Egyptian Journal of Rabbit Science, 31(1): 25- 56 (2021)

SYNERGIC EFFECT OF RAW OR EXTRACTED PHYTOGENIC WITH PREBIOTIC ON PRODUCTIVE AND PHYSIOLOGICAL TRAITS OF GROWING RABBITS

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ABSTRACT: *A total number of ninety mixed sex growing New Zealand White rabbits at age of 5 weeks and weighting 532 g were assigned randomly into six treatments 15 rabbits individual /each for 8 weeks to study the synergic effects of combining either turmeric (as raw single phytogenic source) or Biostrong®510 (as purified extracted mixed phytogenic source) with mannan oligosaccharides; MOS (as prebiotic) on rabbit productive and physiological performance. The rabbits fed basal diet as control (C) or with 0.3% turmeric (TU), 0.05% Bio-mos® (BM), 0.015% Biostrong® 510 (BS), 0.05% BM+ 0.3% TU (BM+TU) and 0.05% BM+0.015% BS (BM+BS).*

The results revealed that *increase body weight and body weight gain among all supplemented groups than control, the body weight gain significantly higher for groups fed BM+TU or BM+BS by 12.90 and 12.23%, respectively over control. Combining BM+TU or BM+BS significant increased dressing, total edible part and meat protein percentage and significant decreased feed conversion, meat cholesterol and meat triglyceride and improved relative economical efficiency for rabbits compared to control. The lowest significant value of meat malondialdehyde recorded by rabbit fed TU or BM+TU however, the highest significant value of meat glutathione peroxidase activity recorded by rabbits fed BM or BM+BS compared to control. All feed additives recorded significant reduction in pathogenic bacteria and significant increased in beneficial bacteria.*

Conclusively, *all feed additives were significantly improved the productive and physiological parameters for growing New Zealand white rabbits. Adding BM+TU or BM+BS to growing rabbit diets recorded significantly the best value of productive and physiological traits and the higher economical efficiency.*

Key word: *Rabbit, Turmeric, Bio-mos and Biostrong, productive, physiological.*

INTRODUCTION:

Numerous studies demonstrated that a great number of medical and aromatic herbs, as well as fruits and leaves of some berry plants biosynthesize phytochemicals possessing antioxidant activity and may be used as a natural source of free radical scavenging compounds (Sacchetti *et al*., 2005 and Yu *et al.*, 2005). Also, Abd El-Hakim *et al* (2009) have been used some plants as natural antioxidants in broiler diet to decrease the damage of protein by free radical and decrease the lost of protein in feces.

Turmeric *(Curcuma longa*) is phytogenic additives, rich in phenolic compounds called curcuminoids, which consists of three main components curcuminoids, curcumin, demethoxycurcumin, they are yellowish turmeric pigments and have antioxidative, anticarcinogenic, anti-inflammatory, antihepatotoxic and hypocholesterolemic activities (Nishiyama *et al*., 2005). Also, Al-Jaleel (2012) revealed that the inclusion of curcuma at the levels of 0.50% in the broiler diets improved body weight compared with other dietary groups fed 0, 0.25, 1 and 1.5% Curcuma longa. Also, *Curcuma longa* can inhibit the generation of reactive oxide species like superoxide anions. Turmeric has the ability to stop reactive oxidation that develops various pathological condition. It has the ability to control these diseases through its active antioxidant activity (Kelly *et al.*, 2001).

Biostrong®510 is a preparation of partially microencapsulated essential oils from thyme and star anise, dried herbs and dried spices (Aquilina 2016). Anise oil and anethole have a number of functional properties antibacterial, antifungal, antioxidant, stimulant, carminative and expectorant (Newall *et al.*, 1996). Also, thymol has capability to work as antispasmodic, antioxidant, antimicrobial, immunomodulatory, anticancer and anti-inflammatory agent by suppressing harmful compounds/free radicals from interacting with cellular biological compounds, ability to alter the gut microbiota, proven active ingredients that improve digestion, enhance metabolic function, and increase nutrient retention. So, Biostrong-510 optimizes performance, production and profitability. Moreover, Biostrong increased feed palatability and nutrient retention and decreased ammonia in growing turkeys resulted to better growth and feed consumption comparable with antibiotic feeds (Habibi *et al*., 2013).

Mannan-oligosaccharides (MOS) is one of the structural cell wall component of *sacchoromyces cerevisiae*. MOS is a natural alternative product for anti-bacterial growth factors, which is known for connecting pathogen microorganisms (*Salmonella Spp*. as well as *E. Coli*) and rendering them unable to attach to the gut

wall, preventing their stabilization and subsequent colonization and multiplication to disease-causing levels their toxins (Newman, 1994; Patterson & Burkholder, 2003, Spring *et al*., 2015). The MOS-protein conjugates are involved in interactions with the animal's immune system and can enhance immune system activity (Wismar *et al*., 2010; Che *et al.,* 2011) and it is thought that they play a role in antioxidant and antimutagenic defences (Krizkova *et al.,* 2006). Although mannose is the key for bacterial attachment, the complex α-1-3 and α-1-6 branched mannan oligosaccharides were found in the outer layer of yeast cell wall, more effective up to 37 times in binding *E. coli* than pure d-mannose (Firon *et al*., 1983). Muchmore *et al*. (1990) observed an inhibitory effect of MOS on lymphocyte function. Stimulation of the immune response is energetically costly and results in metabolic alterations that redistribute resources away from growth (Spurlock, 1997). However, Spring *et al.,* (2015) reviewed a lot of researches on applying MOS in poultry diets and improving the performance and immunity status, they showed little researches on rabbits and included good responses of performance, mortality. Bersenyi and Gippert (1995) reported an improvement in weight gain of weaned rabbits when fed MOS over a 6-week period.

Therefore, this study aimed to determine the effects of combining either turmeric (as raw single phytogenic source) or Biostrong 510 (as purified extracted mixed phytogenic product) with MOS (as prebiotic) in rabbit's diet.

MATERIALS AND METHODS

The study was carried out at Sakha Experimental station, Animal Production Research Institute, ARC, Ministry of Agriculture, Egypt.

Studied feed additives:

Turmeric powder has been brought from local market. the active substances of total Phenols and the total flavonoids content were determined according to Folin-Ciocalteu procedure (Zilic *et al*., 2012). whereas, turmeric essential oil fraction was listed according to Prakash *et al*., (2012). The active components were determined by GC analysis, which performed by using a Perkin Elmer Auto System XL equipped with flame ionization detector (FID). A fused silica capillary column HP-5 (60m x 0.32mm i.d.) was used. The oven temperature was maintained initially at 50°C and programmed from 50°C to 240°C at a rate of 3°C/min. Helium was used as the carrier gas, at flow rate 1.1 ml/min. The injector and detector temperatures were 250 and 250°C, respectively.

Biostrong® 510 (BS), is a mixture of some essential oil produced by Delacon, Austria each gram of it contains 40 mg anethol (from anise oil), 2 mg thymol (from thyme oil) and 4.4 mg saponins (from Quillaja bark powder). Its supplementation level is 150 g /ton diet according to the manufacturer.

Bio-Mos® (BM), is a source of mannan oligosaccharide (*Saccharomyces cerevisiae* cell wall) produced by Alltech Inc, USA each kilogram of product contains 56g MOS/kg of product.

***Experimental animal and management*:**

Ninety weaned mixed sex growing New Zealand White (NZW) rabbits aged 5 weeks in average weight about 532 g were equally and randomly divided into six groups, 15 rabbits /each. Rabbits were individually housed in wire cage and drinking water and diets were supplied *ad-libitum*. The first group was fed basal diet according to NRC (1977) recommendations, served as control group (C). While the other five groups were fed the same basal diet but supplemented with 0.3% turmeric (TU), 0.05% Bio-mos® (BM), 0.015% Biostrong ®510 (BS), 0.05 % Bio-mos and 0.3% turmeric (BM+TU) and, 0.3 % Bio-mos and 0.015 % Biostrong® 510 (BM+BS), respectively. Averages of ambient temperature was 30.23^{o}C and relative humidity 49.30% inside building were determined weekly. Fresh water was automatically available at all time by stainless steel nipples for each cage. The experimental rabbits were kept under the same managerial and hygienic conditions. Ingredients and the chemical composition of the basal experimental diet are shown in Table 1.

***Productive traits*:**

The individual weight gain (g/d) and feed intake (g/d) were recorded weekly for each rabbit during the growing period from 5 to 13 week. Feed conversion ratio (g/g) was calculated as a ratio of g weight gain /g feed intake.

Carcass traits:

At the end of the experiment 13 weeks of age, three growing rabbits from each experimental group were randomly taken for slaughter after being fasted for 12 hours to determined carcass characteristics according to Steven *et al*., (1981). After complete bleeding, the carcass, spleen, kidneys, liver and heart were weighted.

Table 1: Ingredients and chemical composition of the basal experimental diet.

Items	**% as feed**
Ingredients:	
Clover hay (12 % CP)	29.25
Wheat bran	15.15
Barley	23.00
Yellow corn	8.00
Soybean meal (44%)	18.00
Molasses	3.00
Di calcium phosphate	1.85
Calcium carbonate	1.05
Sodium chloride	0.35
Vitamins and minerals premix[1]	0.30
DL-Methionine	0.05
Total	**100.00**
Calculated chemical composition[2]	
Crude protein %	17.215
Digestible energy, kcal/kg	2512.10
Ether extract %	2.26
Crude fiber %	13.10
Calcium %	1.33
Total Phosphorus %	0.80
Na %	0.181
Lysine %	0.897
Methionine %	0.310
Methionine+ Cyctine %	0.595

[1] Mineral and vitamin mixture supplied per kg of diet: Vitamin A 60000 IU, Vitamin D3; 900 UI, Vitamin E; 40 mg, Vitamin K3; 2 mg, Vitamin B1; 2mg, Vitamin B2; 4 mg, Vitamin B6; 2 mg, Vitamin B12; 10µg, Folic acid; 10 mg, Pantothenic acid; 7 mg, Nicotinic acid; 50 mg, Biotin; 50 µg, Choline; 250 mg, I; 0.2 mg, Mn; 85 mg, Cu; 5 mg, Zn; 50 mg, Fe; 50 mg, Co; 0.1 mg, Selenium; 0.1 mg.

[2] According the Egyptian Regional Center for Food and Feed (RCFF, 2001)

***Blood sampling and analysis*:**

Immediately after slaughtering, three blood samples from each experimental group were collected into dry clean centrifuge tubes for serum separation and assigned for determination of Total protein (TP,g/dl) Gornal *et al*., (1949), Albumin (Alb,g/dl) Doumas and Waston (1971), Creatinine (CR,

g/dl) Schirmeister (1964), Cholesterol (mg/dl) Richmond (1973), Glucose (mg/dl), uric acid (mg/dl) and urea (mg/dl) Fawcett and Scott (1960). Aspartate amino transferase (AST, U/ml) and Alanine amino transminase (ALT, U/ml) Reitman and Frankel (1975) levels using commercial kits supplied by Randox (Randox Laboratories ltd, Crumin, co, Antrim,Uk). Globulin (Glb,g/dl) concentration was estimated by subtracting the values of Alb from the corresponding values of TP per sample. Three non-coagulated blood samples were tested shortly after collection for determination complete blood pictures included white blood cells differential count (WBCs, $10^3/mm^3$) concentration according to Drew *et al*., (2004).

***Histopathological Examination*:**

Selected portions from rabbits intestine in each group directly after slaughtering were fixed in 10 % neutral buffered formalin solution and processed by the standard paraffin embedding technique. Tissue sections were cut at 3-4 microns and stained with haematoxylin and eosin (Bancroft *et al*., 1994) and examined morphologically under light microscope (Nikon Eclipse E-200) in Animal Health Research Institute.

Microbiological measurements:

Cecum content were collected from slaughtered rabbits immediately to investigate some bacterial counts which are *Cholsterida spp.* ($x10^5$ CFU/g caecal digesta), *E. Coli spp*. ($x10^5$ CFU/g caecal digesta), *Lactobasillis bacteria* ($x10^5$ CFU/g caecal digesta) and *Urealtic bacteria* ($x10^5$ CFU/g caecal digesta) after slaughtering by Pour Plate Count Technique according to British Standard Institution (1991). Also, pH and NH3 were determined in cecum, pH by digital pH- meter and NH3 (mmol/l) by applying Conway (1958) method.

Meat analysis

Thigh meat of the three carcass were stored on -20°C for 4 days before chemical measurements, Total protein (g/dl), Total lipid (g/dl), Total cholesterol (mg/dl), Triglyceride (mg/dl), Malondialdehyde (MDA, mmol/g), Glutathione peroxidase activity (GPX, mmol/g), Total antioxidants capacity contents (TAC, mmol/g) were determined by colorimetric methods using analytical kits produced by Biodiagnostic Company, Dokki, Giza, Egypt.

***Economic efficiency*:**

Economic efficiency (%) was calculated as a ratio between the return of weight gain and the cost of consumed feed. the costs of feed required for producing one kg of body weight gain was calculated. The cost of the experimental diets was calculated according to the price of different ingredients prevailing at local market, as well as, the price of tested materials at the time of experiment. Relative economical efficiency of the control, assuming that the relative EE of the control =100

Statistical analysis:

Data were statically analysed using the general linear model (GLM) procedure of SAS **(SAS, 2004)**.

$$Y_{ij}= \mu + T_i + e_{ij}$$

Where Y_{ij} = An observation, μ = Overall mean,. T_i = Effect of treatments (i = 1, 2….6), e_{ij} = Random error.

Differences among means were detected using Duncan's new multiple test (Duncan, 1955).

RESULTS AND DISCUTION

Analysis of Turmeric powder:

Analysis of turmeric revealed that total Phenols and total flavonoids were 18.15 % and 17.87 %, respectively. While, the analysis of turmeric essential oil showed 35 active compound which are listed in Table 2. The main components were tumeronne, 45.75 %; phellandrene, 5.73 %; thymol, 5.03; curcumene, 3.29 %; curlone, 14.04 % and cymene, 2.44 %.

Productive traits:

The effects of experimental treatments on productive traits during the first four weeks after weaning (5-9 wks of age), the next four weeks (9-13 wks of age) and the overall fattening period (5-13 wks of age) are shown in Table 3. Significant differences were recorded between treatments in all studied variables. The results reveal that increase body weight (BW) and body weight gain (BWG) among all supplemented groups. The groups fed diets supplemented with either BM+TU or BM+BS recorded significantly high final BW by 8.82 and 8.48 % and final BWG by 12.90 and 12.23%, respectively at (5-13 wks of age) over control. Feed intake at (5-13 wks of age) were

Table 2. The Main components of Turmeric essential oils:

No.	Component	Relative concentration %	No.	Component	Relative concentration %
1	α-Pinene	0.31	19	β-Himachalene	2.44
2	Mycrene	0.14	20	γ-cadinene	0.19
3	α-Phellandrene	5.73	21	β-Curcumene	0.54
4	α-Terpinene	0.13	22	β-Sesquiphellandrene	3.97
5	*O*-Cymene	2.44	23	α-Copen-11-ol	0.37
6	Limonene	0.53	24	Germacrene B	0.13
7	1,8-Cineol	1.86	25	ar-Turmerol	0.49
8	γ-Terpinene	0.10	26	Caryophyllene oxide	0.85
9	Linalool	0.51	27	Curzerenone	1.11
10	Myrtenol	0.22	28	β-Atlantol	1.97
11	Myrtenal	0.19	29	β-Eudesmol	0.64
12	2-Decanol	0.22	30	*epi*-α-cadinol	0.92
13	Thymol	5.03	31	ar-Turmerol	1.02
14	Carvacrol	0.13	32	ar-Turmerone	45.75
15	β-Elemene	0.20	33	β-Turmerone	0.31
16	β-Caryophyllene	0.43	34	Curlone	14.04
17	α-Humelene	0.37	35	(E)-α-Atlantone	0.38
18	ar-Curcumene	3.29			

significantly for groups fed control and BM diets while, BM+TU and BM+BS recorded the lowest value of feed intake compared to control. However, the final feed conversion ratio (FCR) improved significantly among all feed additives at (5-13 wks) as compared to control. Combining BM+TU or BM+BS improved final FCR by 20.26 and 17.10 %, respectively as compared to control.

Turmeric could control and limit the growth and colonization of numerous pathogenic species of bacteria in the rabbit's gut resulting in balanced gut microbial ecosystem that leads to better feed utilization reflected by increase live body weight

Table 3: Effect of experimental treatments on the performance of NZW growing rabbits.

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM +TU	BM + BS		
Initial body weight (g)	533.20	532.20	532.30	531.00	531.50	533.70	28.6	NS
5-9 weeks								
Body weight (g)	1044.9^{b}	1051.5^{b}	1044.0^{b}	1126.2^{a}	1094.5^{ab}	1086.6^{ab}	16.08	**
Body weight gain (g)	511.7^{b}	519.3^{b}	511.7^{b}	595.2^{a}	563.0^{ab}	552.9^{ab}	21.15	*
Feed intake (g)	2031.9^{a}	2003.2^{a}	1743.1^{b}	2062.9^{a}	1787.0^{b}	1786.9^{b}	48.8	**
Feed conversion	3.97^{a}	3.86^{ab}	3.41^{bc}	3.47^{bc}	3.17^{c}	3.23^{c}	0.14	**
9 - 13 weeks								
Body weight (g)	1726.1^{c}	1765.5^{bc}	1766.1^{bc}	1843.3^{ab}	1878.3^{a}	1872.5^{a}	29.02	**
Body weight gain (g)	681.2^{b}	714.0^{ab}	722.1^{ab}	717.1^{ab}	783.8^{a}	785.9^{a}	24.8	*
Feed intake (g)	2504.4^{ab}	2328.5^{c}	2378.4^{bc}	2550.5^{a}	2293.1^{c}	2431.9^{abc}	51.6	**
Feed conversion	3.68^{a}	3.26^{cd}	3.29^{bc}	3.56^{ab}	2.93^{d}	3.09^{cd}	0.11	**
Over all period (5-13 weeks)								
Body weight (g)	1726.1^{c}	1765.5^{bc}	1766.1^{bc}	1843.3^{ab}	1878.3^{a}	1872.5^{a}	29.02	**
Body weight gain (g)	1192.9^{b}	1233.3^{b}	1233.8^{b}	1312.3^{a}	1346.8^{a}	1338.8^{a}	27.2	**
Feed intake (g)	4536.3^{a}	4331.7^{b}	4121.5^{bc}	4613.4^{a}	4080.1^{c}	4218.8^{bc}	77.6	**
Feed conversion	3.80^{a}	3.51^{b}	3.34^{bc}	3.52^{b}	3.03^{d}	3.15^{cd}	0.07	**

$^{a-d}$ = Means in the same raw with different superscripts, differ significantly.
NS: Non-significant *: $P \leq 0.05$. **: $P \leq 0.01$. SEM: Standard errors of means.
C= Control TU= Turmeric BM= Biomos BS= Biostrong

and weight gain (Al-Sultan, 2003 and Al-Mashhadani, 2015). Furthermore, the same results were reported by Luna *et al*., (2018) who recorded that using thymol supplementation for Japanese quail diet enhancing their gut health and productivity. Also, the previous results are in harmony with the findings of El-Faham *et al*., (2014) and Abd El-latif *et al*., (2019). They found that using curcuma as addition to rabbit and chicken diets stimulated protein synthesis by enzymatic system. Moreover, the supplementation of phenolic compounds, like curcumin, may decrease gut inflammation, increase nutrients digestibility and metabolic activity (Buchanan *et al*., 2008; de Beer *et al*., 2008 and Giannenas *et al*., 2010).

Also, Bersenyi and Gippert (1995) reported that some improvements were detected in weight gain of weaned rabbits when fed Bio-mos over a 6-week period. Gültepe (2007) observed increase in growth rates of sea bream fed mannan oligosaccharides (MOS) by adding 2 and 4 %. Radwan and AbdeL-Khalek (2007) showed that, Bio-Mos® at 0.5% supplementation level and mixed herbs extract improve growth and health of rabbits grown. Spring *et al.,* (2015) observed that the improvement in growth performance may be due to the enhancing effect of Bio-Mos for immunity and digestion refer to its ability to bind and limit the colonisation of gut pathogens. Beiki *et al.* (2013) found that using Biostrong led to decrease fed conversion ratio of broilers compared to control. Lavrentyev *et al.* (2019) reported that 150 g/ton (0.015%) Biostrong 510 increased live weight and growth intensity of broiler chickens of the cross "Cobb 500". They also, reported that the mechanism of action is based on the joint action of several plant substances and its active substances, which when combined affect a certain category of animals. Ciftci *et al.,* (2005) recorded the addition of 400 mg/kg anise oil to the diet improved feed conversion ratio by approximately 12 % over the control group for broiler.

Carcass traits

The effect of different treatment groups on carcass traits are presented in Table 4, there were significant differences between control and all treatments in dressing%. The combining between BM with TU or BS treatments recorded the highest dressing % followed by BS, BM and TU alone. The increasing of dressing % as result of diet addition proportionally to the increase in live weight. Moreover, there were significant differences between BS, BM+TU, and BM+BS *vs* control in total edible %, BM+TU recorded the highest percentage, the proportional increasment was 6.95 % over control. There were insignificant improved between treatments vs control in cecum and intestine weight. Abd El-Latif *et al*., (2019)

Table 4: Effect of experimental treatments on some carcass traits of NZW growing rabbits.

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM +TU	BM + BS		
Dressing (%)	48.11^{c}	50.93^{b}	51.25^{b}	51.43^{b}	53.48^{a}	52.21^{ab}	0.57	**
Liver(%)	5.10	3.97	4.04	4.94	3.43	4.68	0.37	NS
Heart(%)	0.34	0.31	0.35	0.41	0.32	0.41	0.04	NS
Kidney(%)	0.70	0.68	0.68	0.60	0.79	0.62	0.67	NS
Edible giblet (%)	6.14	4.96	5.08	5.95	4.54	5.71	0.32	NS
Total edible parts (%)	54.25^{b}	55.89^{ab}	56.33^{ab}	57.38^{a}	58.02^{a}	57.92^{a}	0.70	*
Cecum weight (g)	100.93	105.57	113.37	118.10	111.90	110.00	12.28	NS
Intestine weight (g)	71.87	73.53	74.77	74.63	73.63	76.13	4.93	NS

$^{a-c}$ = Means in the same raw with different superscripts, differ significantly.
NS: Non-significant *: P≤0.05. **: P≤0.01. SEM: Standard errors of means, C= Control TU= Turmeric BM= Biomos BS= Biostrong

Table 5: Effect of experimental treatments on pH and cecal microbial count of growing NZW rabbits

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM +TU	BM + BS		
pH	6.10^{b}	6.07^{b}	6.43^{ab}	6.67^{a}	6.69^{a}	6.60^{ab}	0.16	*
Clostridia spp. (x10^{5})	6.11^{a}	4.54^{b}	4.13^{d}	4.32^{c}	4.35^{c}	3.78^{e}	0.02	**
E. coil (x10^{5})	1.65^{a}	1.28^{b}	1.10^{cd}	1.19^{bc}	0.94^{e}	1.02^{de}	0.03	**
Lactobacilli bacteria (x10^{5})	5.13^{f}	9.85^{e}	10.10^{d}	10.44^{c}	11.28^{a}	10.76^{b}	0.03	**
Urealetic bacteria (x10^{5})	2.85^{a}	1.34^{b}	1.28^{c}	1.20^{d}	1.18^{d}	1.21^{d}	0.02	**
NH3 (mmol/ l)	4.74^{a}	3.74^{b}	3.59^{c}	3.52^{d}	3.49^{de}	3.45^{e}	0.02	**

$^{a-c}$ = Means in the same raw with different superscripts, differ significantly (P≤ 0.05).
*: P≤ 0.05. **: P≤ 0.01. SEM: Standard errors of means., C= Control TU= Turmeric BM= Biomos BS= Biostrong

recorded that 12 weeks age rabbits fed curcuma 0.5% recorded improves in carcass traits of rabbits. Also, adding 150 g Biostrong 510/ ton diets increased meat productivity for broiler chicks (Lavrentyev *et al.*, 2019). On the other hand, Radwan and Abdek-Khalek (2007) observed insignificant different in carcass traits of rabbits fed on Bio-Mos® at 0.5% supplementation level and mixed herbs extract.

Microbial examinations:

The presented data in Table 5 refer to significant increase in cecal pH in BS or BM+TU groups as compared with control or TU. There were significant differences between control and treated groups in *Clostridia spp.* count. The control group had the highest content (6.11 $x10^5$ CFU/g caecal digesta), while the group treated by BM+BS recorded the lowest value (3.78 $x10^5$ CFU/g caecal digesta). All treatment reduced the C*lostridia spp.* count compared to control. The reduction percent were 38.1, 32, 29, 28.8, and 25.7% for treatments BM+BS, BM, BS, BM+TU and TU, respectively. It is known that *Clostridia* prevent weight gain by blocking the intestine's ability to absorb fat. These perhaps explains the improvement in the performance which mention previous in Table 3. The same trend of reduction count of pathogenic bacteria was recorded for *E. Coli spp*. Combining BM with TU or BS could reduce *E. Coli* greatly (43% and 38.2%) compared to control. However, BM, BS and TU decreased *E. Coli* count by 33.3, 27.9 and 22.4%, respectively. Regarding to *urealetic bacteria*, the same trend of reduction by experimental supplementation was recorded. The reduction % were 58.6, 57.9, 57.5, 55.1 and 52.9% for BM+BS, BS, BM+TU, BM and TU compared to control group, respectively. The recorded reduction of pathogenic bacteria counts was reflected on increasing count of beneficial bacteria like *Lactobacilli*. All treatments improved *Lactobacilli* counts compared to control. The improvements percent were 119.9, 109.7, 103.5, 96, and 92 % for treatments BM+TU, BM+BS, BS, BM, and TU compared to control group, respectively. Additionally, the concentration of NH3 in cecum was decreased by experimental treatments compare to control (ranged from 3,74 to 3.45 vs 4.74 mmol/l).

The obtained results show better ability of BM and BS to improve microbiotic status of rabbit cecum than TU. Also, combining BM with TU or BS increased the final impact on microbial traits compared to single supplementation. Generally, the reported results confirmed the reports of prebiotic by Spring *et al*. (2015). They introduced a lot of researches which reported ability of MOS to bind some pathogenic bacteria *spp.* like *E. Coli,* and

Clostridium perfringens then reduce their colonization in chicken intestine and increasing total anaerobic bacteria such as *Lactobacilli and Bifidobacterium.* Also, Dietary MOS in the intestinal tract removes pathogenic bacteria that could attach to the lumen of the intestine (Newman, 1994).

Al-Sultan (2003) and Al-Mashhadani (2015) indicated that, the limitation of the growth and colonization numerous non-pathogenic species causing by turmeric. Also, anethole, a naturally occurring phenylpropanoid extracted from aniseed, exhibited a broad antimicrobial spectrum and the antifungal activity (Kubo 1993), and antibacterial (Newall *et al*., 1996) and inhibit mycotoxin producing Aspergillus species in culture (Leung and Foster, 1996). These agree with Ferket (2003) who reported that essential oils had a beneficial effect on intestinal bacteria and growth promoting effects in comparison with antibiotic-contained control diet.

Haematological indices:

Regarding to the hematological blood parameters (Table 6), there was a significant increase in WBC's in treated groups BM+ TU, BM+BS and BS compared to control. The group BM+TU recorded the highest value (9.36 10^3/ mm^3). There was significant increase in lymphocytes % in groups treated with BS, and BM+TU compared to control. Significant increase in group treated with TU compared to control was detected in monocyte %. While these high values were within the normal ranges. There were insignificant differences in treated groups compared to control group in Neutrophil %. There were significant increases in RBC's in treated groups when compared to control. Also, significant increase was observed in groups of BM+ TU and BM+BS when compared to control group in hemoglobin. The addition caused an increase in total RBC's which in turn caused an increase in Hb values, due to the positive relationship between RBC'S and Hb (Sturkie 1986). Hematocrit % was significantly increase in treatments supplemented with BM+TU, and BM+BS compared to control, however there were insignificant differences between treated groups as compared to control group in MCV, MCH and MCHC. The presented results suggest that the experimental treatments may enhance immune system activity, and positive impact on liver and spleen, as well as, other tissues like bone marrow was noticed where RBC,s are synthesized (Feldman *et al*., 2000). Bayram *et al.* (2007) reported that antibody levels were increased by anise seed positively in hens. This may be due to the antioxidant effect of anise oil (Newall *et al.*, 1996) and thymol supplementation Luna *et al*. (2018).

Table 6: Some blood hematological values of growing NZW rabbits as affected by experimental treatments

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM+TU	BM+BS		
WBCs (10^3/mm^3)	7.10^{d}	8.16^{bcd}	7.20^{cd}	8.23^{bc}	9.36^{a}	8.73^{ab}	0.33	**
Lymphocytes (%)	52.20^{c}	55.73^{abc}	54.80^{bc}	59.57^{a}	58.73^{ab}	51.90^{c}	1.38	**
Monoccyte (%)	5.87^{bc}	7.73^{a}	6.93^{ab}	5.03^{c}	4.93^{c}	5.77^{bc}	0.50	**
Neutrophils (%)	35.50^{a}	28.53^{b}	29.60^{b}	29.07^{b}	28.33^{b}	29.67^{b}	1.80	NS
RBCs (10^6/mm^3)	4.43^{d}	5.73^{b}	5.13^{c}	5.50^{bc}	6.40^{a}	5.83^{b}	0.16	**
Hemoglobin (g/dl)	9.46^{b}	11.10^{ab}	10.10^{b}	10.93^{ab}	12.03^{a}	11.96^{a}	0.55	*
Haematocrit (%)	31.73^{b}	32.50^{b}	32.16^{b}	33.85^{b}	37.56^{a}	37.37^{a}	0.86	**
MCV(1) (fl)	62.93	61.60	62.30	61.63	65.43	63.80	1.05	NS
MCH(2) (pg)	20.03	19.90	19.56	19.90	20.93	20.46	0.46	NS
MCHC(3) (g/l)	32.00	32.00	31.33	32.33	32.33	32.00	0.47	NS

$^{a-c}$ = Means in the same raw with different superscripts, differ significantly ($P \leq 0.05$).

NS: Non-significant *: $P \leq 0.05$. **: $P \leq 0.01$. SEM: Standard errors of means, C= Control TU= Turmeric BM= Biomos BS= Biostrong

(1) Mean corpuscular volume, (2) Mean corpuscular hemoglobin (3) Mean corpuscular hemoglobin concentration

Blood constituents:

Serum constituents of growing NEW rabbits as affected by different treatments are presented in Table 7. Significant difference in treatment groups compared to control was detected in total protein, while insignificant differences detected in albumin, globuline and A/G ratio. This improvement may be partially due to the increasing animal resistance to any physical stress. Furthermore, serum total protein level is a general indication of immune status (White *et al*., 2002). In addition, BM had proven to be an effective means for immunity (Spring *et al.,* 2015). The increasing in globulins concentration may be indication of increased immunity in rabbits since the liver will be able synthesize enough globulins for immunological action as mentioned by Sunmonu and Oloyede (2007).

The presented results in Table 7 show general significant increase in glucose and a decrease in cholesterol, urea, uric acid and creatinine in serum of treated rabbits compared to control rabbits. Furthermore, BM and BS showed the highest glucose level (102.2 and 99.5 mg/dl) which indicated better metabolism status and efficacy of utilizing feed nutrients. Combining BM with TU or BS resulted in decreasing cholesterol concentrations by 55.5, and 50% compared to control rabbits, respectively. The decreased in cholesterol level in treated groups is in agreement with other studies performed on rabbit (Basovaraj *et al.,* 2011). Reduced cholesterol may be due to activities of two liver enzyme HMG-COA reductase and cholesterol -7-alpha-hydroxylase. They found that activity of second enzyme was raised in the liver. Also, Rajput *et al*. (2013) reported that plasma cholesterol level was significantly reduced in broilers fed turmeric supplemented diets. Also, Curcumin reduced the serum LDL cholesterol (Emadi and Kermanshahi, 2007; Seo *et al*., 2008 and Gandhi *et al*., 2011).

The Data show insignificant differences between treated groups compared to control group in liver enzyme activities (AST and ALT). Curcumin improved the liver functions (Emadi and Kermanshahi, 2007; Seo *et al*., 2008 and Gandhi *et al*., 2011). While the determined significant decrease of urea and uric acid in treated groups *vs* control group indicated an improvement of kidney functions and protein metabolism and consequently increase of nitrogen retention and utilization (Abou-sekken *et al*., 2012, and EL-Faham *et al*., 2014). In general, the recorded blood parameters showed clear improvement of nutrient utilization,

Table 7: Blood serum constituents of growing NZW rabbits as affected by experimental treatments.

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM +TU	BM + BS		
Total Protein (g/dl)	6.87^{ab}	6.85^{ab}	6.17^{b}	6.33^{b}	7.57^{a}	7.32^{a}	0.28	*
Albumine (g/dl)	3.75	3.61	3.13	3.32	3.86	3.78	0.22	NS
Glubuline (g/dl)	3.12	3.24	3.04	3.01	3.71	3.54	0.30	NS
A/G ratio	1.21	1.11	1.03	1.10	1.04	1.07	0.13	NS
Glucose (mg/dl)	84.86^{c}	93.22^{b}	99.54^{a}	102.24^{a}	93.40^{b}	81.80^{c}	1.87	**
Cholesterol(mg/dl)	317.83^{a}	216.06^{b}	222.51^{b}	211.97^{b}	141.78^{c}	156.36^{c}	9.04	**
AST (U/ml)	30.39	30.45	30.23	31.42	29.85	28.53	1.50	NS
ALT(U/ml)	45.33	43.89	43.50	39.66	39.98	46.75	1.70	NS
Urea (mg/dl)	47.50^{a}	34.19^{b}	37.17^{b}	36.75^{b}	32.07^{b}	30.30^{b}	2.27	**
Uric acid (mg/dl)	5.62^{a}	4.48^{b}	5.18^{ab}	3.21^{c}	3.47^{c}	4.69^{ab}	0.31	**
Creatinine (mg/dl)	1.37^{a}	1.05^{bc}	1.23^{ab}	1.21^{ab}	0.90^{c}	1.18^{ab}	0.06	**

$^{a-c}$ = Means in the same raw with different superscripts, differ significantly.
NS: Non-significant *: P≤0.05. **: P≤0.01. SEM: Standard errors of means.
C= Control TU= Turmeric BM= Biomos BS= Biostrong

Table 8: Effect of experimental treatments on some chemical analysis in meat of growing NZW rabbits

Items	Treatment groups						SEM	Significance
	C	TU	BM	BS	BM +TU	BM + BS		
Total Protein (g/dl)	0.75^{b}	1.18^{a}	1.06^{ab}	1.64^{a}	1.65^{a}	1.57^{a}	0.20	*
Total Lipid (g/dl)	192.26^{a}	129.81^{ab}	94.56^{b}	134.6^{ab}	136.86^{ab}	80.13^{b}	21.92	*
Cholesterol(mg/dl)	126.48^{a}	89.56^{bc}	114.84^{ab}	113.08^{ab}	91.87^{bc}	76.32^{c}	1.56	**
Triglyceride (mg/dl)	46.02^{a}	45.29^{a}	19.78^{d}	30.40^{b}	27.58^{bc}	23.01^{cd}	1.56	**

$^{a-c}$= Means in the same raw with different superscripts, differ significantly.
*: P≤0.05. **: P≤0.01. SEM: Standard errors of means., C= Control TU= Turmeric BM= Biomos BS= Biostrong

metabolism and immune status of rabbits received experimental diets compared to control.

***Meat quality*:**

1-*Chemical meat analysis*

Effect of different treatments on some chemical analysis of meat of growing NZW rabbits is presented in Table 8. There was clear improvement as increase meat protein and decrease meat total lipid, cholesterol and triglyceride, due to experimental treatment *vs* control group. Combining BM with BS or TU showed better values. However, BM showed significantly the lowest triglyceride value. In the same context, Gelibolu *et al.* (2018) observed that adding MOS decreased triglyceride in sea bream fish, groups fed on diet supplemented with 1, 2, 3and 4 % MOS, the highest value was measured in control group and this was followed by 1‰ MOS. Raskar *et al*. (2019) reported high protein and low fat content in thigh muscle of chicks fed diet supplemented with turmeric compared with non-supplemented diets. These results are in agreement with Daneshyar *et al.* (2011) who found that increase in protein of the thigh meat as result to addition of turmeric rhizome powder. Also, Lavrentyev *et al. (*2019) recorded that supplemented 150 g/ton Biostrong 510 improve meat quality of broiler chickens.

2- *Antioxidative parameters:*

Effect of different treatments on the Malondialdehyde (MDA) in the thigh muscles of growing NZW rabbit is illustrated in Figure 1. There were significant decreases in MDA level in treatment groups *vs* control. The proportional reduction were 30.21 %, 29.75 % and 24.24% for TU, TU+BM and BM, respectively when compared to control. These results are in agreement with Kelly *et al.,* (2001) who reported that turmeric decreases lipid peroxides in rat liver microsomes, erythrocyte membrane and brain homogenates. Insignificant increases were detected in total antioxidant capacity (TAC) in treated groups compared to control (Figure 2). Effect of different treatments on glutathione peroxidase activity (GPX) in thigh muscle of growing NZW rabbits showed in Figure 3. Results show significant increase in determined values for treatment groups compared to control except in BM and BM+TU. This result is in agreement with Yuliani *et al*., (2019) who found that administration of 200 mg /kg body weight of ethanol turmeric extract prevented oxidative stress by decreasing the plasma and brain MDA

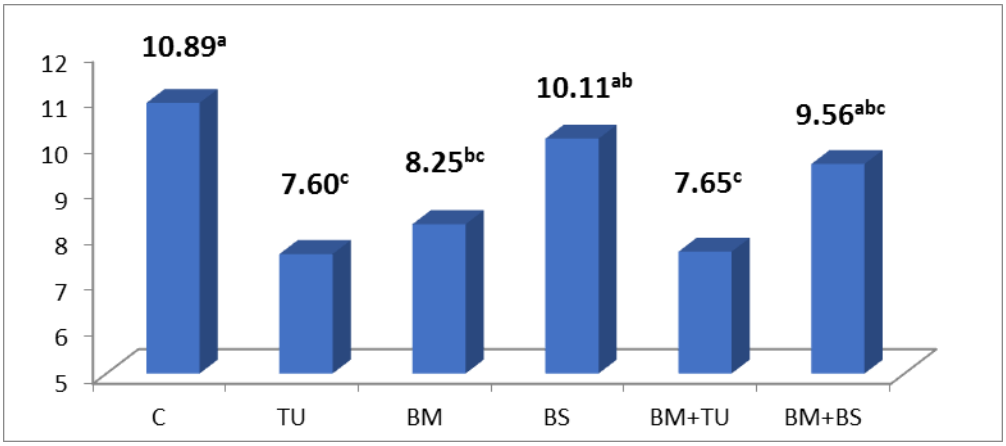


Figure 1: Effect of experimental treatments on malondialdehyde (mmol/g) of thigh muscles C= control TU= turmeric BM= Biomos BS= Biostrong

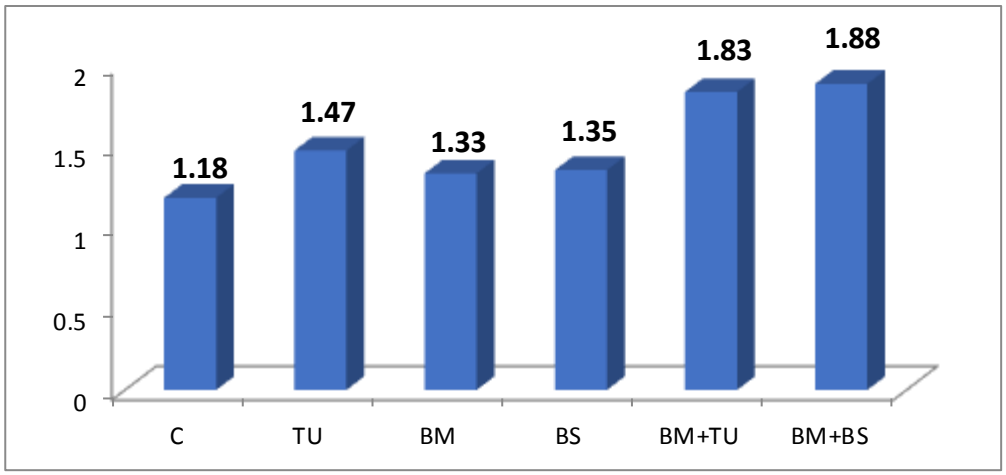


Figure 2: Effect of experimental treatments on total antioxidants capacity (mmol/g) of thigh muscles, C= Control , TU= Turmeric, BM= Biomos, BS= Biostrong

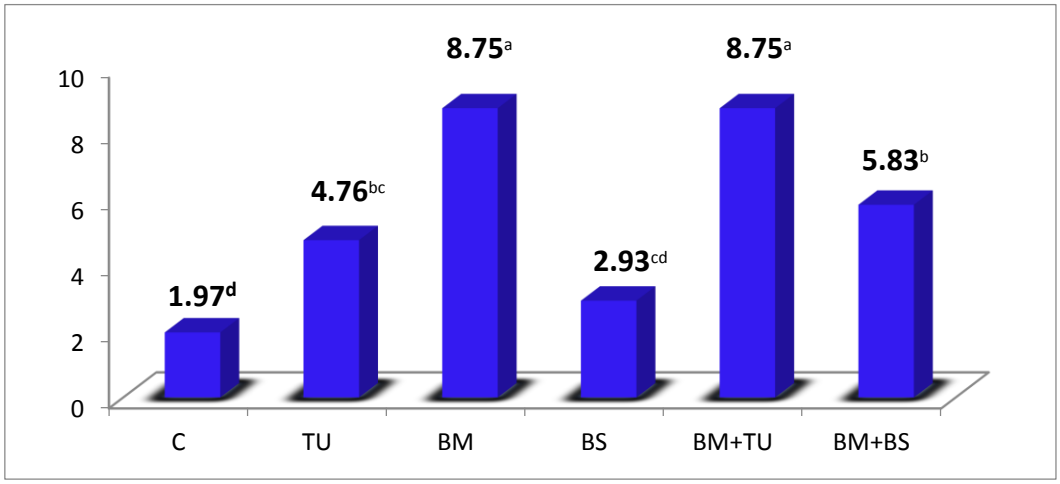


Figure 3: Effect of experimental treatments on glutathione peroxidase activity (mmol/g) of thigh muscles., C= Control, TU= Turmeric, BM= Biomos, BS= Biostrong

level and increasing the superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidise (GPX) reactive enzyme activities. Glutathione *S*-transferases (GST) is one of the most antioxidant enzymes, which play an active role in protecting cell from oxidative stress (OS) by detoxification of H_2O_2. Also, Glutathione *S*-transferases (GST) is catalysing the conjugation of Glutathione (GSH) with organic compounds such as hydroperoixdes. This explain the ability of GST in converting H_2O_2 to water (H_2O), thereby eliminate the hydroxyl radicals (OH^-) then the cell can scavenge the OS (Rao *et al*., 2013). Turmeric has the ability to control ailments through its effective as antioxidant activity (Kelly *et al.,* 2001). Supplemented 150g Biostrong 510/ ton diet for broiler chickens increased meat preservation and meat quality (Lavrentyev *et al.*, 2019). Also, Abd -Hack *et al.* (2016) suggested that useful applications of lowered blood, meat and egg MDA, lipid peroxidation have been noted in animal-fed diets supplemented with thymol molecule., indicating the useful impacts and biological roles of thymol dietary supplementation which could be attributed to its pharmacological activity and useful health effects, like antispasmodic, antioxidant. The antioxidant enzymes

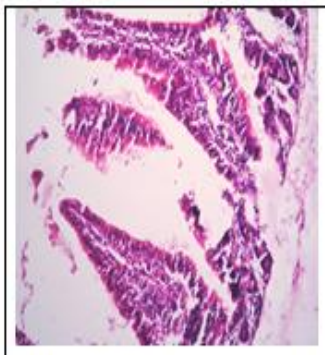
play a key role in cellular defence against oxygen free radicals and oxidative stress (Bernabucci *et al*., 2002). Their synergistic action with other antioxidants makes them more potent compound. It has been suggested that different individual compounds exhibiting a variety of antioxidant activities which may provide additional protection against oxidative stress when ingested simultaneously (Esterbauer *et al*., 1991).

Histopathological results:

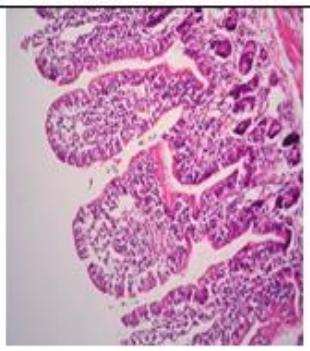
Histopathological examination of rabbits intestine were showed in Plates 1 to 6. The results show that all treatments cause change in intestinal villi. All supplements increased either length or thickness of intestine villi, except supplemented BM increase villi length greatly, and surface area of intestinal villi leading to increase efficiency and intestinal absorption compared to control. All additions increase length or thickness of intestine villi except supplemented BM and BM+BS increase both length and thicken as which reflected on performance and the gut health which mention previous in Tables 3 and 5.

Structure of small intestine plays a vital role in nutrient digestion and absorption (Lenhardt and Mozes, 2003); however, manipulation in the feed may alter villus height to crypt depth ratio, and absorptive area of intestine (Fasina *et al*., 2006). Rajput *et al*., (2013) showed that dietary supplementation of curcumin influenced the histomorphology of small intestinal villi of broiler. The villus height was significantly increased in duodenum, jejunum and ileum in curcumin supplemented broilers. Villus width was also significantly increased in duodenum and jejunum. While, there was no significant difference in ileum villus width. Furthermore, villus height to crypt depth ratio was significantly increased in all segments. Radwan and Abdek-Khalek (2007) recorded that significant effect on ileum by adding Bio-Mos on rabbits diet. Also, Pinheiro *et al.* (2004) show that increased the villi length for rabbits fed Bio-Mos™ which led to increased absorption area compared to the control.

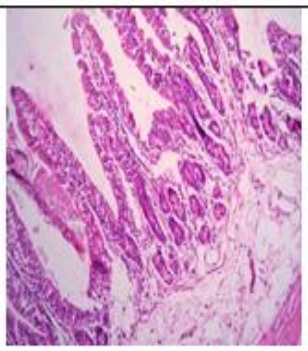
All these improvements in productive traits and other parameters may be due to the improvement in gut health by BM which reflected on the count of microbial, as decreasing of the pathogenic microbial count (*Clostridia spp.* and *E. coli*) and increased the *Lactobacilli bacteria* count and cecum ph in treatments, BM+TU, and BM+BS groups (Table 5) and may be due to the improving in histopathological results of rabbits intestine tissue (plates from



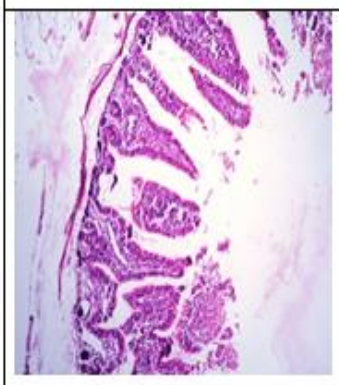
Plates1: Effect of control group on the histology Intestine of rabbit showing normal intestine with desquamation of intestinal villi (H and E stain , x200)



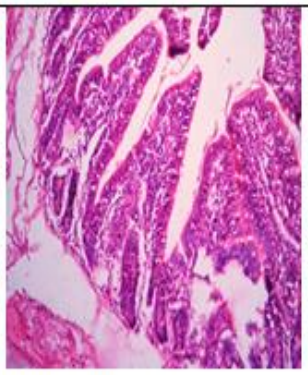
Plates 2: Effect of turmeric on Intestine of rabbit showing increase in thickness of intestinal villi (H and E stain, x 200).



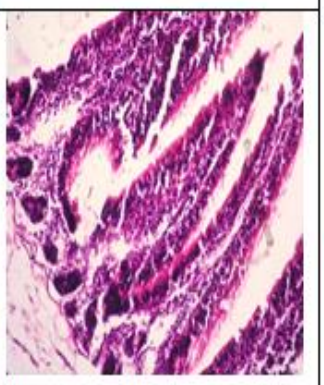
Plates 3: Effect of Biomos on Intestine of rabbit showing increase in length of intestinal villi and edema in sub mucosa (H & E stain, x200).



Plates 4: Effect of Biostrong on Intestine of rabbit showing increase in length and thickness of intestinal villi, ulceration of lamina epithelialis and edema in sub mucosa (H and E stain, x40).



Plates 5: Effect of Biomos + turmeric on high power of figure 5 showing increase in thickness of intestinal villi (H and E stain, x 400).



Plates 6: Effect of Biomos + Biostrong on Intestine of rabbit showing increase in thickness and length of intestinal villi H and E stain, x 400.

1 to 6). Dietary MOS removes pathogenic bacteria that could attach to the lumen of the intestine (Newman, 1994).

Economic efficiency:

Data concerning economical evaluation are summarized in Table 9. The present results indicate an improvement in net revenue for rabbits fed

Table 9: Input- output analysis and economical efficiency of experimental dietary treatments.

Items	C	TU	BM	BS	BM+TU	BM+BS
Body weight gain (kg)	1.19	1.24	1.23	1.32	1.35	1.34
Price/kg sold for body weight	54.00	54.00	54.00	54.00	54.00	54.00
Total revenue / rabbit (LE)	64.35	67.00	66.37	71.42	72.78	72.30
Total feed consumption/rabbit (kg)	4.55	4.33	4.12	4.60	4.07	4.22
Price/kg feed (LE)	5.70	5.82	5.76	5.77	5.88	5.83
Total feed cost /rabbit (LE)	25.95	25.18	23.73	26.57	23.19	24.60
Net revenue [1] (LE)	38.40	41.81	42.64	44.85	48.86	47.70
Economical efficiency[2]	148.01	166.05	179.64	168.80	204.32	193.94
Relative economical efficiency[3] (%)	100.00	112.19	121.37	114.05	138.05	131.03

C= control TU= turmeric BM= Biomos BS= Biostrong

Total price for feeds was calculated according to the price of different ingredients available in ARE., Price of one Kg live weight was 54 LE , [1]Net revenue= total revenue/ chick- total feed cost/chicks, [2]Economical efficiency= net revenue/ total feed cost/chicks, [3]Relative economical efficiency of the control, assuming that the relative E1 of the control =100

treatment diets compared to those fed control diet. Adding phytogenic source improve the relative economic efficiency by 12 and 14%, while using single supplementation of BM increase the relative economic efficiency by 21% compared to control group. Combining between BM and phytogenic sources resulted in great increase in the relative economic efficiency being 138 and 131% for BM+TU and BM+BS, respectively. These results agree with those reported by Lavrentyev *et al.* (2019) who recorded reduce feed costs per unit for broiler chickens fed 150 g Biostrong 510 /ton diet.

Conclusively, it can be concluded that, the addition treatments to growing rabbits diet, exerted benefits on growth performance, carcass characteristics and physiological parameters. Also, increasing the meat antioxidant enzymes and decreased meat cholesterol and triglycerides which improved meat quality.

From the economic point view BM+TU (0.05+0.3 %, respectively) and BM+BS (0.05+0.015 %, respectively) addition is recommended for growing rabbits.

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التأثير التكاملي للنباتات الطبيه الخام او المستخلصة مع البريبيوتيك علي الصفات الإنتاجية والفسيولوجية للأرانب النامية

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هذا البحث اجرى لدراسة التأثير التكاملي لإضافة اودمج الكركم (كمصدر لنبات طبي خام) او البيوسترونج (كمستخلص للنباتات الطبية) مع البيوموس (بريبيوتك) على بعض معدلات الاداء الانتاجى والفسيولوجى للأرانب النيوزلندي البيضاء النامية. اجريت الدراسه على90 ارنب نامى مفطوم حديثا عمر 5 اسابيع. حيث قسمت الأرانب الى ٦ مجموعات تجريبيه متساوية كل مجموعه بها15 ارنب كل ارنب بمفرده لمدة 8 أسابيع. غذيت المجموعة الأولى على العليقة الاساسية بدون اضافة (مجموعة ضابطة) ، بينما اضيف الكركم لعليقة الارانب بنسبة 0.3 % فى المجموعة الثانية واضيف البيوموس بنسبه 0.05 % فى المجموعة الثالثة، واضيف البيوسترنج بنسبة 0.015 % فى المجموعة الرابعة واضيف البيوموس+ الكركم بنفس النسب السابقه للمجموعة الخامسة واضيف البيوموس+ البيوسترونج للمجموعه السادسة بنفس النسب السابقة.

وأوضحت النتائج المتحصل عليها من هذه الدراسه زيادة قيم كل من وزن الجسم ووزن الجسم االمكتسب لكل الإضافات مقارنة بالكنترول وكان أعلي قيمة لوزن الجسم المكتسب للأرانب المغذة على كلا من خليط البيوموس مع الكركم و خليط البيوموس مع البيوسترونج بنسبة 12.90 و 12.23 % علي التوالي أعلي من المجموعة الضابطة. الدمج بين كلا من البيوموس مع الكركم و البيوموس مع البيوسترونج أدي الي زيادة معنوية لنسبة التصافي ونسبة الأجزاء الكلية المأكولة ونسبة بروتين اللحم وإنخفاضا معنويا لمعامل التحويل الغذائي والكوليسترول والدهون الثلاثية في اللحم وحسن الكفاءة الإقتصادية النسبية للأرانب مقارنة بالمجموعة الضابطة. المالونالدهيد في اللحم سجل اقل قيمة معنوية للأرانب المغذاه علي الكركم او خليط البيوموس مع الكركم بينما سجل نشاط الجلوتاثيون بيروكسيديز في اللحم أعلى قيمة معنوية للأرانب المغذاه علي البيوموس او خليط البيوموس مع

الكركم مقارنة بالمجموعة الضابطة. سجلت المجاميع المغذاه علي الإضافات انخفاضا معنويا للبكتريا الممرضه وإرتفاعا معنويا للبكتريا النافعه.
التوصية: مما سبق فأن الدراسه أوضحت أن كل الإضافات العلفية لعليقه الأرانب النيوزلندي البيضاء النامية ادت الى نتائج افضل معنويا فى معدلات الاداء الإنتاجي والفسيولوجى. سجلت الأرانب النامية المضاف لعليقتها خليط البيوموس مع الكركم أو خليط البيوموس مع البيوسترونج معنويا أعلي قيمة لقياسات الأداء الإنتاجي والفسيولوجي مع اعلي كفاءه إقتصاديه لذلك ينصح بإضافة البيوموس مع الكركم أو البيوموس مع البيوسترونج لعلائق الأرانب الناميه.