in feed on biochemical characteristics in Brahma hens

Biochemical characteristics	*M. indica* powder concentration in ration (%)				
	Control (0)	0.25	0.5	0.75	p-value
ALT	51.04±12.89	39.05±15.69	48.42±13.10	44.040±15.18	0.650
AST	185.75±36.99[a]	136.39±30.26[b]	148.40±32.57[ab]	144.880±37.16[ab]	0.120
Creatinine	0.05±0.01[a]	0.04±0.02[ab]	0.02±0.008[c]	0.033±0.007[bc]	0.006
Urea	26.62±0.77	26.28±0.30	26.14±0.54	26.280±1.34	0.730

[a,b]Values affected with the same letter in the same line are not signi cantle different (p>0.05). ALT: Alamin aminotransferase, AST: Aspartate aminotransferase and p: Probability

and terpenoids present in the powder of mango leaves may have destroyed the pathogenic microorganisms of the digestive tract thanks to their bactericidal and antifungal properties, thus promoted the beneficial microorganisms and therefore facilitated digestion, absorption and efficient use of nutrients[22] and increased weight gain and average daily gain though not significantly. Similar results are obtained by Iheukwumere *et al.*[23] who used cassava leaf powder in broiler chicken feed. Wude and Berhan[24] used 10% of sweet potato leaf powder in the diet of broiler chickens and obtained the same results.

Supplementation of mango leaf powder in the feed of the hens, whatever the concentration, induced a reduction in the relative weights of the organs (liver, gizzard and heart) compared to the control. These results agree with the findings of Iheukwumere *et al.*[23] who reported a significant decrease in the weight of the same organs with the incorporation of cassava leaf powder in the ration of broiler chickens at concentrations of 10 and 15%. However, this contradicts with the observation of Bello[20] who mentioned an increase in organ weight with the inclusion of *Moringa oleifera* leaf powder up to 24% in the ration of local hens in Senegal. *M. indica* powder significantly reduced the relative abdominal fat weights of birds compared to control animals. It may be due to the presence of flavonoids, tannins and phenols in mango leaves which inhibit the activity of α-glucosidase and the formation of micelles in the small intestine which decreased digestion and absorption of triglycerides leading to decreased formation

of body fat[25]. Liver volume and gut density observed in hens fed diet supplemented with *M. indica* leaf powder was significantly ($p>0.05$) higher than those of the control birds.

The present study revealed that the different concentrations of *M. indica* powder decreased the activities of superoxide dismutase, catalase, glutathione peroxidase, as well as the rate of malondialdehyde compared to the control group. The low level of MDA may reflect the antioxidant activity of mango leaf powder, which is mediated by vitamins C and E, carotenoids, flavonoids[26], which would have induced a reduction in lipid peroxidation by neutralizing free radicals. The participation of these molecules in the fight against free radicals could justify the increase in serum levels of SOD[19,27]. Antioxidant activity is one of the main defense systems of the body against the adverse consequences of reactive oxygen species in animals.

Serum alamine aminotransferase (ALT) and aspartate aminotransferase (AST) activities provide information on the state of liver cells[28]. In the present research, ALT activity decreased non-significantly ($p>0.05$) in hens fed *M. indica* leaf powder regardless of the percentage compared to control groups. The different concentrations of *M. indica* powder stimulated a reduction in serum AST activity as compared to the control group. However, this decrease was only significant ($p<0.05$) in hens fed *M. indica* leaf powder at the dose of 0.25%. Low level of serum ALT and AST activity in the present study could therefore reflect the fact that the plant was not hepatotoxic; because according to Zounongo[29], an increase in the level of serum transaminases reflects hepatic cytolysis. Moreover, the histology section of the liver also showed an improvement in the structure with the supplementation of the leaf powder of *M. indica*. Nevertheless, flavonoids are recognized for their hepatoprotective activities[30]. The antioxidant and hepatoprotective activities of mango leaves may therefore be due to the presence of flavonoids.

The results of this study revealed that the supplementation of the powder of the leaves of *M. indica* in the feed, whatever the percentage, had no effect on the serum activity of urea and creatinine compared to controls. However, powder supplementation decreased serum urea and creatinine activity, whatever the concentration considered. Creatinine and urea activities serve as markers of the condition and functioning of the kidneys. *M. indica* leaf powder supplementation improved the histological structure of the kidney of hens with an increase in the supplementation rate. The drop in the activity of urea and creatinine in the present study could be explained by the presence of antioxidants such as xanthones and flavonoids which would protect the kidney against the harmful effects of oxidative stress and therefore would avoid damage to the tubular and glomerular cells. Urea and creatinine are among the essential parameters for evaluating renal function and glomerular filtration[31].

CONCLUSION

Supplementation of rations with *M. indica* leaves powder increased live weight and decreased relative organ weight, inhibited lipid peroxidation and decreased superoxide dismutase activity. In view of these, *M. indica* leaf powder could be used as a dietary supplement to improve growth performances, fight against oxidative stress and strengthen immune defenses in growing Brahma hens. Rates of 0.5% and 0.75% have produced the best results, so we recommend them.

REFERENCES

1. Pamo, E.T., A.T. Niba, F.A. Fonteh, F. Tedonkeng, J.R. Kana, B. Boukila and J. Tsachoung, 2005. Effect of supplementation with *Moringa oleifera* or multi-nutritional blocks on post partum weight and pre-weaning growth of guinea pigs (*Cavia porcellus* L.) [In French]. Livest. Res. Rural Dev., Vol. 17.
2. Fotsa J.C., A. Bordas, X. Rognon, M. Tixier-Boichard, K.D. Poné and Y. Manjeli, 2007. Caractérisation des élevages et des poules villageoises et comparaison en station de leurs performances à celles d'une souche commerciale de type Label au Cameroun. 7th Edn., 7e Journées Recherche avicole, Tours, France, pp: 414-417.
3. Alders, R., 2005. L'aviculture: Source de profit et de plaisir. Food and Agriculture Organization, Rome.
4. Ministere de L'Elevage, Des Peches ET Des Industries Animales, 2011. Document de strategie du sous-secteur de l'elevage, des pêches et des industries animales. Division des Etudes, des Statistiques et de la Coopération. https://faolex.fao.org/docs/pdf/cmr146473.pdf.
5. Fotsa, J.C. and Y. Manjeli, 2001. Analyse comparée des performances de croissance en claustration des poussins de souche locale, d'une lignée Jupiter et de leurs croisements F1. Annales Sci. Agronomiques Bénin, 2: 181-192.
6. Jeong, S.H., D.J. Kang, M.W. Lim, C.S. Kang and H.J. Sung, 2010. Risk assessment of growth hormones and antimicrobial residues in meat. Toxicol. Res., 26: 301-313.
7. Nejib, M., B. Taroub, O. Imen, R. François, H. Mokhtar and B. Ridha, 2009. Effet de deux preparations d'huiles essentielles sur la croissance des bacteries *in vitro* et Les performances du poulet de chair. Proceeding of 8th Poultry Research Days, March 25-26, 2009, 1-5.
8. Rajeshwar, Y., M. Gupta and U.K. Mazumder, 2005. *In vitro* lipid peroxidation and antimicrobial activity of *Mucuna pruriens* seeds. Iran. J. Pharmacol. Ther., 4: 32-35.

9. Donoghue, D.J., 2003. Antibiotic residues in poultry tissues and eggs: Human health concerns? Poult. Sci., 82: 618-621.
10. Dibner, J.J. and J.D. Richards, 2005. Antibiotic growth promoters in agriculture: History and mode of action. Poult. Sci., 84: 634-643.
11. Chen, H.Y. and G.C. Yen, 2007. Antioxidant activity and free radical-scavenging capacity of extracts from guava (*Psidium guajava* L.) leaves. Food Chem., 101: 686-694.
12. Chowdhury, N., W. Islam and M. Khalequzzaman, 1970. Insecticidal activities of stem bark extracts from *Vitex negundo* L. against *Tribolium castaneum* (Herbst). J. Bio-Sci., 17: 63-70.
13. Brenes, A. and E. Roura, 2010. Essential oils in poultry nutrition: Main effects and modes of action. Anim. Feed Sci. Technol., 158: 1-14.
14. Bakayoko and M. Tograba, 2001. Etude botanique et phytochimique de trois plantes médicinales en vue de la production d'un médicament traditionnel amélioré (MTA). Ph.D. Thesis, Université de Bamako.
15. Oyedemi, S.O., G. Bradley and A.J. Afolayan, 2010. *In vitro* and -*vivo* antioxidant activities of aqueous extract of Strychnos henningsii Gilg. Afr. J. Pharm. Pharmacol., 4: 70-78.
16. Kodjio, N., S. Atsafack, G. Njateng, J. Sokoudjou, J.R. Kuiate and D. Gatsing, 2016. Antioxidant effect of aqueous extract of *Curcuma Longa* rhizomes (Zingiberaceae) in the typhoid fever induced in Wistar rats model. J. Adv. Med. Pharm. Sci., Vol. 7, 10.9734/jamps/2016/24949.
17. Dimo, T., D.E. Tsala, D.P.D. Dzeufiet, B.V. Penlap and N. Njifutie, 2006. Effects of Alafia multiflora stap on lipid peroxidation and antioxidant enzyme status in carbon tetrachloride-treated quails. Pharmacol. Online, 2: 76-89.
18. Sajeeth, C.I., P.K. Manna and R. Manavalan, 2011. Antioxidant activity of polyherbal formulation on streptozotocin induced diabetes in experimental animals. Der Pharmacia Sin., 2: 220-226.
19. Habbu, P., R. Shastry, K. Mahadevan, H. Joshi and S. Das, 2008. Hepatoprotective and antioxidant effects of *Argyreia speciosa* in rats. Afr. J. Traditional Complementary Altern. Med., 5: 158-164.
20. Bello, H., 2010. Essai d'incorporation de la Farine de Feuilles de Moringa oleifera Dans L'alimentation Chez Les Poulets Indigènes du Sénégal: Effets Sur Les Performances de Croissance, les Caractéristiques de la Carcasse et le Résultat Économique. Phd Thesis, Universite Cheikh Anta Diop De Dakar.
21. Yang, W.Z., C. Benchaar, B.N. Ametaj and K.A. Beauchemin, 2010. Dose response to eugenol supplementation in growing beef cattle: Ruminal fermentation and intestinal digestion. Anim. Feed Sci. Technol., 158: 57-64.
22. Idris, S., G. Ndukwe and C. Gimba, 2010. Preliminary phytochemical screening and antimicrobial activity of seed extracts of P*ersea americana* (avocado pear). Bayero J. Pure Applied Sci., 2: 149-153.
23. Iheukwumere, F.C., E.C. Ndubuisi, E.A. Mazi and M.U. Onyekwere, 2008. Performance, nutrient utilization and organ characteristics of broilers fed cassava leaf meal (*Manihot esculenta* Crantz). Pak. J. Nutr., 7: 13-16.
24. Wude, T. and T. Berhan, 2009. The effect of increasing levels of dried leaves of sweet potato (*Ipomoea batatas*) on dry matter intake and body weight gain performance of broiler finisher chicks. Livestock Res. Rural Dev., Vol. 21.
25. Prashanth, D., A. Amit, D.S. Samiulla, M.K. Asha and R. Padmaja, 2001. α-Glucosidase inhibitory activity of *Mangifera indica* bark. Fitoterapia, 72: 686-688.
26. Tcheghebe, O.T., L.D. Nyamen, F.N. Tatong and A.J. Seukep, 2016. Ethnobotanical uses, phytochemical and pharmacological profiles, and toxicity of *Persea americana* Mill. : An overview. PharmacologyOnLine, 3: 213-221.
27. Haleng, J., J. Pincemail, J.O. Defraigne, C. Charlier and J.P. Chapelle, 2007. Le stress oxydant. Rev. Med. Liege., 10: 628-638.
28. Ogunlade, I., A.A. Alebiosu and A.I. Osasona, 2012. Proximate, mineral composition, antioxidant activity, and total phenolic content of some pepper varieties (*Capsicum species*). Int. J. Bio. Chem. Sci., 6: 2221-2227.
29. Zabre, Z.M., 2013. Détermination des paramètres biochimiques usuels chez les petits ruminants du Burkina Faso et leurs variations chez les sujets infectés naturellement par la trypanosomose. Thèse en Médecine vétérinaire, Université Cheikh Anta Diop de Dakar.
30. Sangare, M.M., B. Bayala, J.M. Ategbo, F. Loko and K.L. Dramane, 2012. Effets de l'extrait aqueux de *Gomphrena celosioides* (amaranthaceae) sur les enzymes hépatiques. Afr. Sci., 8: 107-115.
31. Djeffal, A., 2014. Evaluation de la toxicité d'un insecticide carbamate«méthomyl » chez le rat wistar : Stress oxydant ET exploration des effets protecteurs de la supplémentation en sélénium ET/OU en vitamine C. Ph.D. Thesis, Université Badji Mokhtar-Annaba.