Growth performance, carcass characteristics and villi morphometry of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* leaves meals as phytobiotics

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Abstract

The study was carried out to evaluate *Mentha piperita* and *Adansonia digitata* leaves meals as alternatives to antibiotic growth promoter (AGP) in broiler chickens. This becomes necessary to total ban placed on the use of AGP in livestock production by European Union in 2006. It is necessary secondly to reduce incidence of drug residue in animal products, hence, the need for this study. In achieving this, a total of 396 day-old Cobb 500 broiler chicks were allotted randomly to six dietary treatments in triplicates with 22 chicks in a completely randomized design. *Mentha piperita* and *Adansonia digitata* were included at 0g (T1), 200g and 400g each per 100kg diet (T2-T5) while oxytetracycline was used as positive control (T6). Data collected on growth parameters, carcass characteristics and villi morphometric traits were subjected to analysis of variance and significant differences among treatment means were compared using Tukey procedures. The result showed that final weight, weight gain, feed conversion and feed cost per kg gain were significantly ($p < 0.05$) better in birds fed diets containing oxytetracycline, *Mentha piperita* at 200g and *Adansonia digitata* at 400g per 100kg diets at the starter and finisher phases. Birds fed diets containing oxytetracycline, 200g/100kg of *Mentha piperita* and *Adansonia digitata* had higher ($p < 0.05$) live weight, dressed weight and breast cut. Organ weights were significantly higher in birds fed diets containing *Adansonia digitata* at 400g/100kg diets. Villi area was higher ($p < 0.05$) in birds fed diets containing oxytetracycline, 400g/100kg of *M. piperita* and both levels of *A. digitata* than the control group. Villi height and width were higher in birds fed diets containing *M. piperita* and *A. digitata*. In conclusion, inclusion of *M. piperita* at 200g and *A. digitata* at 400g/100kg diet improved broiler chickens growth performance, carcass and villi morphometric traits.

Keywords: Absorption, Phytobiotics, Additives, Essential Oils, Microbiota

Performances de croissance, caractéristiques de la carcasse et morphométrie des villosités des poulets à griller nourris avec des aliments contenant *Mentha piperita* et *Adansonia digitata* laisse les repas comme phytobiotiques

Résumé

L'étude a été menée pour évaluer les repas de feuilles de *Mentha piperita* et d'*Adansonia digitata* comme alternatives au promoteur de croissance antibiotique (PCA) chez les poulets de chair. Cela devient nécessaire à l'interdiction totale de l'utilisation de PCA dans la production animale par l'Union européenne en 2006. Il est nécessaire d'autre part de réduire l'incidence des résidus de médicaments dans les produits animaux, d'où la nécessité de cette étude. Pour y parvenir, un total de 396 poussins de chair Cobb 500 d'un jour ont été répartis au hasard dans six traitements diététiques en triple avec 22 poussins dans un plan complètement randomisé. *Mentha piperita* et *Adansonia digitata* ont été inclus à 0 g (T1), 200 g et 400 g chacun par 100 kg de régime (T2-T5) tandis que l'oxytétracycline a été utilisée comme contrôle positif (T6). Les données recueillies sur les paramètres de croissance, les

caractéristiques de la carcasse et les traits morphométriques des villosités ont été soumises à une analyse de variance et des différences significatives entre les moyennes de traitement ont été comparées à l'aide des procédures de Tukey. Le résultat a montré que le poids final, le gain de poids, la conversion alimentaire et le coût de l'alimentation par kg de gain étaient significativement ($p < 0,05$) meilleurs chez les oiseaux nourris avec des régimes contenant de l'oxytétracycline, *Mentha piperita* à 200g et *Adansonia digitata* à 400g pour 100kg de régimes en entrée et en finition. phases. Les oiseaux nourris avec des régimes contenant de l'oxytétracycline, 200 g/100 kg de *Mentha piperita* et d'*Adansonia digitata* avaient un poids vif, un poids paré et une poitrine coupés plus élevés ($p < 0,05$). Le poids des organes était significativement plus élevé chez les oiseaux nourris avec des aliments contenant de l'*Adansonia digitata* à raison de 400 g/100 kg. La surface des villosités était plus élevée ($p < 0,05$) chez les oiseaux nourris avec des aliments contenant de l'oxytétracycline, 400 g/100 kg de *M. piperita* et les deux niveaux d'*A. digitata* que le groupe témoin. La hauteur et la largeur des villosités étaient plus élevées chez les oiseaux nourris avec des régimes contenant *M. piperita* et *A. digitata*. En conclusion, l'inclusion de *M. piperita* à 200 g et *A. digitata* à 400 g/100 kg de régime a amélioré les performances de croissance des poulets de chair; les caractéristiques morphométriques de la carcasse et des villosités.

Mots clés : Absorption, Phytobiotiques, Additifs, Huiles essentielles, Microbiote

Introduction

A major feature of poultry production today is the reduction in the use of antibiotics largely due to concerns over bacterial resistance (Cross *et al.*, 2002). This has necessitated the search for viable alternatives such as herbal products which according to Salihu *et al.* (2020) may serve as environmental friendly alternative to antibiotic growth promoters (AGPS) in poultry feeds. Phytogetic feed additives (PFA) derived from herbs, spices or aromatic plants are relatively young classes of feed additive that have gained considerable attention in the recent years in feed industry (Windisch *et al.*, 2008; Hashemipour *et al.*, 2013; Dhama *et al.*, 2015; Abd El-Hack *et al.*, 2016; Alagawany *et al.*, 2016). These plant derived products are residue-free unlike synthetic antibiotics and are also generally considered safe to be used as the ingredients in the food industry as well as in animal diet as an ideal growth promoter (Varel, 2002; Hashemi *et al.*, 2008; Li *et al.*, 2016; Moses *et al.*, 2017). Phyto-genics such as *Mentha piperita* and *Adansonia digitata* have been reported to have beneficial effects on nutrient

utilization possibly by stimulating digestive enzymes such as lipase, amylase, or protease (Platel and Srinivasan, 2004) and improve gastrointestinal morphology (Jamroz *et al.*, 2006; Upadhaya *et al.*, 2016). **Peppermint (*Mentha piperita*)** is a hybrid mint, a cross between watermint and spearmint. It is recognized as plant source of menthol and menthone and are among the oldest herbs used for medicinal product. It contains terpenoids and flavonoids like eriocitrin, hesperidin, and kaempferol 7-O-rutinoside (Dolzhenko *et al.*, 2010). Baobab (*Adansonia digitata*) is a native tree of African origin known for its medicinal and nutritional value (Kamatou *et al.*, 2011). Several plant parts of baobab tree have interesting antimicrobial, antiviral, antioxidant, antiinflammatory, analgesic, antipyretic and anti-diarrhoea properties. Baobab leaves contain significant level of vitamins C and A (provitamin A) which is usually estimated by the amount of carotenoids, which in turn depends on the method of leaf drying and tree type. The oil contains phytosterol such as beta-sterol, campesterol, stigmasterol and delta-5-avenasterol (Abdalla *et al.*, 2010). Phytochemical analysis of these

botanicals have shown the presence of essential oil and phytochemicals that improved performance and reduced bacterial load in non-ruminant livestock (Dhama *et al.*, 2015). The study was carried out therefore to evaluate peppermint leaf (*Mentha piperita*) and baobab leave (*Adansonia digitata*) meals as phytogenic feed additives in broiler chicken diets and their effects on growth performance, carcass characteristics and villi morphometry.

Materials and methods

Experimental site

The experiment was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research farm, Ahmadu Bello University, Zaria, Kaduna State. Zaria is in the Northern Guinea Savannah zone, located on longitude 11° 09' 01.78" N and 7° 39' 14.79" E and 671m above sea level. The climate is characterized by a well-defined dry and wet seasons. The climate is relatively dry with a mean annual rainfall of 700-1400mm (IARMS, 2020).

Experimental design and management of birds

Three hundred and ninety-six-day old Cobb 500 broiler chicks were allocated to six dietary treatments with three replicates of 22 birds each in a completely randomized design (CRD). The birds were housed in deep litter pens and managed with all necessary routine management practices. Feed and water was provided *ad libitum* throughout the experimental period.

Experimental diets

Six treatment diets were formulated as shown in Tables 1 and 2 for the starter and finisher phases, respectively.

Diet 1: Standard diet with neither peppermint nor baobab leaves meals (Control)

Diet 2: Standard diet with peppermint leaf

meal at 200g/100kg diet

Diet 3: Standard diet with peppermint leaf meal at 400g/100kg diet

Diet 4: Standard diet with baobab leaf meal at 200g/100kg diet

Diet 5: Standard diet with baobab leaf meal at 400g/100kg diet

Diet 6: Standard diet with oxytetracycline as recommended by the manufacturer.

Growth study

Initial and final weights of birds were taken at the beginning and at the end of both starter and finisher phases. Weight gain and feed intake were measured weekly while feed/gain ratio and cost per Kg gain were computed for both phases. Mortality was recorded as it occurred.

Carcass analysis

At the end of the finisher phase, three chickens were randomly selected from each treatment, representing the average weight of the group for carcass evaluation. The selected birds were starved, bled by severing the jugular vein and then scalded in hot water to remove the feathers. Live weight for each chicken was taken before slaughter. Dressing percentage, weight of organs and the standard cut parts were measured. The organs and weight were expressed as a percent of live weight while the cut parts were expressed as percentage of dressed weight.

Villi morphometric

Intestinal segment samples (approximately 2cm in length) were taken from birds used for carcass evaluation to ascertain villi morphometric. The morphometric indices that were evaluated include villi height, villi width, crypt depth, surface area, perimeter and the ratio of villi height to villi depth at the Histology Laboratory, Department of Human Anatomy, Ahmadu Bello University, Zaria.

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Table 1: Composition of broiler starter diets containing *M. piperita* and *A. digitata* as phyto-genic additives

		Inclusion of experimental materials (g/100kg Diet)				
Ingredients (%)	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet
		200	400	200	400	
Maize	57.00	56.80	56.60	56.80	56.60	57.00
Soya cake	35.00	35.00	35.00	35.00	35.00	35.00
Groundnut cake	4.00	4.00	4.00	4.00	4.00	4.00
Mint leaf	0.00	0.20	0.40	0.00	0.00	0.00
Baobab leaf	0.00	0.00	0.00	0.20	0.40	0.00
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.25	0.25	0.25	0.25	0.25	0.25
Common Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Vit-min Premix	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
ME (Kcals/Kg)	2,956	2,950	2,943	2,950	2,943	2,956
Crude Protein (%)	23.11	23.12	23.13	23.11	23.11	23.11
Crude Fibre (%)	3.02	3.03	3.04	3.05	3.08	3.02
Ether Extract (%)	4.87	4.88	4.89	4.88	4.89	4.87
Calcium (%)	1.25	1.25	1.25	1.25	1.25	1.25
Phosphorus (%)	0.58	0.58	0.58	0.58	0.58	0.58
Methionine (%)	0.56	0.56	0.56	0.56	0.56	0.56
Lysine (%)	1.24	1.24	1.24	1.24	1.24	1.24
	121.19	125.02	128.85	124.02	126.85	125.19

^A Vitamin- mineral premix provide per kg of diet: Vit. A, 10,000,000 IU; Vit. D₃, 2, 000,000 IU; Vit. E, 40,000mg; Vit. K₃, 2000mg; Vit. B₁, 1,500mg; Vit. B₂, 5,000mg; Vit. B₆, 4,000mg; Vit. B₁₂, 20mg; Niacin, 40,000mg; Calpan, 10,000mg; Folic acid, 1,000mg ; Biotin, 100mg; Choline Chloride, 30,000mg; Manganese, 80,000mg; Iron, 40,000mg; Zinc, 60,000mg; Copper, 80,000mg; Iodine, 800mg; Cobalt, 300mg; Selenium, 200mg. Oxytet = Oxytetracycline.

Results and discussion

Growth performance of broiler chicks fed diets containing Mentha piperita and Adansonia digitata leaves (0-4 weeks)

The growth performance of broiler chicks fed diets containing *Mentha piperita* and *Adansonia digitata* leaves as phyto-genic additive is presented in Table 3. The result showed that there were significant ($p < 0.05$) differences in final weight, weight gain (WG), feed intake, feed conversion ratio (FCR) and feed cost per kg gain. Final weight, WG, FC and feed cost per kg gain were significantly ($p < 0.05$) higher for broiler chicks fed diets supplemented with 200g/100kg *Mentha piperita* leave. The

higher body WG observed in broilers fed the peppermint diet may be related to the reported properties of menthol (Lovkova *et al.*, 2001). This result agrees with the result of Jamrox *et al.* (2004) on increase in growth of chicks fed diet supplemented with *Mentha piperita*. The increase in growth could also be due to improvement of endogenous enzyme secretion and stimulation of appetite, digestibility and nutrient absorption, improvement of microflora balance and decrease of *Escherichia coli* and *Clostridium* population while increasing the population of beneficial bacteria like *Lactobacillus* spp (Hernandez *et al.*, 2004).

Table 2: Composition of broiler finisher diets containing *M. piperita* and *A. digitata* as phytogetic additives

Ingredient	Inclusion of Experimental Materials (g/100kg Diet)					
	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet
		200	400	200	400	
Maize	58.00	58.00	58.00	58.00	58.00	58.00
Soya cake	20.00	20.00	20.00	20.00	20.00	20.00
Groundnut cake	10.00	10.00	10.00	10.00	10.00	10.00
Maize offal	7.75	7.55	7.35	7.55	7.35	7.75
Mint leaf	0.00	0.20	0.40	0.00	0.00	0.00
Baobab leaf	0.00	0.00	0.00	0.20	0.40	0.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Vit-min Premix ^A	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
ME (Kcal/Kg)	2,994	2,988	2,983	2,988	2,983	2,994
Crude Protein (%)	20.15	20.16	20.16	20.15	20.15	20.15
Crude Fibre (%)	3.97	3.97	3.96	3.99	4.00	3.97
Ether Extract (%)	4.54	4.55	4.57	4.55	4.57	4.54
Calcium (%)	1.29	1.29	1.29	1.29	1.29	1.29
Phosphorus (%)	0.57	0.56	0.56	0.56	0.56	0.57
Methionine (%)	0.50	0.50	0.50	0.50	0.50	0.50
Lysine (%)	1.02	1.02	1.00	1.01	1.00	1.02
Feed Cost (₦/kg)	111.00	1114.87	118.74	113.87	116.74	115.00

^A Vitamin- mineral premix provide per kg of diet: Vit. A, 10,000,000 IU; Vit. D₃, 2, 000,000 IU; Vit. E, 40,000mg; Vit. K₃, 2000mg; Vit. B₁, 1,500mg; Vit. B₂, 5,000mg; Vit. B₆, 4,000mg; Vit. B₁₂, 20mg; Niacin, 40,000mg; Calpan, 10,000mg; Folic acid, 1,000mg; Biotin, 100mg; Choline Chloride, 30,000mg; Manganese, 80,000mg; Iron, 40,000m g; Zinc, 60,000mg; Copper, 80,000mg; Iodine, 800mg; Cobalt, 300mg; Selenium, 200mg. Oxytet = Oxytetracycline.

Table 3: Performance of broiler chicks fed diets supplemented with *M. piperita* and *A. digitata* as phytogetic additives

Parameters	Inclusion levels of experimental materials (g/100kg diet)						SEM
	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet	
		200	400	200	400		
Initial weight (g/b)	43.20	43.28	43.16	43.03	43.29	43.19	0.51
Final weight (g/b)	575.49 ^b	674.78 ^a	567.88 ^b	607.18 ^{ab}	663.07 ^a	585.61 ^b	39.46
Weight gain (g/b)	532.30 ^b	631.50 ^a	524.72 ^b	564.15 ^{ab}	619.78 ^a	542.42 ^b	39.54
Feed intake (g/b)	968.98 ^{ab}	1006.94 ^a	898.61 ^c	912.32 ^c	1041.79 ^a	923.66 ^{bc}	47.06
Feed conversion ratio	1.82 ^b	1.60 ^a	1.73 ^{ab}	1.63 ^a	1.69 ^{ab}	1.71 ^{ab}	0.07
Feed cost (₦/kg)	138.59	142.39	146.29	141.39	144.29	142.59	NA
Feed cost/kg gain (₦/kg)	252.23 ^b	227.82 ^a	253.08 ^b	230.47 ^a	243.85 ^{ab}	243.83 ^{ab}	8.78
Mortality (%)	1.45	1.45	0.00	1.45	1.45	0.00	1.18

abc: means with different superscripts along the same row are significantly different, SEM: standard error of means, oxytet: oxytetracycline, NA: Not analysed.

Broiler chicks fed diets supplemented with 400g/100kg *Adansonia digitata* showed better performance as compared to the control diet. This result agrees with the report of Rafiu *et al.*, (2017). The higher WG of birds fed *Adansonia digitata* at 400g/100kg could be due to the essential oil present in baobab leave which has antimicrobial effect thereby reducing the growth of detrimental bacteria and enhancing performance of birds (Rowland *et al.*, 2018). The FCR were better for birds fed diet supplemented with 200g/kg of *Mentha piperita* and *Adansonia digitata* leave respectively. Dietary treatments however had no significant ($P>0.05$) effect on the rate of mortality. The findings of this study showed that inclusion of *Mentha piperita* and *Adansonia digitata* in the diets of broiler chicks have positive effect in improving the growth and economic efficiency. In several studies, researchers have also stated that feed additives may stimulate early gut development and improve overall efficiency of the chicken gastro intestinal tract (Donoghue, 2003; Apajalahti *et al.*, 2004). The high performance of the broiler chicks fed diet containing natural plant products, mainly essential oils, have been evaluated as possible feed additives for animal production, especially considering there in vitro antimicrobial activity (Cowan, 1999). Jang *et al.* (2007) reports that phytobiotics have beneficial effect on gastrointestinal enzymatic activity, most likely improving nutrient digestibility thus enhancing growth and performance in birds.

Performance of broiler chickens fed diets supplemented with Mentha piperita and Adansonia digitata as phytogetic feed additives (5-8weeks)

The growth performance of broiler

chickens fed diets containing *Mentha piperita* and *Adansonia digitata* leaves as phytogetic additives is presented in Table 4. The result showed that there were significant ($p<0.05$) differences in final weight, weight gain, feed conversion ratio (FCR) and feed cost per kg gain. Final weight and weight gain were significantly ($p<0.05$) higher for broiler chickens fed diets supplemented with *Mentha piperita* at 200g/100kg and oxytetracycline. There was no significant ($P>0.05$) difference for feed intake across the treatments. The FCR was better for broiler chickens fed diets containing oxytetracycline and *Mentha piperita* at 200g/100kg and *Adansonia digitata* at 400g/kg. Feed cost per kg gain was higher for broiler chickens fed diet containing *Mentha piperita* at 200g/100kg and oxytetracycline. The result of these findings agrees with that of Emami *et al.* (2012) who reported that feeding broilers chickens with diet supplemented with 200 mg/kg EO from peppermint led to the increase in crude protein digestibility and states that essential oils in these plants positively affect nutrient digestibility in poultry. The improved nutrient digestibility consequently enhances the health status of animals. The higher final weight and total weight gain observed for broiler chickens fed diets containing the experimental material could be as a result of exclusive elimination of harmful bacteria load in the gut of the birds leading to higher concentration of beneficial bacterial that helped in effective feed digestion and nutrient utilization (Khan *et al.*, 2009). The reason for improvement in nutrient absorption may be partly explained due to stimulation in secretions of saliva, bile and enhanced enzyme activity (Platel and Srinivasan, 2004).

Table 4: Performance of broiler chickens fed diets supplemented with *M. piperita* and *A. digitata* as phytogetic feed additives (5-8weeks)

Parameters	Inclusion levels of experimental materials (g/100kg diet)						SEM
	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet	
		200	400	200	400		
Initial weight (g/b)	616.08	619.95	603.22	610.18	619.28	606.00	24.95
Final weight (g/b)	2394.82 ^b	2570.00 ^a	2485.79 ^{ab}	2477.78 ^{ab}	2511.40 ^{ab}	2523.33 ^a	64.06
Weight gain (g/b)	1778.74 ^b	1950.05 ^a	1882.57 ^{ab}	1867.59 ^{ab}	1892.12 ^{ab}	1917.33 ^a	58.94
Feed intake (g/b)	3494.50	3506.30	3455.60	3433.30	3454.90	3462.00	83.80
Feed conversion ratio	1.97 ^b	1.80 ^a	1.84 ^a	1.84 ^a	1.83 ^a	1.81 ^a	0.05
Feed cost (₦/kg)	132.40	136.270	140.14	135.27	138.14	135.90	NA
Feed cost/kg gain (₦/kg)	260.45 ^b	245.11 ^a	257.50 ^{ab}	248.65 ^{ab}	252.98 ^{ab}	245.70 ^a	7.35
Mortality (%)	1.45	0.00	0.00	1.45	0.00	0.00	0.84

ab: means with different superscripts along the same row are significantly different, SEM: standard error of means, oxytet: oxytetracycline, NA: Not analysed.

Phytogenic additives were reported to improve growth rate and efficiency of feed utilization (Weerasingha and Atapattu, 2013). Phytogenic feed additives had been shown to have antimicrobial effect in the gut of livestock (Pandey *et al.*, 2015; Salihu *et al.*, 2020). The better performance of birds fed diet supplemented with antibiotic could be attributed to its antimicrobial effect especially in handling the pathogenic strains of bacteria. In a similar study where the diets of broiler chickens were supplemented with oxytetracycline, it was reported to improve growth rate (Salihu *et al.*, 2020). This could also be attributed to its antimicrobial effect especially in increasing the population of beneficial strains of bacteria. Donoghue (2003) reported that feed supplemented with antibiotic growth promoters stimulate early gut development and improve overall efficiency of the chicken gastro intestinal tract.

Carcass characteristics of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* as phytogetic feed additives

The carcass characteristics of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* is presented in Table 5. There were significant ($p < 0.05$) differences in all parameters measured except for heart and lungs percentages. The results obtained showed

that broiler chickens fed dietary supplements of *Mentha piperita* at 200g/100kg diet and AGPs had higher dressed weight and dressing percentage than those fed diets containing *Adansonia digitata* and the control. Result of the cut parts showed that birds on 200g of both *Mentha piperita* and *Adansonia digitata* had significantly ($p < 0.05$) higher breast cut percentages while birds on 400g of *Adansonia digitata* had significantly ($p < 0.05$) higher drumstick percentages.

Organ weights such as gizzard, liver, kidney and fat were significantly ($p < 0.05$) different across the treatment diets. Studies have reported that the use of antibiotics as a growth promoter has ability to improve weight gain as well as carcass yield of birds (Yang *et al.*, 2009; Al-Kassie, 2010). The result is in agreement with Khaksar *et al.* (2012) who reported significant improvements in some carcass traits due to inclusion of thyme essential oils. However, Schulze *et al.* (2008) did not observe a significant effect in the broiler carcass yield due to the dietary inclusion of essential oil blend based on thyme and cinnamon. Abdominal fat was lower for broiler chickens fed diets containing *Mentha piperita* at 200g/100kg, control diets and diets containing oxytetracycline. Abdominal fats reduced as the inclusion levels of the experimental materials

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Table 5: Carcass characteristics of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* as phytogenic feed additives

Inclusion levels of experimental materials (g/100kg diet)							
Parameters	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet	SEM
		200	400	200	400		
Live weight (g)	2350.00 ^b	2566.67 ^a	2483.33 ^{ab}	2460.00 ^{ab}	2486.67 ^{ab}	2500.00 ^a	72.07
Dressed weight (g)	1595.33 ^b	1842.67 ^a	1730.00 ^{ab}	1745.33 ^{ab}	1735.33 ^{ab}	1819.00 ^a	75.13
Dressing %	67.84 ^b	71.75 ^a	69.70 ^{ab}	70.92 ^{ab}	69.72 ^{ab}	72.70 ^a	1.55
Standard cut expressed as % of dressed weight							
Breast	29.13 ^c	33.72 ^a	29.68 ^{bc}	33.06 ^a	30.65 ^{bc}	32.13 ^{ab}	1.04
Back	16.25 ^b	18.22 ^a	18.69 ^a	18.78 ^a	16.30 ^b	16.67 ^b	0.68
Thigh	16.92 ^a	15.38 ^c	15.75 ^{bc}	16.65 ^{ab}	16.25 ^{ab}	16.41 ^{ab}	0.50
Drumstick	15.22 ^{ab}	14.06 ^c	16.14 ^a	12.77 ^d	15.27 ^{ab}	14.34 ^{bc}	0.53
Wings	12.88 ^a	10.00 ^e	11.23 ^c	10.67 ^d	12.44 ^b	12.27 ^b	0.20
Organs expressed as % of live weight							
Gizzard	2.32 ^a	1.75 ^c	1.90 ^{bc}	2.15 ^{ab}	2.30 ^a	1.93 ^{bc}	0.17
Heart	0.54	0.56	0.49	0.47	0.51	0.44	0.06
Lungs	0.60	0.58	0.63	0.54	0.52	0.57	0.07
Liver	2.24 ^{ab}	2.26 ^{ab}	2.39 ^a	2.18 ^{ab}	2.48 ^a	1.93 ^b	0.20
Kidney	0.50 ^c	0.57 ^{bc}	0.62 ^b	0.61 ^b	0.75 ^a	0.58 ^{bc}	0.05
Fat	2.47 ^c	1.54 ^b	0.58 ^a	0.94 ^a	0.69 ^a	1.71 ^b	0.30

^{abcde} Means with different superscripts along the same row are significantly different, SEM: standard error of means, oxytet: oxytetracyclin

increased. The findings of this study agree with that of Zubair and Leeson (1996) that peppermint and thyme extract lowered abdominal fat level.

Villi morphometry of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* as phytogenic feed additives

Table 12 showed the villi morphometry of broiler chickens fed dietary supplement of *Mentha piperita* and *Adansonia digitata* as phytogenic additives. The results showed that there were significant differences in villi area, villi height, villi width and villi height to crypt depth ratios. Villi area was significantly ($p < 0.05$) higher in birds fed diets containing 400g of *M. piperita*, both levels of *A. digitata* and oxytetracycline than the control group. Villi height was significantly ($p < 0.05$) higher in birds fed

diets containing *M. piperita* and *A. digitata* while villi width was significantly ($p < 0.05$) higher in birds fed diets containing both levels of *A. digitata*.

The morphology of intestinal villi and crypts has been associated with intestinal function and growth in chickens. Higher intestinal villi are associated with increased absorptive surface area of the intestine and thus, an increased absorptive capacity with resultant higher body weight gain (Kanduri *et al.*, 2013). A lower villus/crypt ratio has been associated with the presence of toxins, poor nutrient absorption and increased secretion in the gastrointestinal tract, diarrhoea, reduced disease resistance and lower overall performance. A large crypt indicates a fast tissue turnover and a high demand for new tissue (Xu *et al.*, 2003).

Table 6: Villi morphometry of broiler chickens fed diets containing *Mentha piperita* and *Adansonia digitata* as phytogetic feed additives

Inclusion levels of experimental materials (g/100kg diet)							
Parameters	0	<i>M. piperita</i>		<i>A. digitata</i>		Oxytet	SEM
		200	400	200	400		
Villi Area (μm) ²	19367.27 ^c	35253.47 ^{bc}	50423.44 ^{ab}	48763.82 ^{ab}	58897.88 ^a	44241.4 ^{ab}	10663.00
Villi Perimeter (μm)	683.94	1116.19	895.31	744.43	1059.9	629.13	275.52
Villi Height (μm)	237.00 ^a	319.61 ^a	287.2 ^{ab}	296.87 ^a	292.58 ^a	291.61 ^{ab}	27.02
Villi Width (μm)	87.08 ^c	102.13 ^{bc}	94.03 ^c	129.63 ^{ab}	149.19 ^a	140.75 ^a	14.26
Crypt Depth (μm)	72.75	65.99	71.00	71.17	69.88	70.23	4.20
VH/CD	4.03 ^b	4.84 ^a	4.07 ^b	4.25 ^{ab}	3.47 ^b	4.23 ^{ab}	0.37

^{abc}Means with different superscripts along the same row are significantly different, SEM: standard error of means, oxytet: oxytetracycline, VH: Villi height, CD: crypt depth

The result obtained in this works showed that the gut morphology may be responsible for the higher growth performance and better nutrient utilization in broiler chickens fed dietary supplements of *M. piperita* and *A. digitata*. Presence of longer villi has been reported to increase crypt depth of the mucosa of the small intestine resulting in better feed conversion (Sherief *et al.*, 2011) and support the gut's ability to absorb nutrients for animal maintenance and growth (Awad *et al.*, 2009; Lee *et al.*, 2010).

Conclusions

The study showed that peppermint (*Mentha piperita*) leaf meal at 200 g/100kg diet and baobab (*Adansonia digitata*) leafmeal at 400 g/100kg diet in broiler chicken diets improved growth performance, carcass characteristics and villi morphometric.

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