SMTCT
Society of Land Measurements and Cadastre from Transylvania

Bouchama C *et al*. (2024)
Notulae Scientia Biologicae
Volume 16, Issue 3, Article number 11948
DOI:10.15835/nsb16311948
Research Article

NSB
Notulae Scientia Biologicae

Effect of feed supplementation with *Curcuma longa* and *Zingiber officinale* spices on the zootechnical, biochemical, and microbiological parameters of broiler chickens

Chaymae BOUCHAMA[1,2], Lalla K. YOUSFI[3], Samira EL AKHDARI[4], Noureddine CHADLI[1], Khaoula F. SAMOUH[1], Sidi M. RAOUI[5], Tariq AZIZ[6], Abdellah ZINEDINE[7]*, Faouzi ERRACHIDI[2]

[1]*Hassan II University, Ain Chock Faculty of Sciences, Immunology and Biodiversity Laboratory, Casablanca, Morocco; bouchama.chaymae@gmail.com; khaoulasamouh42@gmail.com; chadlinour2012@hotmail.com*
[2]*Sidi Mohamed Ben Abdellah University, Faculty of Science and Technology, Functional Ecology and Environment Engineering Laboratory, Fez, Morocco; errachidifaouzi@yahoo.fr*
[3]*Lycée Qualifiant Attaquadoum, Moulay Yacoub Delegation, Regional Academy of Education and Training Fez-Meknès, Ministry of National Education, Morocco; youssfilallakhaddouj@gmail.com*
[4]*Lycée Ibn Alkhatib, Delegation of Salé, Regional Academy of Education and Training Rabat-Salé-Kénitra (RSK), Ministry of National Education, Morocco; elakhdari@yahoo.fr*
[5]*Higher Institute of Nursing Professions and Health Techniques, Fes annex of Meknes, Morocco; siraoui@yahoo.fr*
[6]*University of Ioannina, Department of Agriculture, Laboratory of Animal Health, Food Hygiene and Quality, 47132 Arta, Greece; tariqckd@uoi.gr*
[7]*Chouaib Doukkali University, Faculty of Sciences, BIOMARE Laboratory, P.O. Box 20, El Jadida 24000, Morocco; zinedine.a@ucd.ac.ma (*corresponding author)*

Abstract

In recent years, there has been a significant trend to improve poultry zootechnical performances by biological methods to avoid the unwanted chemical growth factor's introduction into breeding process. Medicinal plants and their derivatives are good candidates to achieve this goal. Thus, this work aimed at evaluating the effect of poultry feed supplementation with the spices *Curcuma longa* and *Zingiber officinale* on the zootechnical performance, serological, and microbiological parameters of Ross 308 chicken. To achieve this purpose, 180 chicks divided into five groups and reared for 12 days. The experimental groups consisted of a control group receiving a conventional feed without antibiotics and four groups receiving a conventional feed with 0.5 and 1% turmeric and ginger doses, respectively. Results of the experiment revealed that supplementing the feed with 0.5% turmeric powder increased live weight, and average daily gain and decreased feed conversion compared to the other groups. Turmeric powder supplement (0.5 and 1%) affected blood serum parameters by decreasing triglyceride and aspartate aminotransferase (AST) concentrations. In comparison, the incorporation of 0.5% ginger in the diet decreased triglyceride concentrations, cholesterol, aspartate aminotransferases (ASAT), and alanine aminotransferases (ALAT). Cecum bacteriological analysis showed a total absence of coliforms, *Salmonella* sp., *Clostridium* sp., and lactic acid bacteria in the chick groups supplemented with different doses of turmeric and ginger (0.5 and 1%, respectively). Within this study's limits,

Received: 23 Feb 2024. Received in revised form: 22 Apr 2024. Accepted: 14 Aug 2024. Published online: 024 Sep 2024.
From Volume 13, Issue 1, 2021, Notulae Scientia Biologicae journal uses article numbers in place of the traditional method of continuous pagination through the volume. The journal will continue to appear quarterly, as before, with four annual numbers.

using these two studied spices as additives in poultry feed allowed us to conclude that supplementing with 0.5% turmeric powder positively impacted the evaluated parameters.

Keywords: *Curcuma longa*; microbiological analysis; serological analysis; *Zingiber officinale*; zootechnical parameters

Introduction

Antibiotics employed as growth promoters in chicken feed has been reported to cause undesirable side effects (Ouedraogo *et al*., 2021). This alarming situation has led the European Union (EU) to completely ban the use of antibiotics in poultry feed formulations since 2006. This suppression has caused a deterioration in chicken status health, leading to an increase in mortality rate, index consumption drops of body weight and, consequently, a decrease in poultry farming economic profitability (Abd El-Hack *et al*., 2022).

Poultry meat contributes to human nutrition by providing high-quality protein with low fat levels, with a desirable fatty acid profile (Kafi *et al*., 2017). During breeding, antibiotics are used to ensure a smooth running of the production cycle. Several antibacterial agents have been used as "growth promoters" of farm animals (Chattopadhyay, 2014), and remain as chemical residues in the final product (Idowu *et al*., 2010), This prompted the European Union (EU) to ban their use in 2003. These regulations aim to improve animal welfare, reduce consumer risk and protect the environment. Thus, in recent years, multi-drug resistance prevalence has peaked with resistant bacteria appearing in farm animals that seems to be linked to the continuous administration of antibiotics to poultry at over-therapeutic doses of the order 5 to 50 mg/kg (Froebel *et al*., 2019; Kouadio *et al*., 2019). This bacterial resistance has generated a public health concern that has prompted alternative active biological ingredients. Today, there is a growing trend of substituting antibiotics with natural compounds, probiotics, and phytobiotics (Deng *et al*., 2020; Abd El-Hack *et al*., 2022), which have the potential to stimulate appetite and feed intake, increase endogenous digestive enzyme secretion, stimulate immune responses, and show antimicrobial and antioxidant action (Hosseini *et al*., 2012).

The investigation of alternative ways and new biological ingredients could lead to the improvement of breeding and farming conditions. With this in mind, two spices from the Zingiberaceae family were chosen to evaluate their beneficial effects on chicks' health. Turmeric rhizome (*Curcuma longa*) is grown in southern tropical Asia and is widely used as a preservative and colorant in the food industry; it has biological properties and medicinal applications (Kafi *et al*., 2017). The second spice (*Zingiber officinale* rhizome), commonly named ginger, is a medicinal plant used worldwide in the culinary arts and it was selected to investigate its beneficial potential due to its richness in secondary metabolites, such as flavones, phenolic acids, anthocyanin, hydrolysable tannins and organic acids, that are responsible for several biological effects, including being anti-inflammatory, antimicrobial, and anticancer (Gigon, 2012; Gurbuz *et al*., 2017).

Our recent studies focused on improving the performance of broilers by introducing rosemary leaf powder stabilized with chitin (1%, w/w), and results have shown that the EO and phenolic compounds of this plant contribute effectively to improving cellular maintenance. This explains the reduction in the consumption index and the increase in the weight production yield of the chair (Samouh *et al*., 2024). This work raised some research questions, which could have elements of answer through a generalization via the use of more efficient combination of two plant matrix such as turmeric and ginger.

This study evaluates the supplementation effects of poultry feed with turmeric and ginger powders at two doses of 0.5 and 1% on zootechnical performances, serological characteristics (biochemical and enzymatic), and chicken microbiological parameters for 12 days (start-up phase). The choice of this critical development phase poses a problem for poultry farmers because chicks are extremely sensitive at this age. In this start-up period, chick morality is high (Heier *et al*., 2002; Yassin *et al*., 2009; Yerpes *et al*., 2020) due to immature

digestive and immune capacities (Bigot *et al*., 2001). The success of this phase determines the success of the final result of the batch of broilers. At the same time, it is useful to expand the number of physiological parameters to better understand the effect of supplementing conventional foods with the active ingredients of turmeric and ginger.

Materials and Methods

Plant material

Spices in the form of dry rhizomes of *Curcuma longa* and *Zingiber officinale* were procured from herbalists in Fez city in the center-north of Morocco. At the arrival, plant samples were identified by Dr. Chaimae Rais from The National Agency for Medicinal and Aromatic Plants (ANPMA) in Taounate, Morocco (Document no. 015/2021) and then ground by a grinding system (GM 200 knife mill) and sifted through sieves to obtain a size of 0.1mm.

Animal material

The breeding was conducted following the guidelines of recognized international standards for animal use. The "Institutional Animal Care Committee" approved the protocol at the Faculty of Medicine and Pharmacy of Fez (FMPF) according to French technical specifications for production. The care and use of animals were carried out at the animal facility belonging to the Faculty of Sciences and Techniques of the city of Fez and at Sidi Mohamed Ben Abdellah University in Morocco. The study was conducted over 12 days, which included the start-up phase of breeding. Two days before the chicks arrived, the room was cleaned from ceiling to floor and disinfected with bleach. The chicks were reared on a litter of wood shavings 10 cm high and floor areas of 1 m^2. Each area was intended to receive a batch of chicks during the experimental period according to the targeted treatment. The floors were each equipped with a feeder and drinker, and the chicks had free access to food. Room heating was provided by an air conditioner adjusted according to the chicks' age to ensure efficient heating according to a day (D) program (from D0 to D6 at 30 °C and D7 to D12 at 28 °C). Temperature values were recorded using a thermometer, and an air extractor provided ventilation. The lighting was 24 h a day (Omar *et al*., 2016).

Chick rearing

A total of 180-day old chicks (Ross 308 with an average weight of 41 g) procured from a local production unit were divided into five batches of 12 chicks each (× 3), as follows:

Batch 1: Control batch where chicks received conventional feed without antibiotics;

Batch 2: Chicks received a conventional feed supplemented with 0.5% turmeric;

Batch 3: Chicks received a conventional feed supplemented with 1% turmeric;

Batch 4: Chicks received a conventional feed supplemented with 0.5% ginger;

Batch 5: Chicks received a conventional feed supplemented with 1% ginger.

The chicks were fed with a starter food in the form of crumbs (size = 2 mm) prepared in the industrial unit which delivered the product formulated according to our experimental plan. The dietary formula is shown in Table 1.

Table 1. Composition of starter diets

Composition	Contents
Raw material	
Corn	59%
Soybean meal	27.5%
Salt	0.5%
Water	13%
Nutritional composition	
Metabolizable energy (Kcal/kg)	3200
Crude protein materials	19.5%
Oily material	2%
Mineral matter	6%
Phosphorus	0.7%
Calcium	1%
Crude fiber	5%
Humidity	13%
Vitamin A	1000000
Vitamins D	150000
Vitamin E	2000

Studied parameters

This experiment aimed to carry out zootechnical, serum and microbiological tests. From the zootechnical point of view, the mortality (%), the live weight (LW), the average daily gain (ADG), the consumption index (CI) and the morphometric parameters were measured in the five batches of chicks. Serum component analysis targeted total proteins, triglycerides, total cholesterol and transaminases enzymatic content, namely aspartate aminotransferase (ASAT) and alanine aminotransferase (ALAT). Finally, the microbiological task aimed at studying cecum microbial load.

Zootechnical performance

Mortality was recorded daily and evaluated according to the following formula:

$$\% \text{ mortality} = \frac{\textit{Number of subjects dead}}{\textit{Initial number}} \times 100$$

The live weight (LW) measurement and consumption index (CI) were calculated by weighing the chicks and the poultry feed in the morning before the distribution of the latter on the following days: D_0, D_3, D_6, D_9, and D_{12} of animal age. Morpho-metric parameters were centered on feet length and feathers which were taken using a ruler at the end of day 12 (Sola-Ojo *et al*., 2020).

At the end of the treatment period, the animals were anesthetized with diethyl ether. Blood samples were taken by puncture at the level of the retroorbital sinus. The blood sample is collected in tubes containing heparin. The latter are centrifuged at 4000 g for 10 minutes and the serum obtained is stored at -20 °C for blood biochemistry analyses. All chicks were dissected to assess liver and spleen weights after sacrifice.

Biochemical analysis

The biochemical study concentrated on the additional effect of turmeric and ginger powders on certain biochemical parameters of chick blood. Sample collection and analysis were performed on the last day (day 12) after the sacrifice. A blood sample of each batch was taken from a vein at the level of the joint between the humerus and radius-ulna, where almost 2 mL of blood were collected in tubes containing an anticoagulant

(citrate + tri-sodium citrate). The chicks' blood samples were centrifuged, and the serum obtained was subjected to biochemical and enzymatic analyses using reagent kits.

Total protein contents were evaluated by the Biuret method where serum, standards, and blank were mixed with a Biuret reagent (Spinreact), then a chromatophore reading was made using a spectrophotometer at 540 nm. Triglycerides, which are energy reserve lipids, come from fats provided by poultry feed and hepatic synthesis (Nedjoua, 2013).

Cholesterol, a precursor of all steroid hormones, is a major component of animal cell membranes, which contributes to their stability and structural maintenance by intercalating between phospholipids (Nedjoua, 2013). The cholesterol content was determined by an enzymatic colorimetric method with peroxidase (Spinreact), where the absorbance reading was 505 nm. Alanine aminotransferases (ALAT) and aspartate aminotransferases (ASAT) are intracellular enzymes. Alanine aminotransferases (ALAT) are found mainly in liver and kidney cells and are a good indicator of liver disease if observed in large amounts. Aspartate aminotransferases (ASAT) are found in large amounts in heart muscle, liver cells, and skeletal muscle cells and smaller amounts in other tissues. The assay of these two enzymes was conducted using specific kits (Spinreact), and the absorbance reading was measured at 540 nm.

Cecum bacteriological analysis

During dissections, cecal sample contents were systematically taken for three individuals from each batch and were subjected to bacteriological analysis for strains colony counting of coliforms, *Clostridium* sp., *Salmonella* sp., and lactic acid bacteria (LAB). Eosin methylene blue (EMB), Tryptone-Sulfite-Cycloserine (TSC), and Man, Rogosa, and Sharpe (MRS) agars were inoculated to detect Coliforms, *Clostridium* sp., and LAB, respectively. Enrichment was carried out with a Rappaport broth to search for *Salmonella* sp. and then subcultured with an SS culture medium. Bacterial isolation was performed according to strain requirements. Indeed, incubation at 37 °C for 24 hours was ensured for *E. coli*, *Salmonella* sp., and LAB, which require 30 °C. However, *Clostridium* sp. required anaerobic conditions and incubation at 45 °C for 48 h.

Statistical analysis

Microsoft Excel was used for graphical data construction. Morphometric graphs parameters were produced using the Prism 7 software for Windows (GraphPad Software Inc), then subjected to variance analysis (ANOVA) at the threshold of 0.05 (significance level of P). Past free software evaluated the multi-correlation between batches and various biochemical parameters using a principal component analysis (PCA).

Results and Discussion

Zootechnical performance

The effects of supplementing poultry feed with phytobiotics on zootechnical performance (mortality, live weight, average daily gain, consumption index, and morphometry) were made as a function of time expressed in days according to the targeted treatments.

Mortality evaluation

The effect of the chick treatment on mortality is shown in Table 2, where it is noted that no chick groups had adverse health effects during the experiment, and no mortality was observed between the initial and final states of the experiment.

Table 2. Effect of treatments on mortality

Batches	NC	TUR 0.5%	TUR 1%	GING 0.5%	GING 1%
Initial state	12	12	12	12	12
Final state	12	12	12	12	12
% mortality	-	-	-	-	-

NC: Negative control, TUR 0.5%: Turmeric 0.5%, TUR 1%: Turmeric 1%, GING 0.5%: Ginger 0.5% and GING 1%: Ginger 1%.

Effect of turmeric and ginger on weight gain

The chicks' live weights are exhibited in Figure 1 as a result of evaluating the effects of incorporating turmeric and ginger powders in the chicks' feed on growth performance.

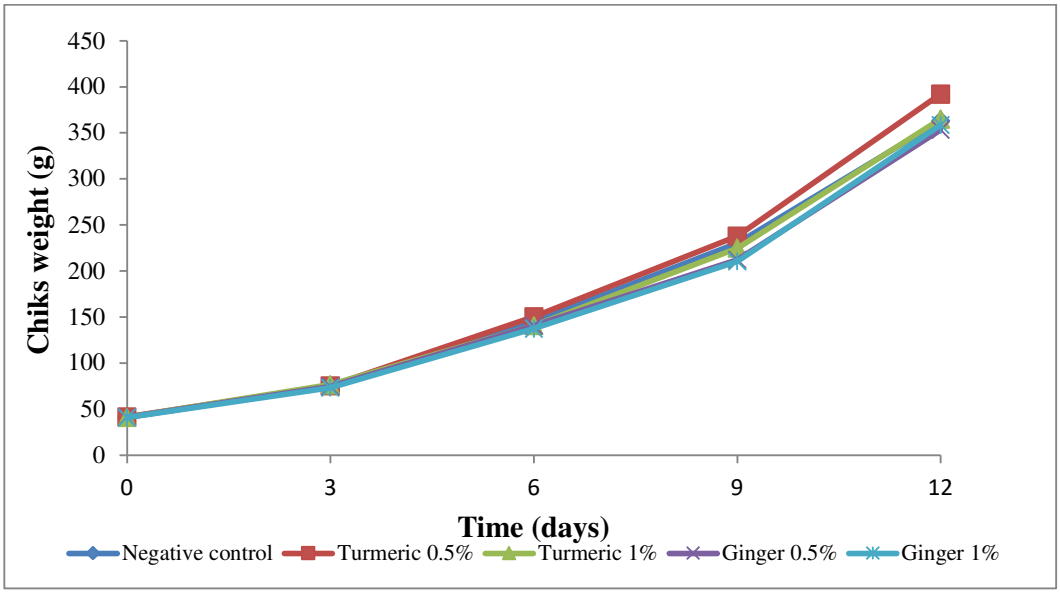


Figure 1. Chicks live weight evolution

In poultry farming, supplementing with phytogenic feed additives (phytobiotics) is commonly used with the objective of improving growth performance, and the quality of the food derived from these animals (Suryanarayana *et al*., 2018). Obtained results showed that supplementing poultry feed with turmeric powder at 0.5% increased body weight. It was also noted that weight gain decreased when the turmeric dose increased to 1%. Supplementing the feed with 0.5% and 1% of ginger showed the lowest weight gain. The difference in body weight gain between the control groups fed turmeric and ginger may be due to the phytochemical composition of the spice powders that affects the response of Ross 308 chicks, which, in turn, influences growth performance. This agrees with the results of other authors. (Durrani *et al*., 2006) found that supplementing 0.5% turmeric powder in poultry diets significantly improved in body weight gain and feed efficiency without any adverse effects or mortality. (Gumus *et al*., 2018) also observed that adding 0.5% turmeric increased egg production and weight, but reduced feed conversion compared to the control group. Zomrawi *et al*. (2013) concluded that ginger powder at 0.5% and 1% levels in broiler diets had no significant effect on feed conversion rate and also decreased weight gain. The inclusion of ginger in poultry feed reduced abdominal fat and gizzard weight in a dose-dependent manner, revealing the greatest weight loss when chicks were fed 0.25% ginger. From these results, it can be concluded that using a 0.5% ratio of turmeric is beneficial for improving broiler growth performance. The effect of the latter in all these studies could be explained by the fact that turmeric has antimicrobial, antifungal, and antioxidant activities that can improve the utilization of dietary nutrients by

chicks (Radwan *et al*., 2008). The improvement in growth performance due to the incorporation of turmeric powder in broilers could be attributed to improvements in the digestive system (Ouedraogo *et al*., 2022). Indeed, other works do not agree with these results, such as those carried out by (Kafi *et al*., 2017), who found that the highest weight gain in all treatments is obtained when chicks were fed a diet supplemented with 0.5% ginger. However, weight gradually increases when using a higher proportion of turmeric (0.75%). (Ademola *et al*., 2009) , reported supplementing broilers' feed with dietary ginger reduced the relative abdominal fat weight.

Effect of turmeric and ginger on daily gain

The average daily gain of chicks according to diet is represented in Figure 2. This illustration shows the daily average gain variations of chicks according to their diet formulation.

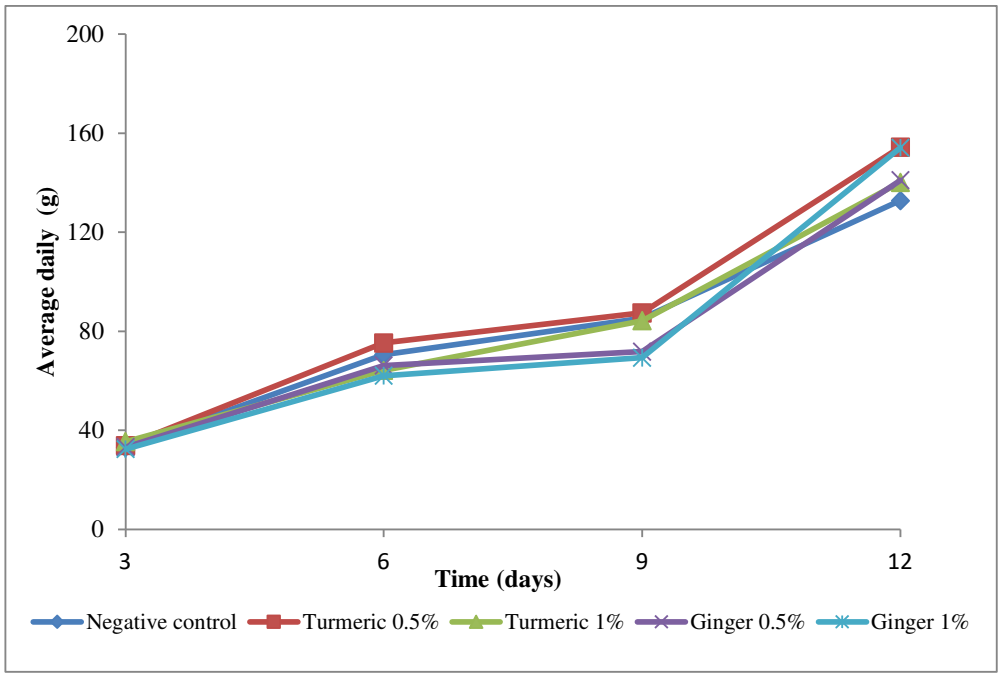


Figure 2. Variations in chicks' mean daily gain

It appears at the end of the trial that chicks fed with 0.5% turmeric have the best average daily gain and a 1% dose of ginger, which o rewarded the increase in gain between the 9th and 13th day of the experiment. The lowest value was recorded in chicks fed 0.5% ginger.

Effect of turmeric and ginger on feed conversion

Figure 3 shows the effect of different treatments in chicks on the feed consumption index.

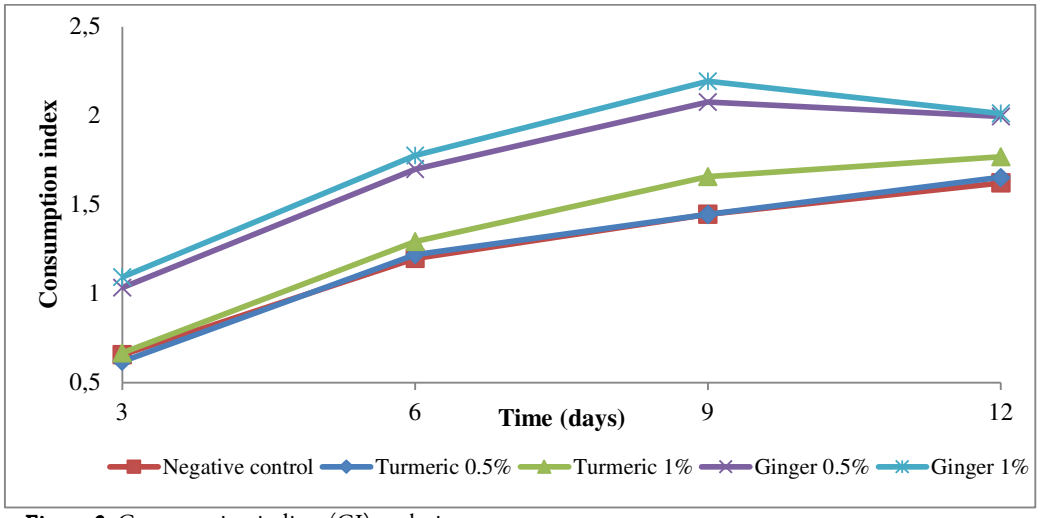


Figure 3. Consumption indices (CI) evolution

Overall, obtained indices during the 12 days of the experiment are better for chicks treated with different proportions of turmeric powder (0.5 and 1%). Thus, the untreated batch compared to batches treated with conventional feeds closing the ginger powder presented the greatest values of consumption index, which resulted in a large consumption of poultry feed. This could be explained by the inclusion of these spices containing flavonoids in the diet of broiler chickens which increases feed intake (Idowu *et al*., 2010) .

Effect of turmeric and ginger on organ weight

Good knowledge of organ weights in broiler chickens is an essential piece of data to assess their state of health. The low weight of the spleen (lymphoid organ) is an indication of stress and compromised immunity in chicks, making them more susceptible to pathogen invasion (Heckert *et al*., 2002).

The variation in liver and spleen weight is shown in Figure 4.

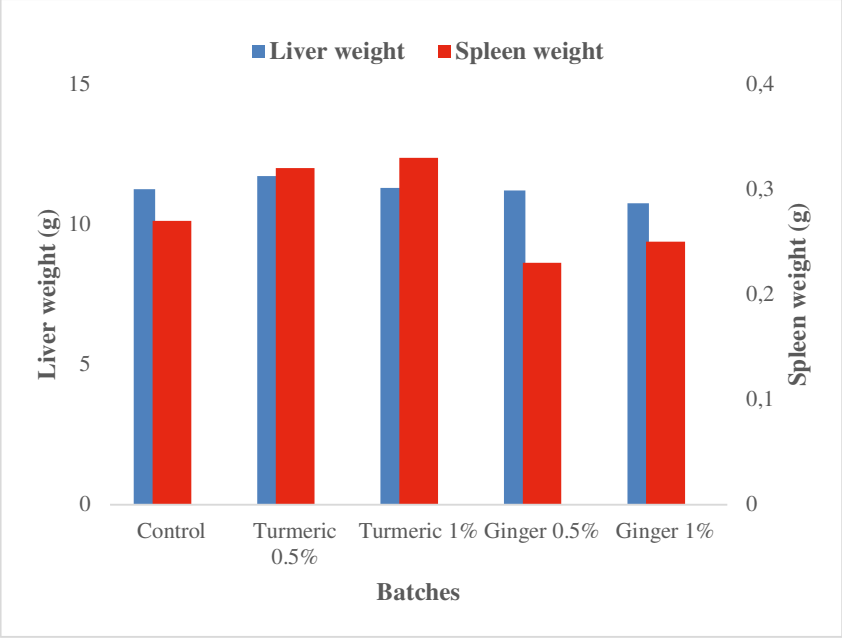


Figure 4. Variation of organ mass values (Liver and Spleen)

Statistical analysis shows the difference between the mean liver and spleen weights with the five treatments studied is not significant, with F=0.60 < F'=2.54 and a probability of 0.66 for the difference in liver weight and F=2.06 < F'=2.60 with a probability of 0.10 for the difference in mean weight of the spleen. Generally, the results obtained in Figure 4 show a decrease in weight with the use of turmeric powder (0.5% and 1%) and ginger 1% when compared to the other batches. However, the spleen mass of the chicks treated with turmeric was slightly increased unlike the batches treated with ginger, which marked a slight decrease.

Similar results were obtained with garlic, turmeric, ginger and their powder mixtures in broiler feed (Atay, 2023). The obtained results showed that powder addition of these medicinal plants and aromatics in broiler feed has beneficial effects on performance, carcass characteristics and meat quality. Supplementing poultry feed can boost the immune system. Similar results were obtained by the introduction of spirulina in poultry feed (El-shall *et al*., 2023). These authors highlighted the immune-stimulating properties of spirulina and its potential use as a dietary supplement in poultry to improve growth, intestinal health and disease resistance.

Effect of food additives on the length of feet and feathers

Figure 5 shows the effects of incorporating turmeric powder in poultry feed on foot length and feathers development.

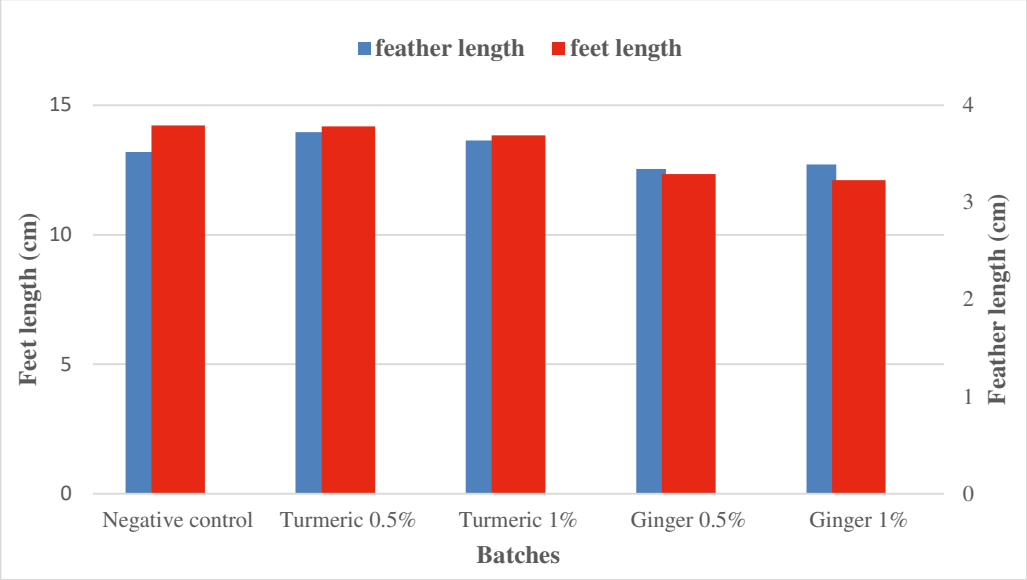
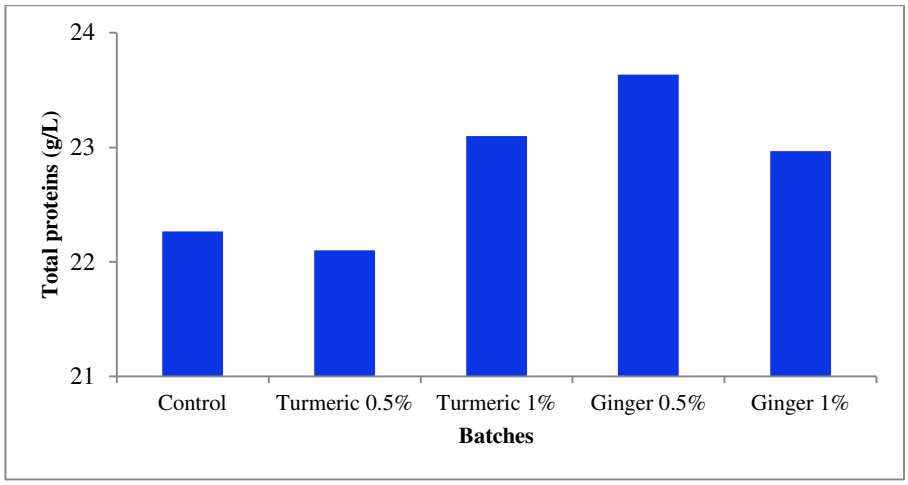


Figure 5. Influence of the incorporation of turmeric and ginger on the length of feet and feathers

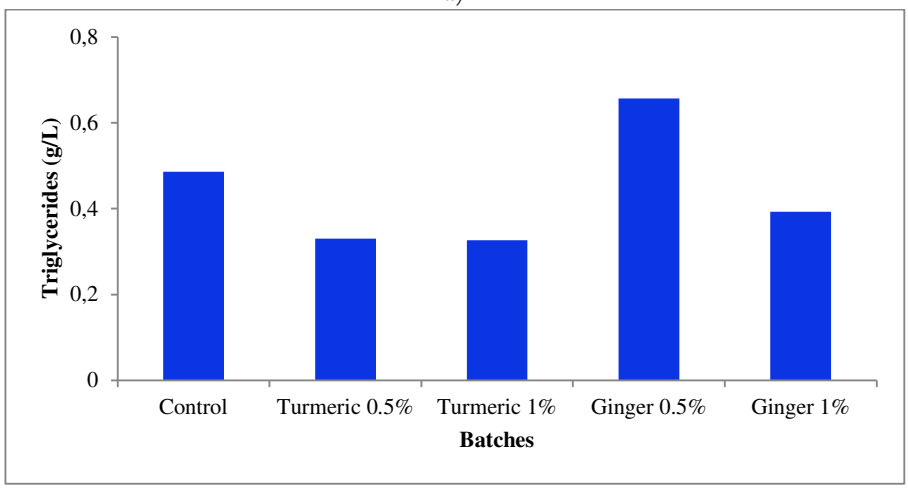
Statistical analysis shows that the difference in the average length of the feathers of the chicks studied is not significant, F=2.36 < F'=2.53, with a probability of 0.06. The difference in means between liver weight and treatments is significant, F=10.9 > F'=2.53 with a probability (P<0.05). According to Figure 5, it can be noticed that the chicks' feet were longer in the untreated batches and those treated with different rations of turmeric. However, short lengths were observed for batches that were fed ginger. The average feather length differs between the experimental batches according to what product was added to the poultry feed, of which the two doses of turmeric (0.5 and 1%) had the greatest length followed by the control batch at 13.96, 13.64, and 13.19 cm respectively. Both doses of ginger (0.5 and 1%) recorded poor feather development with results of 3.29 and 3.23 cm, respectively.

Biochemical analyses

Figure 6 presents the effect of studied spice powders at different doses in poultry feed (0, 0.5, and 1%) on the chicks' blood serum parameters.



a)



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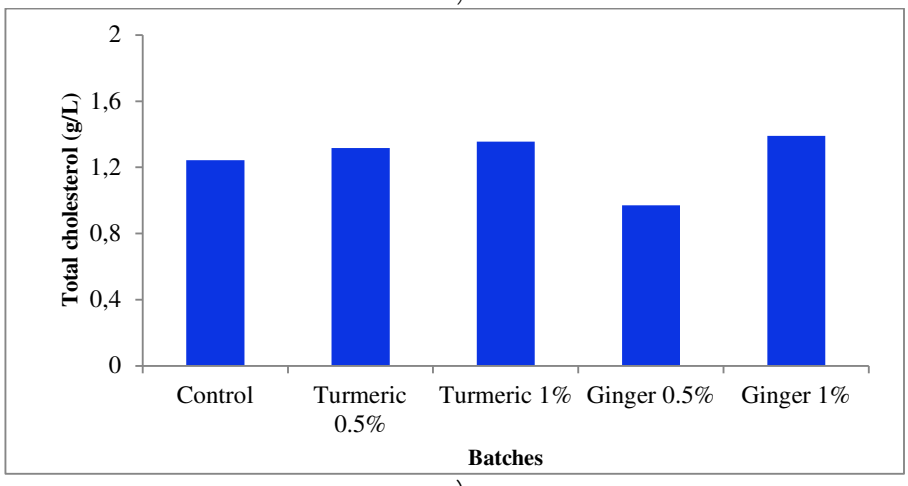

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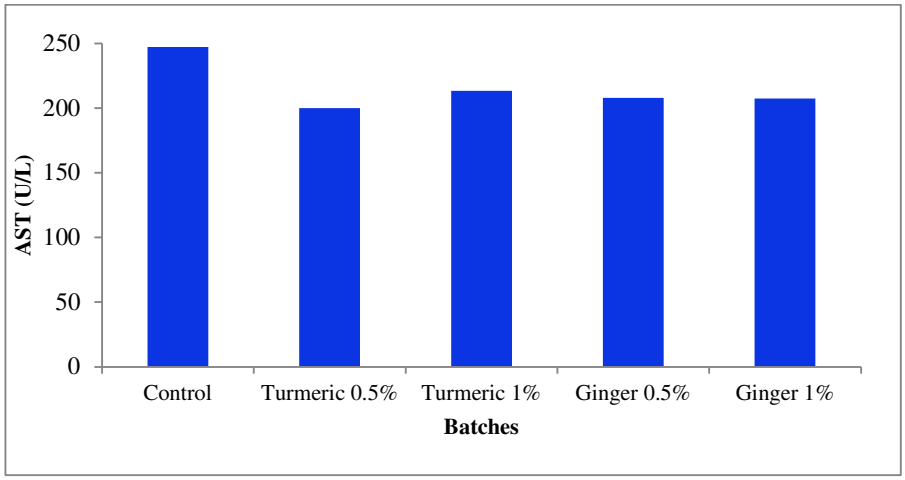

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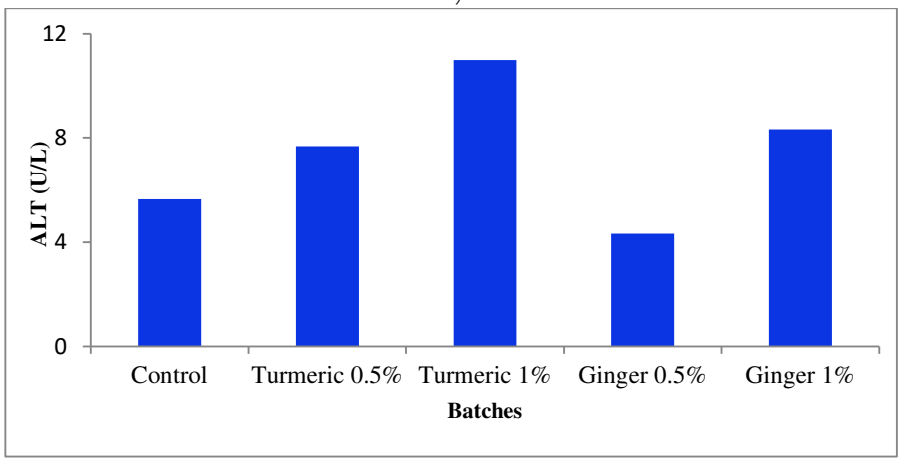

e)

Figure 6. Effect of the incorporation of turmeric and ginger powder on some biochemical blood parameters. 6a: Total proteins, 6b: Triglycerides, 6c: Cholesterol, 6d: Aspartate aminotransferases (AST) and 6e: Alanine aminotransferases (ALT)

Serum indices are among the tools used to examine the chicks' physiological states. The evaluation of the different biochemical parameters of Ross 308 broilers fed with feed supplemented with turmeric and ginger powder shows a decrease in the concentration of total proteins in batch 2 (conventional feed supplemented with 0.5% turmeric). The other batches recorded high levels when compared to the control groups. These results show no harmful clinical signs for the chicks during this experiment. Therefore, it can be inferred that the total protein range obtained in this study did not hinder adequate protein utilization due to the dietary inclusion of turmeric and ginger powder in the chicks' diet (Kujero *et al*., 2021).

Serum analysis provided a basic knowledge of the state of organs and tissues, including the animal metabolic state. In some cases, a higher serum total protein level may accompany the incidence of acute inflammation, dehydration, or cause tissue damage (Kujero *et al*., 2021), which explains the low body weight and high total protein levels found in batches of ginger-fed chicks.

The addition of turmeric (0.5% and 1%) and ginger (1%) powder resulted in a reduction in triglyceride levels when compared to the untreated group. However, it appears from cholesterol values that batches treated with different doses of turmeric and 1% ginger recorded slightly low values. Aspartate aminotransferases (ASAT) were low between treated batches when compared to control. However, the Alanine

aminotransferases (ALAT) level presents high values obtained in the batches fed with different doses of turmeric and ginger at 1% when compared to the control batches. Triglycerides contents and Aspartate aminotransferases (ASAT) were influenced by the dietary supplements of turmeric and ginger. They were reduced in treated chicks, which suggests that phytobiotic compounds can reduce serum triglycerides and Aspartate aminotransferases (ASAT).

Consumption and storage of total cholesterol in very large quantities can predispose the body to certain health problems (Adeniyi et al. 2016). During this study, there was a slight increase in this parameter, which does not pose a danger to chicks treated with phytobiotics. This experiment shows that supplementing the diet with turmeric (0.5 and 1%) and ginger at 1% influenced the reduction of triglyceridemia. This may be due to the active ingredients present in this spice which contribute to the reduction of the latter. Liver function enzymes are reliable markers for assessing liver function. High levels of these enzymes in the blood indicate the disordered state of liver tissues and the resulting liver dysfunction (Noor *et al*., 2022). According to (Pariente 2013) , reported that an increase in aspartate aminotransferase causes hepatic cytolysis. The reduction of the levels of this parameter by the incorporation of these spices (turmeric and ginger) in the diet (Figure 6d) indicates that at these levels of supplementation, these powders did not have a harmful effect on the hepatic function.

To have a general idea that links all biochemical and enzymatic parameters, a dimensional analysis was used, namely principal component analysis (Figure 7).

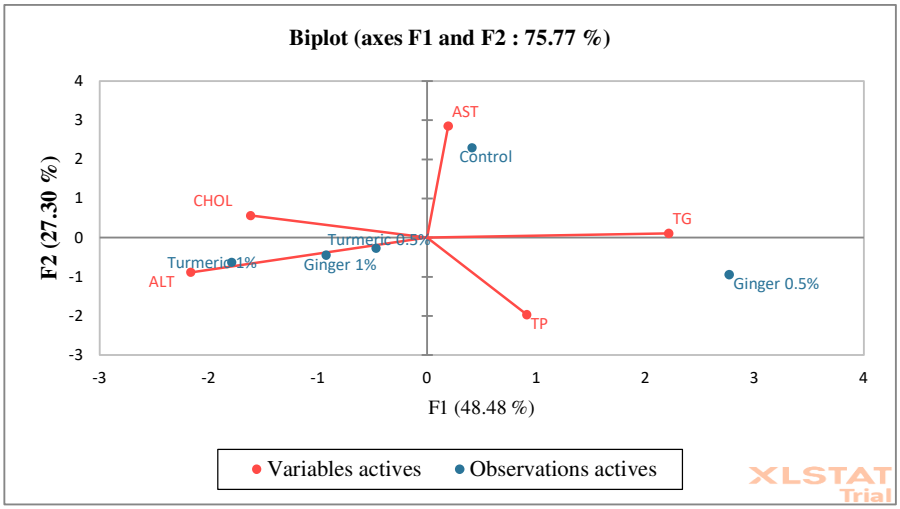

Figure 7. Principal component analysis of data illustrated in Figures 4, 5, and 6. TP: Total proteins, TG: Triglycerides, CHOL: Cholesterol, AST: Aspartate aminotransferases and ALT: Alanine aminotransferases

Axes 1 and 2 gather 75.77% of the information. In axis 1, the contribution of triglycerides, cholesterol, and Alanine aminotransferases (ALAT) are represented. On axis 2, Aspartates aminotransferases (ASAT) are found to contribute to the positive part of axis 2. The total protein contributes to the negative part of axis 2 and is strongly correlated with the ginger treatment at 0.5 % (toxic concentration). Turmeric (0.5% and 1%) and ginger at 1% are non-toxic by correlating with Alanine aminotransferases (ALT) which presents a good indicator of toxicity.

Cecum bacteriological analysis

The bacteriological load was evaluated by the classic technique of colonies formed counting, except for *Salmonella sp.*, they are based on the criteria presence/absence of the colonies. The effect of including powders of two spices in the diet of chicks on the cecal microflora is shown in Table 3.

Table 3. Effect of treatments on bacterial growth

Treatments	Coliforms	*Salmonella sp.*	*Clostridium sp.*	LAB
Negative control	2.109 cell/mL*	Absence	0	0
Turmeric 0.5%	0	Absence	0	0
Turmeric 1%	0	Absence	0	0
Ginger 0.5%	0	Absence	0	0
Ginger 1%	0	Absence	0	0

*: per mL of cecum suspension.

According to these results, it can be noticed a total absence of coliforms, *Salmonella* sp., *Clostridium* sp., and LAB observed in the treated batches and the control batch, except for the coliforms, which marked their presence in the control batch. It can be concluded that there is an eradication of coliforms thanks to the different treatments. This could be explained by supplementing the feed with spices during the start-up phase, where it participates in the chicks' health protection against pathogenic germs. From these results, supplementing the chicks' feed with spice powders appears to be beneficial due to their richness in microbial inhibitory substances, especially phenolic compounds and essential oils.

Microbial strains have not been detected throughout the growth cycle except for *E. coli*. It can be observed that the absence of bacteria in the cecum in the starting phase which lasts 12 days, is probably because intestinal microbiota is not yet well-developed. However, dietary treatments with these phytobiotics have led to changes in the digestive microbiota which could be one of the factors influencing the inhibition of microbial growth.

The cost of this supplementation remains derisory (0.035 to 0.07 US dollars per kg of poultry food) and in no way constitutes a financial burden such as that relating to the introduction of antibiotics.

Conclusions

The present study showed the positive effect of chick feed supplementation with turmeric and ginger powder on Ross 308 broilers zootechnical performances. Obtained results demonstrated a good modification of weight growth, average daily gain (ADG), consumption index (CI) and blood serum parameters in the batch treated with 0.5% turmeric. The bacteriological analysis revealed that the chicks treated with studied spice powders prevented coliform growth during the 12 days of the experiment. Obtained results also showed that supplementing the poultry feed with 0.5% of turmeric powder has beneficial effects on good liver function, normal intestinal flora, and growth parameters.

Authors' Contributions

Conceptualization: F.E; Methodology: C.B and N.C; Software: K.F.S; Validation: S.M.R; Formal analysis: T.A; Investigation: C.B; L.K.Y; S.E. and K.F.S; Resources: C.B; L.K.Y; S.E. and K.F.S; Data curation: F.E; Writing—original draft preparation: C.B; Writing—review and editing: A.Z., T.A and F.E; Visualization: A.Z; Supervision: F.E and A.Z. . All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

The animal study protocol was approved by the Institutional Review Board (or Ethics Committee) of the (CEHUF) protocol (code 001, approval date 2020) for studies involving animals.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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