Received: 30 June 2023, Accepted: 07 August 2023

Original Research

Journal of Advanced Veterinary Research
(2023) Volume 13, Issue 8, 1530-1536

Assessment of the Impact of *Bacillus* Probiotics, Coconut Oil and *Nigella sativa* Oil on Productive Performance, Economic Indicators and Carcass Characteristics of cobb 500 Broiler Chickens

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Abstract

This experiment was conducted to evaluate the impact of dietary inclusion of probiotic mixture (*B. subtilis* and *B. licheniformis*), Coconut oil (CO) and *Nigella sativa* oil (NSO) or Black cumin oil (BCO) on productive performance, economic efficiency indicators and carcass characteristics of broiler chicks. For this purpose, 140 day-old broiler chicks (Cobb500) were weighed individually and assigned randomly into four treatments (T) 35 chicks in each, divided into five replicates of 7 chicks in each. (T1) control fed a basal diet, (T2) fed a basal diet + Coconut oil (10 ml/kg feed); (T3) fed a basal diet + *Nigella sativa* oil (1ml/kg feed) and (T4) fed a basal diet + *Bacillus* probiotics (1g/kg of diet). Results clarified that CO, NSO and probiotic mixture groups improved significantly (P>0.05) the productive parameters (final body weight (FBW), body weight gain (BWG) and feed conversion ratio (FCR)) compared to control group. CO-based diet group recorded the highest BW and BWG, while probiotics mixture group was superior in feed intake value. The lowest FCR value was recorded in CO and NSO-based diet groups. The best economic efficiency measures were scored in CO followed by NSO then *Bacillus* probiotics. Also, there are significant differences (P<0.05) among dietary treatments on relative weight of carcass, inner organs and immune organs. Diet containing NSO acquired the highest dressing percent (73.50%), while the highest relative weight of (heart, proventriculus, thymus, spleen %) was registered in broilers fed probiotics mixture diet. In conclusion CO, NSO, probiotics mixture-based diet has a beneficial influence on productive performance and economic indicators, thus highly recommended utilizing those supplements as natural feed additives.

KEYWORDS
Bacillus probiotics, Coconut oil, *Nigella sativa* oil, Productive performance, Economic indicators, Carcass characteristics, Broiler chickens.

INTRODUCTION

Poultry broiler meat is more desirable and healthy than red meat for people due to low cholesterol level (Starčević *et al*., 2015). In Egypt, the most remarkable poultry species which contributes significantly to providing protein from an animal source are broiler chickens and the total meat of broiler chicken increased from 909,000 tons meat in 2013 to 1256,000 tons meat in 2017 (CAMPAS, 2019). The major obstacles facing broiler industry is feed costs due to the feed is considered the most substantial input for broiler production in terms of cost and represents approximately 70% from total variable costs (TVC), also has a main role in accomplishing high productivity and efficiency (Ravindran, 2013; Abdurofi *et al*., 2017). From the last 50 years, antibiotic growth promoter (AGP) was being utilized in animal diet with small amount for the improvement and maximization of production and decreasing diseases (Castanon, 2007), as well AGPs have a beneficial effect on weight gain, improved feed conversion efficiency with 3.48 % so reducing feed cost. Preventing the use of antibiotics in animal ration had been resulted in raising the cost of production with 0.8% (Maria Cardinal *et al*., 2019). In January 2006 the European Union (EU) banned and restricted using AGP because of increasing antibiotic-resistant bacteria and rising awareness and concerning about human health and food safety from residues of antibiotics. Viable alternatives as feed additives which enhancing immunity of intestine and help to maintain profit margin like probiotics, prebiotics, organic acids and phytogenic feed additives including essential oils and herbs (Çenesiz and Çiftci 2020; Côté *et al*., 2021; Seidavi *et al*., 2021).

Bacillus species are the most common probiotics which recommended to be used as feed supplements (Sanders *et al*., 2003; European Commission, 2016). In 2000, total selling of probiotics reached for $186 million in all over world (Cheng *et al*., 2014). The main constituting of coconut oil is medium chain fatty acids which containing about 45-50 % lauric acid and the lauric acid possess potentials as anti-inflammatory, antimicrobial and improve immunity, so coconut oil used as feed additives or an alternative medication against pathogenic microorganisms (Dayrit, 2015; Peedikayil *et al*., 2015; Baltić *et al*., 2017; Nasir *et al*., 2018; Çenesiz and Çiftci 2020; Joshi *et al*., 2020). Diet supplemented with black cumin oil has a positive impact on productive parameters also has antibacterial, anti-inflammatory and antioxidant effect so can be used as natural substitute for APG (Abd El-Hack *et al*., 2018; Hermes *et al*., 2009; Seidavi *et al*., 2020). The aim of our current study was to investigate the impact of *Bacillus* probiotics, coconut oil and *Nigella sativa* oil on productive parameters and economic indicators and carcass characteristics of broiler chickens.

ISSN: 2090-6277/2090-6269/

MATERIALS AND METHODS

Ethical Approval

The experimental design and procedure presented in this work are reviewed and approved by the Institutional Animal Care and Use Committee of Alexandria University (Approval number:2023/013/215).

Source of natural feed additives which utilized in this experiment

The final product of probiotic mixture was provided by the Animal Health Research Institute, Kafr El-Sheikh Governorate, Egypt, containing *B. subtilis* and *B. licheniformis* at least 1×1011 CFU/g. Cold-pressed oil (Virgin Coconut oil (VCO), *Nigella sativa* oil (NSO) were purchased from National Research Centre in Cairo, Egypt.

Experimental design and management

The present experiment was carried out at Faculty of Veterinary Medicine, Alexandria University, Egypt. A total of 140 one-day old broiler chicks (Cobb 500) having nearly similar mean initial body weight, were obtained from EL-Wataniya Company. Randomly, the chicks were allocated to four treatments with 5 replicates, 7 chicks per each. The vaccination program was according to the followed routine in the region of experiment. Experimental birds were raised in the floor on wood shaving litter, provided adequate ventilation, proper temperature and exact humidity. The length duration of experiment continuously has been offered clean water and the feed was added in appropriate amount. Gradually, the temperature was reduced from 33°C on the 1st day to 25°C on day 21, then remained constant until the trial ending. The followed lighting program for each treatment was: continuous light through the 1st three days then from the 4th day to 8th day was 23 hour while from the 8th to 14th day was 20 hour and from the 14th to 28th day was 16 hour and the end of experiment from days 28 to 38 was 18 hour.

Experimental diets and feeding

A 3-phase feeding programme was used as illustrated in Table (1), with a starter diet from day 1 to 18 then a grower diet from day 19 to 28 and a finisher diet from day 29 to 38. All diets were formulated according to recommended nutrient levels of Cobb500 broiler strain. However, for this research four rations were used. (T1) basal diet, (T2) basal diet + coconut oil (CO) at 10 $ml.kg^{-1}$ of feed (Oyebanji *et al.*, 2020; Yuniwarti *et al.*, 2013). (T3) basal diet + *Nigella sativa* oil (NSO) at 1 $ml.kg^{-1}$ of feed (Erener *et al.*, 2010). (T4) basal diet + *Bacillus* probiotics at $1g.kg^{-1}$of feed.

Data and variables

Measuring the chicks' weights at the 1st day (initial body weight) then, Body weights (BW) were obtained at days 7, 14, 21, 28, 35, 38 of age by weighting birds individually every week. Feed intake (FI), body weight gain (BWG), FCR (Feed intake (g) / weight gain (g)) and final body weight (FBW) were measured (Śliżewska *et al.*, 2020). Economic analysis through calculation of the total variable costs (TVC) which included feed costs, feed additive costs, chick costs, and managemental costs (litter, energy, disinfectants, vaccine cost and others). Total Fixed costs (TFC)= (building depreciation + equipment dep.). Total costs (TC) = TVC+TFC. Total revenue (TR) from sales of broilers at the of experiment + litter sale. Net profit (NP) = TR – TC. Economic efficiency measures included Benefit Cost Ratio (BCR) = (Total Return /Total cost) x 100 (Pishgar-Komleh *et al.*, 2017), Profitability index = (Net Profit / Total return) x 100 (Rubina Bano *et al.*, 2011), Net Profit/total cost = (NP / TC) x 100, Additive cost / TC (%) (Hassan and El-Ktany, 2020), European Efficiency Production Factor (EEPF)= (average BW*livability%)/(FCR*age (days))*100 (Marcu *et al.*, 2013; Śliżewska *et al.*, 2020; Zaghari *et al.*, 2020; Zhang *et al.*, 2021).

Table 1. Ingredient composition and calculated chemical analysis of the basal diets.

Ingredients	Starter (1–18 d)	Grower (19–28 d)	Finisher (29–38 d)
Yellow corn	57.55	63.85	68.25
Soya bean meal (46%)	32	28	24
Corn gluten (62%)	5	2.5	2
Vegetable oil	1.5	1.8	2
MCP	1.35	1.3	1.2
limestone	1.6	1.55	1.55
Lysine	0.15	0.2	0.2
Dl- Methionine	0.15	0.1	0.1
Choline chloride	0.1	0.1	0.1
Salt	0.25	0.25	0.25
Vitamin premix	0.15	0.15	0.15
Mineral premix	0.15	0..15	0.15
Mycotoxin binder	0.05	0.05	0.05
Calculated analysis			
Crude protein	22.94	20.1	18.32
ME (kcal/kg)	2974	3030	3088
Calcium (%)	0.95	0.90	0.87
Available phosphorus (%)	0.42	0.40	0.37
Methionine (%)	0.52	0.42	0.40
Methionine + Cystine (%)	0.89	0.75	0.7
Lysine (%)	1.18	1.10	1
Na (%)	0.16	0.16	0.16
Chloride (%)	0.19	0.19	0.19

Relative weight of inner organs

According to the average BW within the group at day 38, 5 birds from each experimental treatment were picked out, weighted individually, slaughtered then skin, head, and feathers were removed. Eviscerated to evaluate carcass weight. Subsequently, the inner organs (liver, gall bladder, heart, gizzard, proventricular, abdominal fat, bursa of Fabricius, thymus, spleen) were collected and weighed for each treatment. The organ weights were expressed as a percentage of live body weight.

Statistical analysis

The experiment comprised of a complete randomized design with four treatments. The model was:

$X_{ij}=M+T_i+E_{ij}$ where, X_{ij}=observations, M=treatment average, T_i=effect of treatment, E_{ij}=error

All data were exhibited as the mean with pooled standard error (SE) values. Statistical analyses were done by SPSS/PC+ "version 25". One-way ANOVA followed by The Duncan's multiple range test to evaluate the differences (P≤0.05) among different treatment means.

RESULTS

As shown in Table 2, there were significant differences (P≤0.05) in FI, BWG, FBW, and FCR among varied treated groups (T2, T3, T4) and untreated control group (T1). The lowest feed intake (FI) was noticed in T2 and T3 groups (3603.91, 3644.12g, respectively) while T4 and T1 (control) had the highest value of FI (3796.58, 3779.87g respectively). T2, T3, T4 showed highly significant (P≤0.05) increases in BWG and FBW traits in comparison with T1. Broilers fed diet containing 1% CO, 0.1% BCO and 1g *Bacillus* probiotics recorded higher BWG (2357.11g, 2242.29g, 2184.77g respectively) than those without any additive (control) (1937.91g). Additionally, the highest FBW was noticed for coconut oil (T2) followed by black cumin oil (T3) and *Bacillus* probiotics (T4) then control (T1) (2404g, 2289.29g, 2232.57g, 1984g respectively). Concerning FCR, the birds fed coconut oil diet (T2) had the lowest value (1.53) followed by BCO (T3) diet (1.63) then probiotics mixture (T4) (1.74) while untreated control group(T1) showed the highest (1.95) FCR.

The observed data in Table 3 revealed a significant variation at (P≤0.05) among different experimental treatments on economic efficiency indicators. Feed cost was scored the largest value in T4 and T1 (68.40, 68.04 EGP respectively). While TC, TVC, TR, NP, T1 and T4 obtained low average value compared to T2 and T3. However, the average percentage value of (NP/TC) and profitability index (NP/TR) was the greatest in T2 and T3 groups (30.93%, 26.28%, 23.62%, 20.81% respectively). In addition, results pointed out that the highest value of BCR and EEPF scored in T2 and T3 groups (1.31, 1.26, 412.8, 369.71 respectively).

Results in Table 4 expounded a significant variation (P≤0.05) among different groups on dressing percent. The highest percent was recorded in T3 followed by T2 then T4 (73.5, 72.05, 69.08% respectively) compared to T1 (68.20 %). As well, we observed significant differences (P≤0.05) on relative weight of heart and proventriculus, whereas T4 and T1 had registered superior value (0.56, 0.48, 0.58, 0.44% respectively) than T2 and T3 (0.51, 0.38, 0.45, 0.39 % respectively). Moreover, T4 has the greater average relative weight of thymus and spleen (0.54, 0.15% respectively) than other treated groups (T1, T2, T3).

DISCUSSION

As explicated in Table 2, the feed consumption in broilers supplemented with 1% coconut oil (T2) decreased and this may be back to the fact that coconut oil is plentiful with medium chain fatty acids (MCFs) which give more energy, consequently decreasing feed consumption. This finding is supported by Londok and Rompis (2019) who reported that amount of feed intake would be determined by energy content in the diet whereas birds would be raising their consumption if the standard of metabolic energy in the diet is low. As well, in accordance with the above findings, several research studies (Veras *et al*., 2019; Pehowich *et al*., 2000; Dong and Van Thu 2021) lighted that feeding coconut oil was associated with lower feed consumption. While Khatibjoo *et al*. (2018); Wang *et al*. (2015); Yuniwarti *et al*. (2013); and Zimboran *et al*. (2021) noticed that there was no significant difference on feed consumption. In contrast with our finding, Müller *et al*. (2011) and Oyebanji *et al*. (2020) concluded that coconut oil improved feed consumption because of dietary fat decreased the digesta passage rate through the gastrointestinal trait. Also

Table 2. Effect of different dietary treatments on growth traits of broiler chickens (Means±SE).

Traits	Treatment			
	T1	T2	T3	T4
IBW	46.66±0.4[a]	46.89±0.37[a]	47.00±0.35[a]	47.30 ±0.44[a]
FI	3779.87±0.89[b]	3603.91±0.72[d]	3644.12±0.79[c]	3796.58±0.80[a]
BWG	1937.91±50.05[c]	2357.11±26[a]	2242.29±34.54[b]	2184.77±34.54[b]
FBW	1984.57±50.1[c]	2404.00±25.9[a]	2289.29±34.6[b]	2232.57±34.6[b]
FCR	1.95±0.07[a]	1.53±0.02[d]	1.63±0.03[c]	1.74±0.03[b]

Means with different superscripts in the same row differ significantly (P≤0.05). IBW: Initial body weight (g); FBW: Final body weight (g); FI: Feed intake (g); BWG: Body weight gain (g); FCR: Feed Conversion Ratio (g feed/g body wt. gain).

Table 3. Effect of various dietary treatments on economic efficiency indicators (Means±SE).

Traits	Treatment			
	T1	T2	T3	T4
Feed cost	68.04±0.01[a]	64.8±0.01[c]	65.52±0.01[b]	68.40±0.06[a]
Additive cost	0.000[d]	7.21±0.007[a]	5.47±0.004[b]	1.90±0.001[c]
Chick cost	3.5	3.5	3.5	3.5
Management costs	4.75	4.75	4.75	4.75
TVC	76.29±0.01[d]	80.26±0.01[a]	79.24±0.01[b]	78.55±0.01[c]
TC	76.82 ±0.01[d]	80.79 ±0.01[a]	79.77 ±0.01[b]	79.08±0.01[c]
TR	89.62±1.57[c]	105.78±1.14[a]	100.73±1.52[b]	98.23±1.52[b]
NP	12.80±1.46[d]	24.99 ±1.14[a]	20.96 ±1.52[b]	19.15 ±1.52[c]
BCR (TR/TC)	1.17 ±0.02[c]	1.31±0.01[a]	1.26±0.02[ab]	1.24±0.02[b]
(NP/TC) (%)	16.66±1.89[c]	30.93±1.41[a]	26.28±1.91[ab]	24.22±1.93[b]
Profitability index (NP/TR) (%)	14.28±1.43[c]	23.62±0.78[a]	20.81±1.15[ab]	19.50±1.19[b]
Additive cost /TC (%)	0.000[d]	8.92±0.002[a]	6.85±0.0001[b]	2.40±0.0004[c]
EEPF	267.21±12.61[d]	412.8±9.34[a]	369.71±11.67[b]	337.27±10.97[c]

Means with different superscripts in the same row differ significantly at (P≤0.05), BCR): Benefit cost ratio, (EEPF): European Efficiency Production Factor; (TC): Total cost; (TVC): Total variable cost; (TR): Total return; (NP): Net profit.

Abd El-Hack *et al.* (2015) showed that diet with cold oils would be improving feed consumption due to the enhancing the palatability. As for our finding of black cumin oil (BCO) supplemented group (T3), this could be related to the taste of BCO which is bitter so decreasing feed consumption. The present result are inconsistent with Erener *et al.* (2010) who demonstrated that feed consumption increased in BCO compared to control group, also disagree with Seidavi *et al.* (2021). As well, Abd El-Hack *et al.* (2018) showed that the superior feed consumption was noted in the group that received 1.0 g *Nigella sativa* oil/kg diet. Conversely, Attia and Al-Harthi, (2015) noticed that feed consumption was not significantly affected by black cumin extract levels. The finding about increasing feed consumption in the group fed diet containing *Bacillus* probiotics ((*B. subtilis* and *B. licheniformis*) due to improve appetite. The findings are in contrast with Biswas *et al.* (2022); Park *et al.* (2018); Zhang *et al.* (2021); and Zhang *et al.* (2013) who depicted that no significant differences between negative control group and *Bacillus subtilis* supplemented group. Our results agree with previous investigation of Flores *et al.* (2019) who showed that *Bacillus* probiotics increased feed intake.

With reference to our result about FBW and BWG that T2, T3 and T4 attained larger values than T1. This could be in T2 due to coconut oil is rich with medium chain fatty acids (MCFAs) especially lauric acid (LA) which increase digestive enzymes and bile secretion so improves digestion in addition to its anti-inflammatory and antimicrobial effect consequently reduces the incidence and harmful effects of coccidiosis and clostridiosis which directly affect the utilization, absorption and conversion of feed to meat. Similar findings were investigated by other studies (Yuniwarti *et al.*, 2013; Oyebanji *et al.*, 2020; Dong and Van Thu 2021; Wu *et al.*, 2021), which displayed that treatment with coconut oil and lauric acid supplement was more effective than untreated control group because of lauric acid stimulates growth of broilers by altering intestinal microbiota, inhibition of inflammation, and modulation of fat metabolism, so lauric acid could be used as an antibiotic substitution in poultry feed. Also previous studies agree with our findings (Dayrit 2015; Peedikayil *et al.*, 2015; Abbas *et al.*, 2017; Nasir *et al.*, 2018; Joshi *et al.*, 2020). Along the same line, Çenesiz and Çiftci (2020) highlighted that medium chain fatty acids (MCFAs) improved body weight gain by an average of 4% due to the generation of more stable and healthy gut microbiota. Additionally, Decuypere and Dierick (2007); Lee *et al.* (2015) Baltić *et al.* (2017); Hovorková *et al.* (2018) and Nguyen *et al.* (2018) clarified that medium chain fatty acids have antibacterial, anticoccidial and antiviral effects. This is in contrast to what was reported by Wang *et al.* (2015) who proposed that addition of coconut oil had no impact on body weight gain. As well contrary with our result, Khatibjoo *et al.* (2018) postulated that supplementing of medium chain fatty acids positively reduced broiler meat. While in T3, this might be attributed to the presence of high level of phenolic compounds, many essential unsaturated fatty acids such as oleic, linolic and linoleic acids. The main active component in phenolic compounds is thymoquinone which has a positive influence on thyroid gland hormones also inducing greater secretion of bile and digestive enzymes. The result of the current trial is consistent the previous studies (Kiralan *et al.*, 2014; Mohammed *et al.*, 2016) which confirmed that nigella seed oil (NSO) has high levels of polyphenols, in addition Mazaheri *et al.* (2019) and Seidavi *et al.* (2021) stated that NSO contains phenolic compounds, unsaturated fatty acids, thymoquinone and P-cymenes. Moreover, in accordance with the obtained findings, Starčević *et al.* (2015); Tufarelli *et al.* (2017) and Mahfuz *et al.* (2021) expounded that phenolic or polyphenols compounds has impact as antimicrobial and antioxidants as well rising essential fatty acids, reducing level of cholesterol, have a positive effect on growth rate and used as natural supplements in diet. Our present result is in line with those stated by Abd El-Hack *et al.* (2018) who documented that the biggest weight gain were in supplemented feed with BCO compared with the control group due to BCO stimulate the secretion of growth and thyroxine hormones. Furthermore other observations conducted by Hermes *et al.* (2009) and Erener *et al.* (2010) inconsistent with our findings. Interestingly in other studies by Bourgou *et al.* (2010) who clarified that black cumin oil contains thymoquinone which acts as active principal and responsible for antibacterial activity against pathogenic bacteria. As for our observation about supplemented group with probiotic inclusion (*B. subtilis* and *B. licheniformis*) (T4), This might be due to their effect on improving the digestibility and increasing the absorption of nutrients and reducing the pathogenic bacteria. The results are inconsistent with Biswas *et al.* (2022) who noted that during starter, growing and finisher stages there was linearly ($p < 0.05$) increasing in broiler weight gain. Further our results agree with prior investigations of Molnár *et al.* (2011); Bader *et al.* (2012); Liu *et al.* (2012); Zhang *et al.* (2012); Zhang *et al.* (2013); Mingmongkolchai and Panbangred (2018); Nguyen *et al.* (2018); Park *et al.* (2018); Arif *et al.* (2021) and Zhang *et al.* (2021) who deduced that *Bacillus* probiotic has a powerful effect on pathogenic bacteria such as *Clostridium perfringens*, so reducing necrotizing enteritis, *E. coli* and *Salmonella* and have a positive impact on digestion and absorption of feed. Likewise Aliakbarpour *et al.* (2012) cleared that probiotics supplemented group got better final body weight than untreated control group. It is worth noting that Chang and Yu (2022); Musa *et al.* (2019) and Xu *et al.* (2021) reported that *Bacillus* probiotics improved digestion by increasing short chain fatty acids which degrade and release butyric acid thus decreasing the gastric pH and also raising the intestinal villi height consequently improving absorption

Our explanation about the finding of FCR among different dietary treatment, we observed that lower values were recorded

Table 4. Effect of dietary treatments on relative weights of carcass, inner organs, immune organs (Means±SE).

Items	Treatment			
	T1	T2	T3	T4
Live BW (g)	2088±112.17^{a}	2273±134.19^{a}	2361±86.23^{a}	2137±133.56^{a}
Carcass weight (g)	1430±104.02^{a}	1643±118.65^{a}	1741±101.84^{a}	1478±99.68^{a}
Dressed percent (%)	68.49±1.4 ^{b}	72.28±1.21^{ab}	73.74±1.72 ^{a}	69.1±0.69^{b}
Liver (%)	2.46±0.09^{a}	2.02±0.10^{a}	2.18±0.07^{a}	2.40±0.22^{a}
Gall bladder (%)	0.12±0.01^{a}	0.11±0.02^{a}	0.09±0.03^{a}	0.11±0.02^{a}
Heart (%)	0.58±0.03^{a}	0.51±0.02^{ab}	0.45±0.04^{b}	0.56±0.03^{a}
Gizzard (%)	2.02±0.04^{a}	1.96±0.12^{a}	1.92±0.08^{a}	2.03±0.04^{a}
Proventriculus (%)	0.44±0.02^{ab}	0.38±0.02^{b}	0.39±0.02^{b}	0.48±0.04^{a}
Abdominal fat (%)	44±4.77a	48.2±4.54a	40±1.82a	45±5.36a
Thymus (%)	0.26±0.06^{b}	0.29±0.04^{b}	0.20±0.04^{b}	0.54±0.02^{a}
Bursa of Fabricius (%)	0.15±0.02^{a}	0.13±0.01^{a}	0.13±0.01^{a}	0.13±0.03^{a}
Spleen (%)	0.11±0.01^{b}	0.11±0.01^{b}	0.10±0.01^{b}	0.15±0.01^{a}

Means with different superscripts in the same row differ significantly at ($P \leq 0.05$).

in T2 and T3 then T4. This effect may be in T2 caused by active component in coconut oil (MCFAs and LA-enriched) and in T3 may be attributed to the biological content of BCO, while *Bacillus* probiotics (T4) increased the beneficial bacteria, decreased the pathogenic bacteria and thus improved the digestion by raising digestive enzymes. These obtained results are in agreement with Çenesiz and Çiftci (2020); Dong and Van Thu (2021); Oyebanji *et al.* (2020) and Wu *et al.* (2021). Also Hovorková *et al.* (2018) and Nguyen *et al.* (2018) who stated that the predominant fatty acid in coconut oil is lauric acid which represented (42%). This finding was however disagree with the results of Khatibjoo *et al.* (2018) and Veras *et al.* (2019) who noticed no significant effect on FCR. Furthermore, previous studies (Abd El-Hack *et al*., 2018; Erener *et al*., 2010; Hermes *et al*., 2009) elucidated that nigella seed oil recorded low feed conversion ratio. On the contrary Attia and Al-Harthi (2015) concluded that BCO has no significant impact on FCR. On other the hand, the obtained result about *Bacillus* probiotics are consistent with the findings of Molnár *et al.* (2011); Aliakbarpour *et al.* (2012) ; Nguyen *et al.* (2015); Li *et al.* (2016); Flores *et al.* (2019); Zhang *et al.* (2021) and Biswas *et al.* (2022) who reported that *Bacillus* based probiotics improved feed conversion ratio. This is in contrast to what was reported from other research (Park *et al*., 2018) with no significant effect on FCR.

As illustrated in Table 3, treatment supplemented with CO and BCO obtained higher average value compared with *Bacillus* probiotics and untreated control group. Our commentary about the result that coconut oil (CO) and black cumin oil (BCO) were the highest in FBW and BWG so achieving the highest TR and NP, at the same time they were the largest in cost of feed and additives consequently they got the highest TVC and TC. In addition, the average value of net profit to total cost and net profit to total return have a significant difference among different treatments. We found that coconut oil and black cumin oil-based diet have higher value than *Bacillus* probiotics-based diet and untreated control because of coconut oil recorded the best body weight gain as for probiotics was the minimal value in feed cost (lowest total cost). Consistent with the present results Zaghari *et al.* (2020) and Zhang *et al.* (2021) found that NP/TC and EEPF were in broilers fed diet containing *Bacillus* probiotics better than control group. Also, the percent of additive cost from TC was higher in diet supplemented with CO than other dietary treatment due to the high cost for coconut oil. As for BCR, EPEF, some studies agree with this study (Ghazal *et al*., 2014; Veras *et al*., 2019) who indicated that the largest economic efficiency was in the treated group with 1% coconut oil. Moreover, inconsistent with our findings, Hassan (2018) assured that black cumin seed improved economic efficiency.

Table 4 represented the effect of various dietary treatments on relative weight of carcass traits, inner organs and immune organs The highest dressing percent was for BCO group, this might be due to the inner organs and abdominal fat relative weight of broilers supplemented diet with BCO were the lowest percent among other dietary treatment. In line with our result, Erener *et al.* (2010) demonstrated a useful effect on carcass weight in broiler fed diet provided with *Nigella sativa* oil (BCO) with no significant impacts on edible inner organs, abdominal fat. While, un-supplemented control group (T1) and *Bacillus* probiotics group (T4) scored the maximal average value in heart and proventriculus relative weight and the minimal average value was in T2 and T3 groups. These result disagree with the finding of Oyebanji *et al.* (2020) who interpreted that coconut oil based diet obtained a greater liver, heart and gizzard relative weight than control group. As well as Veras *et al.* (2019) who indicated that broilers fed diet containing 1% coconut oil acquired higher heart and gizzard weight than control group. In addition, a previous study (Çenesiz and Çiftci, 2020) indicated that medium chain fatty acids can decrease abdominal fat by up to 30% in broiler chickens. While some of the obtained findings agree with Khatibjoo *et al.* (2018) who documented that there were no significant impact in carcass traits between control and coconut oil based diet. Furthermore, the finding of the current study in contrast with Abd El-Hack *et al.* (2018) and Hermes *et al.* (2009) who explicated that the majority of carcass traits involving (carcass, liver, heart) were maximized by birds provided with feed containing *Nigella sativa* oil. With regard to broilers provided with feed containing *Bacillus* probiotics, our result was however in contrast to the observations of Flores *et al.* (2019) who noticed that increasing carcass weight compared to untreated control group. In addition to Zhang *et al.* (2013) who reported that liver relative weight was not impacted by *Bacillus* probiotics and also Molnár *et al.* (2011) expounded that carcass weight was reduced in dietary supplementation with *Bacillus subtilis*.

The current study revealed that broilers fed supplemented diet with *Bacillus* probiotics have greater average relative weight of thymus and spleen than control and other treated groups (CO, BCO). This possibly may be due to probiotics have a direct effect on immune cells and stimulate proliferation of cells in thymus and spleen. These results are in accordance with the investigations of Zhang *et al.* (2012) who declared that diet containing *Bacillus subtilis* increased spleen relative weight. As well as Zhang *et al.* (2013) who observed that supplementation of diet with *Bacillus subtilis* attained 30.9% higher relative weight of thymus than untreated groups, however probiotic had supplemented diet no effect on bursa and spleen relative weight. In addition, Biswas *et al.* (2022) concluded that bursa weight was minimized by supplementing the broiler diet with *Bacillus* probiotic.

Further, some previous studies agree with our finding (Khatibjoo *et al*., 2018; Oyebanji *et al*., 2020) that no significant impact from coconut oil based diet on bursa weight, but didn't support our finding about the significant variation in spleen and thymus weight. Our results agree with previous work of Khan *et al.* (2012) and Toghyani *et al.* (2010) who explicated that weight of immune organs affected with addition of black cumin seed (BCS) in diet and excessed their weight compared with control group. On the contrary Al-Mufarrej (2014) displayed no significant effect from *Nigella sativa* seed on weight of spleen and thymus. Additionally Salam *et al.* (2013) concluded that black cumin seed increased relative weight of spleen with no effect on thymus and bursa relative weight.

CONCLUSION

Dietary supplementations with CO, NSO and probiotics mixture improve productive performance (FBW, BWG, FCR), also have effective impact on economic efficiency measures (EPEF, BCR, profitability index) and carcass characteristics of broilers. Diet supplemented with coconut oil achieve the best productive and economic efficiency. Moreover, *Bacillus* probiotics give satisfactory results, and the same time is the lowest additive cost. Thus, these dietary treatments recommended to be used as feed supplements in poultry diet.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abbas, A.A., Assikong, E.B., Akeh, M., Upla, P.,Tuluma, T., 2017. Antimicrobial activity of coconut oil and its derivative (lauric acid) on some selected clinical isolates. Int. J. Med. Sci. Clin. Invent. 4, 3173-3177.

Abd El-Hack, M.E., Mahgoub, S.A., Alagawany, M., Dhama, K., 2015. Influences of dietary supplementation of antimicrobial cold pressed oils mixture on growth performance and intestinal microflora of growing Japanese quails. International Journal of Pharmacology 11, 689-696. doi:10.3923/ijp.2015.689.696

Abd El-Hack, M.E., Mahgoub, S.A., Hussein, M.M.A., Saadeldin, I.M., 2018. Improving growth performance and health status of meat-type quail by supplementing the diet with black cumin cold-pressed oil as a natural alternative for antibiotics. Environmental Science and Pollution Research 25, 1157-1167. doi: https://doi.org/10.1007/s11356-017-0514-0

Abdurofi, I., Ismail, M.M., Kamal, H.A.W., Gabdo, B.H., 2017. Economic analysis of broiler production in Peninsular Malaysia. International Food Research Journal 24, 761-766.

Al-Mufarrej, S.I., 2014. Immune-responsiveness and performance of broiler chickens fed black cumin (*Nigella sativa* L.) powder. Journal of the Saudi Society of Agricultural Sciences 13, 75-80. doi:https://doi.org/10.1016/j.jssas.2013.01.006

Aliakbarpour, H., Chamani, M., Rahimi, G., Sadeghi, A., Qujeq, D., 2012. The *Bacillus subtilis* and lactic acid bacteria probiotics influences intestinal mucin gene expression, histomorphology and growth performance in broilers. Asian-Australasian Journal of Animal Sciences 25, 1285. doi: 10.5713/ajas.2012.12110

Attia, Y. A., Al-Harthi, M., 2015. *Nigella* seed oil as an alternative to antibiotic growth promoters for broiler chickens. Europ. Poult. Sci. 79, 10.1399.

Bader, J., Albin, A., Stahl, U., 2012. Spore-forming bacteria and their utilisation as probiotics. Beneficial Microbes 3, 67-75.

Baltić, B., Starčević, M., Đorđević, J., Mrdović, B., Marković, R., 2017. Importance of medium chain fatty acids in animal nutrition. Paper presented at the IOP Conference Series: Earth and Environmental Science.

Biswas, S., Kim, M.H., Baek, D.H., Kim, I.H., 2022. Probiotic mixture (*Bacillus subtilis* and *Bacillus licheniformis*) a potential in-feed additive to improve broiler production efficiency, nutrient digestibility, caecal microflora, meat quality and to diminish hazardous odour emission. Journal of Animal Physiology and Animal Nutrition 107, 1065-1072. doi: https://doi.org/10.1111/jpn.13784.

Bourgou, S., Pichette, A., Marzouk, B., Legault, J., 2010. Bioactivities of black cumin essential oil and its main terpenes from Tunisia. South African Journal of Botany 76, 210-216. https://doi.org/10.1016/j.sajb.2009.10.009

CAMPAS., 2019. Annual bulletin of statistics production in 2017. Central Agency for Public Mobiliztion and Statistics.Ref No 71-22112-2017.

Castanon, J., 2007. History of the use of antibiotic as growth promoters in European poultry feeds. Poultry Science 86, 2466-2471.

Çenesiz, A., Çiftci, I., 2020. Modulatory effects of medium chain fatty acids in poultry nutrition and health. World's Poultry Science Journal 76, 234-248. doi: https://doi.org/10.1080/00439339.2020.1739595.

Cheng, G., Hao, H., Xie, S., Wang, X., Dai, M., Huang, L., Yuan, Z., 2014. Antibiotic alternatives: the substitution of antibiotics in animal husbandry? Frontiers in Microbiology 5, 217. doi: https://doi.org/10.3389/fmicb.2014.00217

Côté, H., Pichette, A., St-Gelais, A., Legault, J., 2021. The Biological Activity of Monarda didyma L. Essential Oil and Its Effect as a Diet Supplement in Mice and Broiler Chicken. Molecules 26, 3368. doi: https://doi.org/10.3390/molecules26113368

Dayrit, F.M., 2015. The properties of lauric acid and their significance in coconut oil. Journal of the American Oil Chemists' Society 92, 1-15.

Decuypere, J.A., Dierick, N.A., 2007. The combined use of triacylglycerols containing medium-chain fatty acids and exogenous lipolytic enzymes as an alternative to in-feed antibiotics in piglets: concept, possibilities and limitations. An overview. Nutrition Research Reviews 16, 193-210. doi:10.1079/NRR200369

Dong, N.T.K., Van Thu, N., 2021. Effects of dietary supplementation levels of coconut oil in crossbred Noi chicken on nutrient intake, growth performance, carcass values. Livestock Research for Rural Development, 33(5). http://www.lrrd.org/lrrd33/5/3363ntkdn.html

Erener, G., Altop, A., Ocak, N., Aksoy, H., Cankaya, S., Ozturk, E., 2010. Influence of black cumin seed (*Nigella sativa* L.) and seed extract on broilers performance and total coliform bacteria count. Asian Journal of Animal and Veterinary Advances 5, 128-135.

European Commission, 2016. Safety and efficacy of *Bacillus subtilis* DSM 28343 as a feed additive for chickens for fattening. EFSA Journal 14, e04507. doi: https://doi.org/10.2903/j.efsa.2016.4507

Flores, C.A., Duong, T., Augspurger, N., Lee, J.T., 2019. Efficacy of *Bacillus subtilis* administered as a direct-fed microorganism in comparison to an antibiotic growth promoter and in diets with low and high DDGS inclusion levels in broiler chickens. Journal of Applied Poultry Research 28, 902-911. doi:https://doi.org/10.3382/japr/pfz048

Ghazal, M., Morsy, W., Ramadan, N., Ali, W., 2014. Effect of different dietary levels of coconut oil as a source of medium chain fatty acids on some production and physiological traits of growing rabbits. Egyptian Journal of Rabbit Science 24, 67-88.

Hassan, S., El-Ktany, E., 2020. Effect of hot red pepper oil on the productivity, carcass characteristics and economic efficiency of broiler chickens. Journal of Animal Health and Production 9, 128-134.

Hassan, S.S., 2018. Effect of *Nigella sativa* seeds on growth performance, carcass traits and economic efficiency of broiler chicks under Egyptian condition. Egyptian Poultry Science Journal 38, 331-344.

Hermes, I., Attia, F.A., Ibrahim, K., El-Nesr, S., 2009. Effect of dietary *Nigella sativa* L. on productive performance and nutrients utilization of broiler chicks raised under summer conditions of Egypt. Egyptian Poultry Science Journal 29, 145-172.

Hovorková, P., Laloučková, K., Skřivanová, E., 2018. Determination of in vitro antibacterial activity of plant oils containing medium-chain fatty acids against gram-positive pathogenic and gut commensal bacteria. Czech Journal of Animal Science 63, 119-125.

Joshi, S., Kaushik, V., Gode, V., Mhaskar, S., 2020. Coconut Oil and Immunity: What do we really know about it so far. J. Assoc. Physicians India 68, 67-72.

Khan, S.H., Ansari, J., Haq, A., Abbas, G., 2012. Black cumin seeds as phytogenic product in broiler diets and its effects on performance, blood constituents, immunity and caecal microbial population. Italian Journal of Animal Science 11, e77. doi:10.4081/ijas.2012.e77

Khatibjoo, A., Mahmoodi, M., Fattahnia, F., Akbari-Gharaei, M., Shokri, A.-N., Soltani, S., 2018. Effects of dietary short-and medium-chain fatty acids on performance, carcass traits, jejunum morphology, and serum parameters of broiler chickens. Journal of Applied Animal Research 46, 492-498.

Lee, S.I., Kim, H.S., Kim, I., 2015. Microencapsulated organic acid blend with MCFAs can be used as analternative to antibiotics for laying hens. Turkish Journal of Veterinary & Animal Sciences 39, 520-527.

Li, Y., Xu, Q., Huang, Z., Lv, L., Liu, X., Yin, C., Yuan, J., 2016. Effect of *Bacillus subtilis* CGMCC 1.1086 on the growth performance and intestinal microbiota of broilers. Journal of Applied Microbiology 120, 195-204.

Londok, J., Rompis, J., 2019. Supplementation of lauric acid and feed fiber to optimize the performance of broiler. Paper presented at the IOP Conference Series: Earth and Environmental Science.

Marcu, A., Vacaru-Opriş, I., Dumitrescu, G., Ciochina, L.P., Marcu, A., Nicula, M., Kelciov, B., 2013. The influence of the genotype on economic efficiency of broiler chickens growth. Scientific Papers Animal Science and Biotechnologies 46, 339-346.

Maria Cardinal, K., Kipper, M., Andretta, I., Machado Leal Ribeiro, A., 2019. Withdrawal of antibiotic growth promoters from broiler diets: performance indexes and economic impact. Poultry Science 98, 6659-6667. doi:https://doi.org/10.3382/ps/pez536

Mingmongkolchai, S., Panbangred, W., 2018. *Bacillus* probiotics: an alternative to antibiotics for livestock production. Journal of Applied Microbiology 124, 1334-1346. doi:10.1111/jam.13690

Molnár, A., Podmaniczky, B., Kürti, P., Tenk, I., Glávits, R., Virág, G., Szabó, Z., 2011. Effect of different concentrations of *Bacillus subtilis* on growth performance, carcase quality, gut microflora and immune response of broiler chickens. British Poultry Science 52, 658-665.

Müller, C., Jenni-Eiermann, S., Jenni, L., 2011. Heterophils/Lymphocytes-ratio and circulating corticosterone do not indicate the same stress imposed on Eurasian kestrel nestlings. Functional Ecology 25, 566-576.

Nasir, N.A.M.M., Abllah, Z., Jalaludin, A.A., Shahdan, I.A., Abd Manan, W.N.H.W., 2018. Virgin coconut oil and its antimicrobial properties against pathogenic microorganisms: a review. Paper presented at the International dental conference of sumatera utara 2017 (IDCSU 2017).

Nguyen, A.T.V., Nguyen, D.V., Tran, M.T., Nguyen, L.T., Nguyen, A.H., Phan, T.N., 2015. Isolation and characterization of *Bacillus subtilis* CH16 strain from chicken gastrointestinal tracts for use as a feed supplement to promote weight gain in broilers. Letters in Applied Microbiology 60, 580-588. doi:10.1111/lam.12411

Nguyen, D.H., Lee, K.Y., Mohammadigheisar, M., Kim, I.H., 2018. Evaluation of the blend of organic acids and medium-chain fatty acids in matrix coating as antibiotic growth promoter alternative on growth performance, nutrient digestibility, blood profiles, excreta microflora, and carcass quality in broilers. Poultry Science 97, 4351-4358. doi:https://doi.org/10.3382/ps/pey339

Oyebanji, B., Aderinoye, V., Adeniyi, A., Akinnadeju, O., 2020. Efects of Coconut Oil (*Cocos nucifera*), Avocado Oil (*Persea americana*), Melon Seed Oil (*Citrullus colocynthis* L.) on Growth Performance, Blood, Biochemical, Haematological Parameters, and Total Microbial Loads of Noiler Birds. FOLIA 64, 27-36.

Park, J., Yun, H., Kim, I., 2018. The effect of dietary *Bacillus subtilis* supplementation on the growth performance, blood profile, nutrient retention, and caecal microflora in broiler chickens. Journal of Applied Animal Research, 46, 868-872.

Peedikayil, F. C., Sreenivasan, P., Narayanan, A., 2015. Effect of coconut oil in plaque related gingivitis—A preliminary report. Nigerian med-

ical journal: journal of the Nigeria Medical Association 56, 143.
Pehowich, D., Gomes, A., Barnes, J., 2000. Fatty acid composition and possible health effects of coconut constituents. West Indian Medical Journal 49, 128-133.
Pishgar-Komleh, S. H., Akram, A., Keyhani, A., van Zelm, R., 2017. Life cycle energy use, costs, and greenhouse gas emission of broiler farms in different production systems in Iran—a case study of Alborz province. Environmental Science and Pollution Research 24, 16041-16049. doi:10.1007/s11356-017-9255-3.
Ravindran, V., 2013. Poultry feed availability and nutrition in developing countries. Poultry Development Review 2, 60-63.
Rubina Bano, H.S., Sharif, M., Akhtar, W., 2011. profitability index and capital turn over in open house broiler farming: a case study of district rawalpindi. Pakistan J. Agric. Res, 24, 1-4.
Salam, S., Sunarti, D., Isroli, I., 2013. Physiological responses of blood and immune organs of broiler chicken fed dietary black cumin powder (*Nigella sativa*) during dry seasons. Journal of the Indonesian Tropical Animal Agriculture 2013, 38, 185-191. doi:10.14710/jitaa.38.3.185-191
Sanders, M. E., Morelli, L., Tompkins, T., 2003. Sporeformers as human probiotics: *Bacillus*, *Sporolactobacillus*, and *Brevibacillus*. Comprehensive Reviews in Food Science and Food Safety 2, 101-110.
Seidavi, A., Laudadio, V., Khazaei, R., Puvača, N., Selvaggi, M., Tufarelli, V., 2020. Feeding of black cumin (*Nigella sativa* L.) and its effects on poultry production and health. World's Poultry Science Journal 76, 346-357.
Seidavi, A., Tavakoli, M., Slozhenkina, M., Gorlov, I., Hashem, N.M., Asroosh, F., Taha, A.E., Abd El-Hack, M.E., Swelum, A.A., 2021. The use of some plant-derived products as effective alternatives to antibiotic growth promoters in organic poultry production: a review. Environmental Science and Pollution Research 28, 47856-47868. doi:10.1007/s11356-021-15460-7
Śliżewska, K., Markowiak-Kopeć, P., Żbikowski, A., Szeleszczuk, P., 2020. The effect of synbiotic preparations on the intestinal microbiota and her metabolism in broiler chickens. Scientific Reports 10, 1-13.
Starčević, K., Krstulović, L., Brozić, D., Maurić, M., Stojević, Z., Mikulec, Ž., Mašek, T., 2015. Production performance, meat composition and oxidative susceptibility in broiler chicken fed with different phenolic compounds. Journal of the Science of Food and Agriculture, 95, 1172-1178.
Toghyani, M., Toghyani, M., Gheisari, A., Ghalamkari, G., Mohammadrezaei, M., 2010. Growth performance, serum biochemistry and blood hematology of broiler chicks fed different levels of black seed (*Nigella sativa*) and peppermint (*Mentha piperita*). Livestock Science 129, 173-178. doi:https://doi.org/10.1016/j.livsci.2010.01.021
Veras, A.G., Souza, J.G., Teixeira, E.N.M., Moreira, J.A., Marinho, A.L., Diógenes, G.V., Ferreira, L.H.G., Chemane, I.A., 2019. Canola and coconut oils in the feed of European quails (*Coturnix coturnix*). Revista Brasileira de Zootecnia 48.
Wang, J., Wang, X., Li, J., Chen, Y., Yang, W., Zhang, L., 2015. Effects of dietary coconut oil as a medium-chain fatty acid source on performance, carcass composition and serum lipids in male broilers. Asian-Australasian Journal of Animal Sciences 28, 223.
Wu, Y., Zhang, H., Zhang, R., Cao, G., Li, Q., Zhang, B.,Yang, C., 2021. Serum metabolome and gut microbiome alterations in broiler chickens supplemented with lauric acid. Poultry Science 100, 101315. doi:https://doi.org/10.1016/j.psj.2021.101315
Yuniwarti, E.Y.W., Asmara, W., Artama, W., Tabbu, C., 2013. Virgin coconut oil increases the productivity of broiler chicken post avian influenza vaccination. Animal Production 14(3).
Zaghari, M., Sarani, P., Hajati, H., 2020. Comparison of two probiotic preparations on growth performance, intestinal microbiota, nutrient digestibility and cytokine gene expression in broiler chickens. Journal of Applied Animal Research 48, 166-175. doi: https://doi.org/10.1080/09712119.2020.1754218
Zhang, S., Zhong, G., Shao, D., Wang, Q., Hu, Y., Wu, T., Shi, S., 2021. Dietary supplementation with *Bacillus subtilis* promotes growth performance of broilers by altering the dominant microbial community. Poultry Science 100, 100935. doi:https://doi.org/10.1016/j.psj.2020.12.032
Zhang, Z.F., Cho, J.H., Kim, I.H., 2013. Effects of *Bacillus subtilis* UBT-MO2 on growth performance, relative immune organ weight, gas concentration in excreta, and intestinal microbial shedding in broiler chickens. Livestock Science 155, 343-347. doi:https://doi.org/10.1016/j.livsci.2013.05.021
Zhang, Z.F., Zhou, T.X., Ao, X., Kim, I.H., 2012. Effects of β-glucan and *Bacillus subtilis* on growth performance, blood profiles, relative organ weight and meat quality in broilers fed maize–soybean meal based diets. Livestock Science 150, 419-424. doi:https://doi.org/10.1016/j.livsci.2012.10.003
Zimboran, A., Weber, M., Szabo, S., Szabo, R., Drobnyak, A., Erdelyi, M., 2021. Effect of different oils supplementation on broiler chicken performance. Animal Nutrition and Feed Technology 21, 205-211. doi:10.5958/0974-181X.2021.00017.2