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Research Article

Effects of Mango (*Mangifera indica*) Leaf Powder Supplementation on Growth Performance and Carcass Characteristics of Broiler Chickens (*Gallus gallus domesticus*)

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ABSTRACT

This study evaluated the effects of *Mangifera indica* (mango) leaf powder (MLP) on the growth performance and carcass characteristics of broiler chickens. A total of 90 ROSS 308 broiler chicks (male and female), aged 21 days, with an average weight of 783 ± 51 g (males) and 651 ± 39 g (females), were randomly assigned to three dietary treatment groups (T0: control, T1: 0.5% MLP, T2: 1% MLP) in a fully randomized design. Treatment started from 21 days of age to 49 days old. Live weight, average daily gain, and feed consumption were highest in chickens fed 1% MLP. Although feed conversion did not significantly differ across diets ($P > 0.05$), the 1% MLP group exhibited the best feed efficiency. Commercial carcass yield (CoCY) and conventional carcass yield (CvCY) were significantly higher in chickens fed 0.5% MLP, whereas the 1% MLP group showed superior growth performance. Regardless of diet, no significant differences ($P > 0.05$) were observed in pancreas weight. However, intestine density and liver percentage were significantly lower in chickens fed 1% MLP. This study suggests that *Mangifera indica* leaf powder supplementation can enhance broiler growth and carcass characteristics, with 1% MLP improving overall growth and 0.5% MLP optimizing commercial carcass yield.

Keywords: Antioxidants, Broiler chickens, Growth performance, *Mangifera indica* leaf powder, Oxidative stress

RÉSUMÉ

Cette étude a évalué les effets de la poudre de feuilles de *Mangifera indica* (mangue) (MLP) sur les performances de croissance et les caractéristiques des carcasses de poulets de chair. Au total, 90 poussins de chair ROSS 308 (mâles et femelles), âgés de 21 jours, d'un poids moyen de 783 ± 51 g (mâles) et 651 ± 39 g (femelles), ont été répartis au hasard dans trois groupes de traitement alimentaire (T0 : contrôle, T1 : 0,5 % MLP, T2 : 1 % MLP) dans un plan entièrement randomisé. Le traitement a débuté entre l'âge de 21 jours et l'âge de 49 jours. Le poids vif, le gain quotidien moyen et la consommation alimentaire étaient les plus élevés chez les poulets nourris avec 1 % de MLP. Bien que la conversion alimentaire ne diffère pas significativement selon les régimes ($P > 0,05$), le groupe MLP à 1 % a présenté la meilleure efficacité alimentaire. Le rendement en carcasse commerciale (CoCY) et le rendement en carcasse conventionnelle (CvCY) étaient significativement plus élevés chez les poulets nourris avec 0,5 % de MLP, alors que le groupe avec 1 % de MLP présentait des performances de croissance supérieures. Quel que soit le régime alimentaire, aucune différence significative ($P > 0,05$) n'a été observée dans le poids du pancréas. Cependant, la densité intestinale et le pourcentage de foie étaient significativement plus faibles chez les poulets nourris avec 1 % de MLP. Cette étude suggère que la supplémentation en poudre de feuilles de *Mangifera indica* peut améliorer la croissance des poulets de chair et les caractéristiques de la carcasse, avec 1 % de MLP améliorant la croissance globale et 0,5 % de MLP optimisant le rendement commercial des carcasses.

Mots clés: Antioxydants, Poulets de chair, Performance de croissance, Poudre de feuilles de *Mangifera indica*, Stress oxydatif

1. INTRODUCTION

Cameroon, like any other developing country, is facing protein shortages, especially with the increasing population. A per capita daily intake average of about 24.6 grams is needed by an average Cameroonian given the cereal-based diet, deficient in both calories and proteins (Merar.com, 2015). The average protein requirement for a Cameroonian, like most adults worldwide, is 0.8 g of protein per kilogram body weight per day. Out of it, 27.4 g comes from animal sources. The amount of protein per 100 g of Chicken is 31 g, which therefore means that each Cameroonian needs to consume 200 g of animal meat per day. To meet the demand

of this nutrient, Cameroonians need an additional production of 0.5 million large animals, 1.5 million small animals, and 3.01 million births per year; making the industry one with high potential in Cameroon, given that poultry meat and eggs are the most consumed animal proteins, unrestricted by any religion or culture in the nation (Tequia and Beynen, 2004).

Poultry accounted for 34.38% of total meat production in Cameroon between 2011 and 2016 (Mbodiam, 2018) due to restrictions on the import of frozen chicken implemented by the government in 2005. Imports of frozen poultry meat then fell from 3,500 t in 2005 to 41 t in 2016. This has encouraged the growth of local production, which reached 135,000 t in 2015.

To reach these high production rates, breeders turn towards the use of products and methods that are said to improve animal production. Unfortunately, some of these products and methods have undesirable effects. High genetic selection for fast growth rate, and commercial animal farming conditions could bring about oxidative stress which could hinder health, optimum productivity, welfare as well as product quality (Mishra and Jha, 2019). Oxidative stress occurs when there is an imbalance between antioxidant and free radicals production. It may come from the internal or the external environment of the animal. Broiler meat has high levels of poly-saturated fatty acid that is known to be the main substrate for oxidative spoilage (Adeyemi et al., 2020). To fight against this oxidative damage, breeders turn towards the use of antioxidants known to scavenge free radicals. Antioxidants can be from natural or synthetic sources.

In poultry farming the use of synthetic antioxidants is often resorted to as a growth accelerator in the production cycle of broiler chickens. Indeed, research has shown that continuous use of synthetic antioxidants has been implicated in various risks for human health (Du et al., 2019). This is a justification for the exploration of appropriate alternatives and dietary antioxidants could lead to improvement in production performance and prevent oxidative damage of meat in broiler chickens (Freitas et al., 2012; Park et al., 2015; Adu et al., 2020). Considerable evidence suggests that medicinal plants such as mango leaves, husks and seeds may be a good candidate for accelerating broiler growth and resolving oxidative stress in broilers.

Mango tree is a tree of the Anacardiaceae family, native to southern Asia, widely cultivated in tropical countries for the fruits it bears. It is of great importance in tropical and subtropical regions (Tharanathan et al., 2006). The peel, leaves and seeds of mangoes have antimicrobial, anti-inflammatory, antioxidant and medicinal properties thanks to various phytochemicals especially mangiferin (Okwu and Ezenagu, 2008, Luo et al., 2012). Generally, broilers have shown low tolerance to dietary fiber and therefore diets containing high levels of leaf meal may hinder nutrient digestibility and thereby impair broiler growth performance (Buragohain, 2016). Currently, mango leaves are of no commercial value and few studies have been done on the potential of mango leaves (Zhang et al., 2017) in broiler chickens, especially as dietary supplements. It is in this perspective that the present study was initiated with the general objective of evaluating the influence of dietary supplementation with mango leaf powder on production performance and carcass yield in broiler chickens.

2. MATERIALS AND METHODS

2.1. Ethical considerations

The experimental protocols used in this study were approved by the Faculty of Agronomy and Agricultural Sciences of the University of Dschang, Cameroon and in strict compliance with internationally accepted guidelines for the care and handling of laboratory animals. These were also in accordance with the European Union guidelines Act 1986/609/EEC adopted by the Ethics Committee of the Ministry of Scientific Research and Innovation of Cameroon.

2.2. Animal material, feeding, and prophylaxis

A total of 90 broiler chicks of ROSS 308 strain, male and female, aged 21 days with an average weight of 783±51) g and 651±39 g were used. Subjects were randomly assigned to three dietary treatment groups with three replicates of 10 subjects per treatment as follows:

T0: Control ration; without mango leaf powder

T1: Diet supplemented with 0.5% mango leaf powder by weight.

T2: Diet supplemented with 1% mango leaf powder by weight.

Statistically, 5% significance level and 30 uniform birds per treatment at the beginning of the trial were accepted for the above test to be applied.

The composition of the experimental ration (21st day to 49th day) is shown in Table 1. This was analyzed in the Animal Nutrition Laboratory of the Department of Animal Science in the Faculty of Agronomy and Agricultural Science of the University of Dschang. The disinfection of the building was done using cresyl, ViruNet, and bleach diluted in 10 liters of water. The room had been divided into 9 compartments with an area of 2.32m2 each using wooden and bamboo boards, on the floor a thickness of 5cm of wooden litter. Chicks were raised under controlled environmental conditions: Temperature (26°C), Humidity (65%), and a 12-hour light/dark cycle.

Table 1: Composition of experimental ration

Ingredients (%)	**Grower Phase**
Maize	67
Cotton seed cake	5
Soya bean meal	15
Fish meal	5
Wheat middlings	2
Shell	1
Mineral Nitrogen and Vitamin Complex	5
5%	
Total	100
Calculated chemical composition	
Metabolizable energy (kcal/kg)	3108
Crude protein (%)	20.3
Energy /Protein	153.1
Calcium (%)	1.03
Phosphorus (%)	0.6
Calcium/Phosphorus	1.72
Lysine (%)	1.2
Methionine (%)	0.45
Lysine/Methionine	2.7
Cellulose (%)	2.61

2.3. Plant material

Fresh mango leaves (*Mangifera indica* L.) were harvested from a mango tree in the Ndengue District in the city of Bafia. They were dried in the shade at 25°C for eight days till a constant weight was obtained, after which the leaves were ground into powder with the use of a grinding mill, and the powder obtained was stored in opaque bottles until use.

This powder was analyzed in the laboratory of the Research Unit of Microbiology and Antimicrobial Substances (URMSA) at the University of Dschang for the determination of the classes of compounds present in the leaves powder using the method described by Harbourne (1973), and the results are presented in Table 2.

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

Component	**Alcaloïds**	**Phenols**	**Flavonoids**	**Sterols**	**Triterpenoids**	**Tannins**	**Saponins**	**Anthocyanins**	**Anthraquinons**
Quality	+	+	+	+	+	+	-	+	+

+: presence; -: absence

2.4. Collection of data and studied parameters

The weights of the birds were taken at the beginning of the experiment and once every week throughout the experimental period with the use of a balance of capacity of 7000 g and precision of 1 g in order to determine growth performance.

2.5. Growth Characteristics

2.5.1. Feed consumption

Feed was weighed at the start of each week and distributed to the birds on a daily basis. The leftovers of each replicate of the treatments were weighed every day with the balance described above. The consumption of feed was then evaluated by subtracting the quantity of remains from feed served during a week.

2.5.2. Live body weight (LBW) and weekly body weight (WBWG)

The chickens were weighed at the start of the trial and after every seven days subsequently between 7–9 am. The live body weight of each bird was recorded per week, and weekly bodyweight gain was evaluated by taking the difference in live body weight of 2 consecutive weeks using the methods proposed by McDonald et al. (2022) as follows:

$$WBWG = Pn - Pn-1$$

WBWG = Weekly body weight gain

Pn = Live body weight of the considered week

Pn−1 = Live body weight of the preceding week

2.5.3. Daily weight gain (DWG)

This was obtained by dividing the weekly weight gain by seven.

2.5.4. Feed Conversion Ratio (FCR)

The weekly feed conversion ratio was obtained by dividing the weekly feed intake by the weight gain of the birds for the same week.

$$FCR = \text{Weekly feed intake (g)} / \text{weekly weight gain (g) per group}$$

2.5.5. Feed efficiency (FE)

It was evaluated by taking the inverse of the feed conversion ratio.

$$FE = 1 / \text{Feed conversion ratio}$$

2.5.6. Relative weight, volume, and density of organs

At 49 days of age, 8 birds per treatment were randomly selected and fasted for 24 h, weighed, and slaughtered to evaluate the weights of the different organs and carcass yields. After slaughtering the birds, the abdominal cavity was opened, and organs like the liver, heart, pancreas, intestine, and gizzard were removed, carefully freed of all adipose tissues, and weighed separately with the use of a balance of capacity of 160 g and precision 10−3 g. The head and legs were also weighed.

The relative weight of each organ was calculated with the use of the following formula:

$$\text{Relative weight of organ (\%)} = \text{weight of organ (g)} / \text{Live body weight (g)} \times 100$$

The liver volume was obtained by the water displacement method, which consisted of putting a quantity of 0.9% NaCl in a graduated cylinder at an initial known volume and reading the volume (V1). Then, introducing the organ and recording the volume (V2). The volume of the organ was then determined using the following formula:

$$V\ organ = V2 - V1$$

The length of the intestine was measured from the duodenal burl to the cloaca using a tape measure. The intestine density was obtained with the use of the following formula according to Abdel-Fattah et al. 2008:

Intestine density (g/cm) = Intestine weight / Intestine length

2.6. Carcass characteristics

The carcass yield (CY) was calculated by the following formula:

CY (%) = carcass yield (g) / live weight on fasting (g) × 100

2.7. Statistical analysis

A one-way analysis of variance was used to show treatment effects on growth and carcass characteristics. When the differences were significant, Duncan's test at the 5% threshold was used to compare or to separate the means. Excel and SPSS software were used for data processing and statistical analysis.

3. RESULT AND DISCUSSION

3.1. Effects of mango leaf powder supplementation on broiler cumulative growth performance

Table 3 shows that the supplementation of mango leaves at 1% significantly ($P< 0.05$) increased average feed consumption, live weight, weight gain, and daily weight gains compared to the control ration, with no significant effect on consumption index. Meanwhile, a dose-dependent significant ($P< 0.05$) increase in survival rate was recorded with mango leaf powder supplementation.

These results are in line with the work of Adeyemi et al. (2021) which recorded a higher live weight and feed intake compared to the control ration in the finishing phase with 2.5 g/kg and 5 g/kg of mango leaves in ration; and Zhang et al. (2017) who observed that supplementation with mango leaf extract improved weight gain in broilers. This could be explained by the fact that the use of phytogenic feed additives has been established as a potent growth promoter in broiler chickens (Vidanarachchi et al., 2005; Hashemi & Davoodi, 2012).

The improved weight gain of broilers fed supplementation with mango leaf powder could be attributed to the ability of phytochemicals in mango leaf powder to scavenge free radicals, thereby maintaining the integrity of the intestinal mucosa and, consequently, improving feed efficiency and body weight gain (Vidanarachchi et al., 2005).

This could also be due to antimicrobial properties present in *Mangifera indica* leaf powder that lower the pathogenic microbial load in the gut, thereby improving the nutrients available to birds (Brisbin et al., 2008; Yang et al., 2009).

Despite the absence of significant difference for the consumption index, chickens fed the 1% ration had the best value for consumption index. This corroborates with the work of Enas and Eman (2022) on the aqueous extracts of mango leaves in drinking water. The improvement in feed conversion rate in their work can be explained by the supplementation of the aqueous extract of mango leaves with 20 mL/L of drinking water to optimize the efficiency of broiler chicks to better utilize diets. It is possible that their results are due to the health-promoting qualities of aqueous mango leaf extracts especially thanks to their contents in mangiferin which is a phenolic compound that has potent antioxidant, antibacterial, antidiabetic, antiviral and immunomodulatory antitumor, lipometabolism regulating, antipyretic, cardioprotective, anti-hyperuricemic, neuroprotective, antifungal, and anti-inflammatory, multifactorial pharmacological, as well as analgesic properties that may be associated with positive responses to growth performance due to supplemented mango leaf extract (Garcia et al., 2003, Mirza et al., 2013; Du et al., 2018). These properties of mango leaf may justify the dose-dependent significant ($P< 0.05$) increase in survival rate observed in birds that received a diet supplemented with mango leaf powder in the present study.

Table 3: Effects of mango leaf powder on cumulative growth characteristics

Growth characteristics	Treatments			p
	T0	T1	T2	
Average live weight (g)	2005.66 ±40.85[a]	2016.00 ± 13.52[a]	2208.33 ± 48.01[b]	0.00
Average weight gain (g)	302.75 ± 8.79[a]	313.75 ± 5.91[a]	338.83 ± 2.46[b]	0.00
Average daily gain (g)	43.25 ± 1.25[a]	44.82 ± 0.84[a]	48.40 ± 0.35[b]	0.00
Average feed consumption (g)	808.1292 ± 14.5[a]	799.84 ± 0.04[a]	899.19 ± 0.32[b]	0.00
Consumption index	2.82 ± 0.13[a]	2.71 ± 0.18[a]	2.65 ± 0.02[a]	0.33

[a,b]: means with identical letters are not significantly different (p>0.05) for the same characteristics. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2 ration supplemented with 1% mango leaves; p: probability

3.2. Effects of mango leaf powder supplementation on broiler evolution of growth performance

In addition to the cumulative values for the characteristics of growth, the evolution per week throughout the study period is also evaluated. Figures 1 to 4 put to evidence the evolution of feed consumption, live weight, weight gain, and feed consumption index.

3.2.1. Effects of mango leaf powder supplementation on broiler evolution of feed consumption

Figure 1 shows the evolution of feed consumption according to the incorporation of mango leaves throughout the trial. It appears that feed consumption between the first and the second week was higher for the chickens fed with the 1% ration than for those fed with the 0.5% and control rations. From the third week until the end of the trial, it appears that feed consumption was comparable.

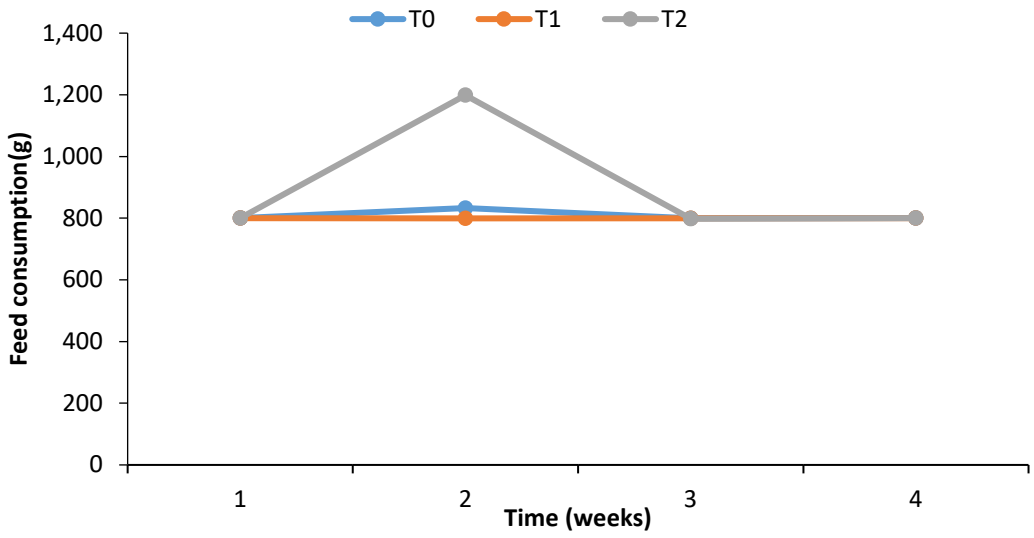

Figure 1: Evolution of feed consumption according to the rate of mango leaf powder supplementation in the ration. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2: ration supplemented with 1% mango leaves.

3. 2. 2. Effect of mango leaf powder supplementation on evolution of live weight

The evolution of live weight according to the rate of supplementation of powdered *Mangifera indica* leaves in the ration is illustrated in Figure 2. It shows that from the beginning to the end of the trial, the live weight of

animals fed with the ration containing 1% mango leaf powder supplementation was higher than those of animals fed with the other two rations.

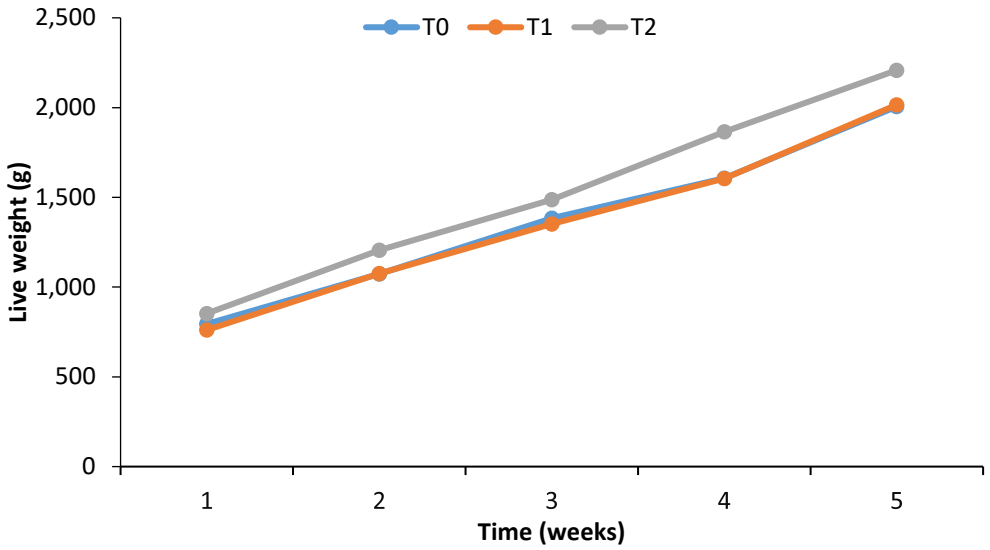

Figure 2: Evolution of live weight according to the rate of supplementation of powdered mango leaves in the ration. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2: ration supplemented with 1% mango leaves.

3. 2. 3. Effects of mango leaf powder supplementation on the evolution of weight gain in broilers

Figure 3 reflects the influence of mango leaf powder supplementation on weight gain. According to this curve, the first week the animals fed with the 1% ration had a greater weight gain than the animals fed with the 0.5% ration and the control ration. However, in the second week, the animals fed the control ration had improved weight gain while animals fed the 1% ration had a drop in weight gain. Then, in the third week, the animals fed the 1% ration had a greater gain than the animals fed the 0.5% and control rations, which induced a higher weight gain than those fed the 1% ration at the fourth week.

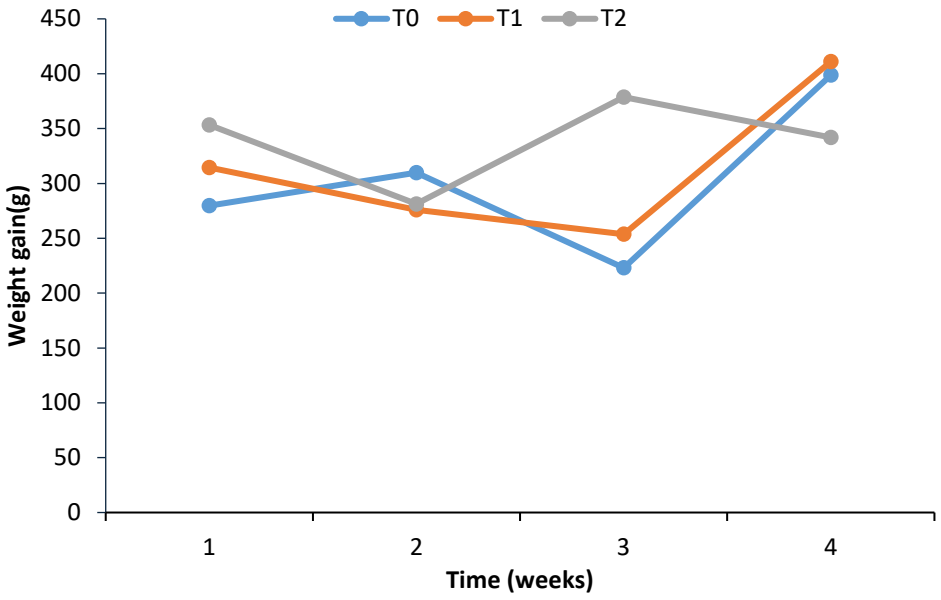

Figure 3: Evolution of weight gain according to the rate of supplementation of mango leaf powder in the ration. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2: ration supplemented with 1% mango leaves.

3. 2. 4. Effects of mango leaf powder supplementation on broiler evolution of feed consumption index

The evolution of the consumption index is summarized in Figure 4. The feed conversion index was low in the first week for the animals fed the ration with 1% mango leaf powder in the ration than for the other two rations. Then, in the second week, the feed efficiency was higher than for the animals fed at 0.5% and the control ration. In the third week, the feed efficiency at 1% ration was lower than those of animals fed 0.5% and control rations. Finally, in the fourth week, the animals fed the 0.5 and control rations had comparable consumption indices, which were lower than that of the animals fed the 1% ration.

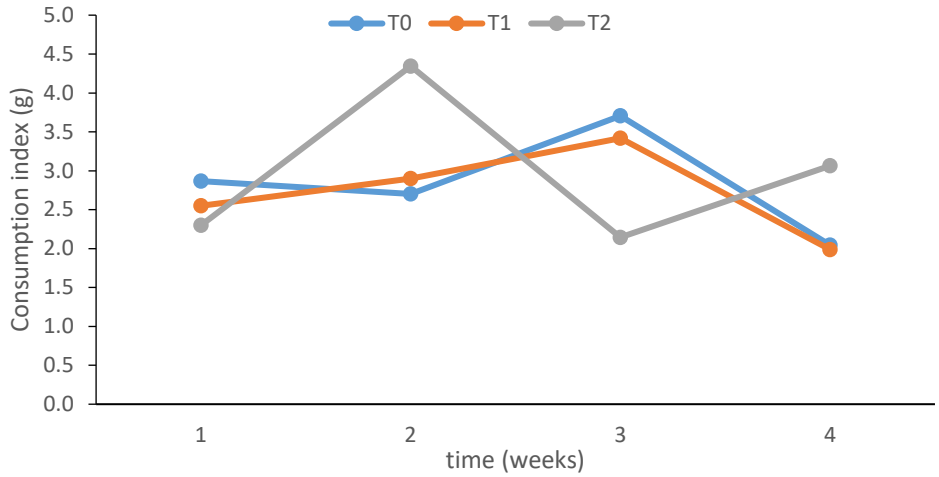

Figure 4: Evolution of the consumption index according to the supplementation of powdered mango leaves in the ration. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2: ration supplemented with 1% mango leaves

3. 3. Effects of mango leaf powder supplementation on broiler survival rate

Figure 5 shows the survival rate of animals throughout the test. There was a dose-dependent increase in the survival rate of birds, with the highest rate recorded in those given feed supplemented at 1%. The overall hepato-protective effects of mango leaf powder suggested in the present work may justify the increase in survival rate of birds in this study, with the highest rate registered with the birds in the group fed with a diet containing the maximum dose of mango leaf powder. However, this justification is not with certainty since we find no other studies on mango leaves powder as feed supplements on survival rate in farm animals, in general, and broilers in particular.

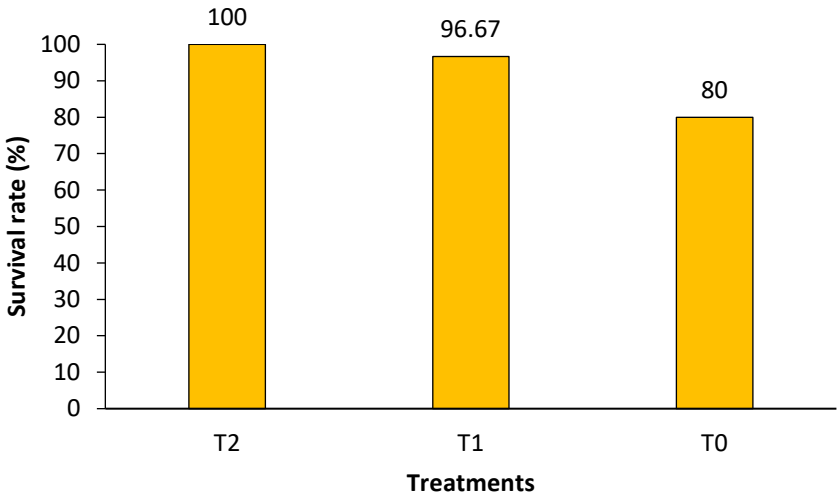

Figure 5: Survival rate of the animals according to the supplementation of the powder of the mango leaves in the ration throughout the test. T0: control with 0% mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2: ration supplemented with 1% mango leaves.

3.4. Effects of mango leaf powder supplementation on carcass characteristics

Table 4 demonstrates the effects of *Mangifera indica* leaf powder supplementation in broiler diets on carcass characteristics. It emerges that in general, the chicken supplements at 1% presented significantly ($P<0.05$) higher carcass yield than the chickens fed 0.5% mango leaf powder supplementation, which, in turn, was superior to the chickens fed the control diet.

The weight of the organs of the animals supplemented with 1% mango leaf powder in the ration showed significantly ($P<0.05$) lower liver and gizzard percentages compared to the rations supplemented at 0.5% and control diets, which were comparable ($P>0.05$). However, supplementation of mango leaf powder had no significant ($P>0.05$) effect on pancreas percentage and density of the intestine, no matter the dose considered.

These results are consistent with the work of Zhang *et al*. (2017), in which, although carcass weight reflects weight gain data, abdominal fat, percent dressing, and relative weight of meat cuts were not influenced by dietary treatments, as well as mango leaf extract supplementation. Similar studies were carried out by Adu *et al*. (2020) on leaves of *Syzygium aromaticum* and seeds of *Myristica fragrans,* which did not affect the relative weight of carcass cut in broilers.

The hepato-protective effects of mango leaves justify the percentage of the liver of animals fed with a ration supplemented with mango leaf powder in the present work, and this corroborates with the work of Karuppanan *et al*. (2014) which demonstrated the hepato-protective and antioxidants effects of mango leaf extracts against mercuric chloride-induced liver toxicity in mice. Likewise, the work of Dar *et al*. (2005) showed that magiferine is a potent hepato-protective against carbon tetrachloride-induced liver injury, thereby reinforcing its free radical scavenging activities.

Table 4: Effects of mango leaf powder supplementation on carcass and organ parameters.

Carcass characteristics (%)	Treatments			p
	T0	T1	T2	
Live weight (g)	2112.77±131.05^{b}	1847.77±190.47^{a}	1856.11±129.12^{a}	0.001
CoC (g)	1537.11±93.45^{b}	1397.77±119.06^{a}	1476.66±58.84^{ab}	0.015
CvC (g)	1714.44±111.86^{b}	1549.55±65.20^{a}	1653.33± 90.69^{b}	0.003
CoCY (%)	73.09±3.54^{a}	74.93± 3.35^{a}	79.50 ±1.50^{b}	0.000
CvCY (%)	81.04±2.44^{a}	83.87± 3.76^{b}	89.06 ± 1.79^{c}	0.000
Liver (%)	2.44±0.28^{b}	2.49± 0.57^{b}	1.79 ± 0.17^{a}	0.001
Pancreas (%)	0.29 ± 0.07^{a}	0.26± 0.04^{a}	0.25±0.05^{a}	0.270
Intestine density (g/cm)	2.44 ± 0.28^{a}	2.29± 0.57^{a}	1.79±0.17^{a}	0.271
Gizzard (%)	3.77 ± 0.74^{b}	3.68±0.48^{b}	3.00±0.30^{a}	0.011

$^{a, b, c}$: means with identical letters are not significantly different ($p>0.05$) for the same characteristics CoCY: commercial carcass yield; CvCY: conventional carcass yield; CoC: commercial carcass; CvC: conventional carcass; T0: control with 0 % mango leaves diet; T1: ration supplemented with 0.5% mango leaves; T2 ration supplemented with 1% mango leaves; p: probability

4. CONCLUSION

This study demonstrates that supplementing broiler feed with 0.5% or 1% Mangifera indica leaf powder enhances growth performance and carcass characteristics. While 1% MLP improves overall growth, 0.5% MLP appears to optimize commercial carcass yield. These findings suggest that MLP could serve as a natural alternative to synthetic antioxidants in broiler nutrition. However, the observed reduction in liver and intestine density at 1% MLP supplementation requires further investigation to determine its physiological implications. Future research should assess the long-term effects of MLP on meat oxidative stability, gut microbiota, and immune function in broilers. Additionally, economic feasibility studies are needed to determine the viability of MLP as a commercial feed additive.

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CONTRIBUTION OF AUTHORS. Chongsi MMM: Data collection and interpretation, manuscript final writing, editing and approval; Tchoffo H: Data collection and analysis; Bend EFM: Data collection and literature review; Noumbissi MNB: Drafting of the article and literature review; Ngoumbe AM**:** Data collection and interpretation, designed research methodology; Hako TBA: Conceptualization and supervision of the study.

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