Determination of The Effect of Mixture of Essential Oil and Organic Acid Containing at Different Levels on Broiler Rations on Fattening Performance, Carcass Parameters and Some Internal Organ Weights

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Abstract: In this study, the effect of supplementing essential oil and organic acid on fattening performance, feed utilization, carcass yield and some visceral weights of different levels (1g / kg, 2g / kg, and 3g / kg) as feedstock of broiler chicks were investigated.

One day old, 240 chickens (Ross-308) were used as animal material. The study was divided into 1 control and 3 experimental groups and each group had 4 subgroups with 15 chickens.

The mean body weights (BW) and body weight gain (BWG) of the control and experimental groups were examined during the study. The mean body weights (BW) and body weight gains (BWG) for control and experimental groups were 2323.53 g, 2399.91 g, 2418.27 g and 2462.36 g, respectively. The BW and BWG were higher and statistically significant ($P < 0.05$) in the first, second and third experimental groups compared to the control group. The average feed consumption in the control and experiment groups were calculated as 4111,93 gr, 4376,04 gr, 4214,29 gr and 4317,51, respectively, while there was no difference between the groups, while the feed utilization rates in the control and experimental groups were 1,81, 1,82, 1.73 and 1.75, respectively. While there was no statistical difference in feed utilization rates, it was calculated numerically in the lowest (better) groups 2 and 3. At the end of the study, there was no difference between control and experiment groups in hot carcass, carcass yield, heart, liver, stomach and spleen weights.

This study showed that the mixture of essential oils and organic acids at different levels in broiler rations significantly increased the body weight and body weight gain while negatively affecting the performance of the animals and positively affected the feed utilization rate.

Key words: Broiler, essential oil and organic acid, performance.

Broyler Rasyonlarına Farklı Düzeylerde Katılan Esansiyel Yağ ve Organik Asit Karışımının Besi Performansı, Karkas Parametreleri ve Bazı İç Organ Ağırlıkları Üzerine Etkisinin Belirlenmesi

Özet: Yapılan bu araştırmada broyler civcivlerinin yemlerine katkı maddesi olarak farklı düzeylerde (1g/kg, 2g/kg, ve 3g/kg) katılan esansiyel yağ ve organik asit'in besi performansı, yemden yararlanma, karkas randımanı ve bazı iç organ ağırlıkları üzerine etkisi incelenmiştir.

Hayvan materyali olarak 240 adet 1 günlük (Ross-308) etlik civcivleri kullanılmıştır. Araştırmada 1 kontrol ve 3 deneme grubuna dağılmış ve her grup kendi içinde 15 adet etlik civciv içeren 4 alt gruba ayrılmıştır.

Araştırma süresince kontrol ve deneme gruplarına ait ortalama canlı ağırlıklar (CA), ve canlı ağırlık artışları (CAA) sırası ile, 2323,53 g, 2399,91 g, 2418,27 g ve 2462,36 g olarak bulunmuştur. Canlı ağırlık ve canlı ağırlık artışı bakımından birinci, ikinci ve üçüncü deneme grupları kontrol grubuna göre yüksek ve istatistiki olarak önemli ($P<0.05$) bulunmuştur. Yapılan hesaplamalarda kontrol ve deneme gruplarında ortalama yem tüketimi sırası ile 4111,93 gr, 4376,04 gr, 4214,29 gr ve 4317,51 olarak hesap edilmiş ve gruplar arasında fark bulunmazken, kontrol ve deneme gruplarında yemden yararlanma oranları sırası ile 1,81, 1, 82, 1,73 ve 1,75 olarak hesaplanmıştır. Herhangi bir istatistiki farkın çıkmadığı yemden yararlanma oranları rakamsal olarak en düşük (daha iyi) 2. ve 3. Deneme gruplarında hesaplanmıştır. Çalışma sonunda kesilen hayvanlardan elde edilen karkas ve iç organ ağırlıkları bakımından kontrol ve deneme gruplarında sıcak karkas, karkas randıman, kalp, karaciğer, taşlık ve dalak ağırlıkları arasında bir fark oluşmamıştır.

Yapılan bu araştırma broyler rasyonlarına farklı düzeylerde katılan esansiyel yağ ve organik asit karışımının hayvanların performansına olumsuz bir etki yapmazken canlı ağırlık ve canlı ağırlık kazancını önemli derecede artırdığı, yemden yararlanma oranını rakamsal olarak olumlu etkilediği görülmüştür.

Anahtar Kelimeler: Broyler, esansiyel yağ ve organik asit, performans.

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Introduction

Along with the prohibition of antibiotics added to rations for the purposes of animal feeding, the production and use of alternative feed additives is increasing day by day. In recent years studies have been reported that organic acids, essential oils, probiotics and prebiotics are added to the feed of poultry feeds or other animal species to provide benefits in terms of yield and health in animal production [2, 3, 15].

Essential oil and organic blends are also found in the animal feeding area, especially in feed additives used in poultry feeding [25]. Essential oils obtained from aromatic plants have aromatic properties and are preferred because of their ability to improve appetite, improve body weight gain, improve feed consumption and utilization of feed, as they improve poultry performance positively with egg weight in laying hens [17]. It has also been reported that essential oils have antimicrobial, antiviral and antioxidant properties [19, 22, 23].

Essential oils are obtained by a variety of fermentation, extraction or expression methods, most of which are obtained by distillation. Essential oils, which have a characteristic odor of their own, are lighter than water as specific gravity. The enclosures are kept in dark glass bottles and in a cool place [17].

Many products containing organic acids are used as Salmonella inhibitors in rations of poultry and other animal species. Organic acids have also been reported to have bacteriostatic and bactericidal effects on gram-negative bacteria, provided that they have sufficient dissociation-free acid molecules in the environment and are in contact with bacteria for a long time [7, 26]. It has been reported that organic acids in breeding and egg poultry feeds reduce the incidence of Salmonella and prevent recontamination by participating in rations [13]. When organic acids are used as a feed additive, their bacteriostatic activity depends largely on their concentration in the crop and subsequent digestion zones. [12]

This study was designed to investigate the effects of the supplementation of different levels of essential oil and organic acid in broiler chicks rations on fattening performance, feed utilization, carcass yield and some internal organ weights.

Materials and Methods

One day old 240 chicks (Ross-308) were used in the study. One control and three experimental groups were formed. Each group was divided into 4 subgroups which contains 15 chickens. The ingredients and chemical composition of the rations are presented in Table 1. Chicks were fed with three different ratios, broiler chicks 1st period ration (24% HP and 3000 kcal / kg ME); broiler 2nd stage chick ration (22% HP and 3100 kcal / kg ME) and whole broiler feed stuff (21% HP and 3200 kcal / kg ME). While the control group was fed with the basic ration, 1 g / kg, 2 g / kg, and 3 g / kg of essential oil and organic acid mixture were added to the experimental groups respectively.

Table 1. Composition and nutrient level of basal ration

Ingredients	Starter 0-14 days	Grower 15-34 days	Finisher 35-42 days
Corn	41	45	47
Wheat	11,25	11,25	10
Soybean meal	36	31	29
Full-fat soybean	6	6	6
Vegetable oil	3	4	5,25
Limestone	1,25	1,25	1,25
Dicalcium phosphate	1	1	1
Salt	0,25	0,25	0,25
[1]Vit-Min Premix	0,25	0,25	0,25
Calculated nutrient levels			
Crude protein %	24,01	21,98	20,97
Metabolisable energy (kcal kg)	3002	3104	3201

[1]Contained per kg: Vit-Min. A, 4,500,000 IU; vit D3, 1,000,000 IU; vit E, 10,000 mg; vit K, 600 mg; thiamin, 1,000 mg; riboflavin, 4,000 mg; niacin, 25,000 mg; biotin, 20 mg; folic acid, 500 mg pantothenic acid, 5,000 mg, pyridoxine, 1,500 mg; vitamin B12, 10 mg. Cu, 8,000 mg; Fe, 25,000 mg; Zn, 15,000 mg; Co, 150 mg; I, 500 mg; Se, 120 mg; Mn

On days 0-7-14-21-28-35 and 42 of the study, the animals were weighed to determine individual body weight and feed consumption. Using the resulting differences, body weight gain and feed utilization rates were calculated. The study lasted 42 days. At the end of the experiment, 3 animals from each subgroup were randomly selected and separated and a total of 48 animals were kept for slaughter.

After the cutting process, the internal organs were separated from the carcasses and hot carcass weight was measured. This parameter divided to weight that before the cutting to calculate the carcass yield. Likewise in internal organs; heart, liver, stomach and spleen were weighed and recorded. During the 42-day trial, the poultry was heated with the help of electric radiant heaters. Wood shavings were used as a base. The poultry was illuminated 24 hours a day. One way ANOVA with SPSS program was used in the statistical analysis of the study [11].

This research was based on the permission of *Kafkas University Animal Experiments Local Ethics Committee* (KAÜ-HADYEK / 2016-073) report. The product that was used in the study was a synergistic combination of essential oils and organic acids, from Sinerji Tarım. Essential oils content; Thymol, Carvacrol, Gamma-Terpinen, Linalol, Para-Cymen, Cuminaldehyde and organic acids content; Softacid, Lactic acid, Formic acid.

Statistical Analysis

One-way ANOVA was used to determine the significance of the differences between the statistical calculations and the mean values of the groups. The Duncan test was employed to determine the significance among the groups [10].

Results

The mean body weight and body weight gain of the control and experimental groups during the trial are shown in Table 2. In the second week of the trial and at the end of the trial, the first, second and third experimental groups' BW and BWG were higher and statistically significant (P <0.05) when compared with control group.

The feed consumption (FC) and feed conversion ratio (FCR) of animals during the 6-week trial period are shown in Table 3. The average feed consumption in the control and experimental groups was calculated as 4111.93 gr, 4376.04 gr, 4214.29 gr and 4317.51, respectively, while there was no difference between the groups, the feed utilization rates in the control and experimental groups were 1.81, 1.82, 1.73 and 1.75, respectively. The rates of benefit for which no statistic is recognized are calculated in the numerically lowest (better) in groups 2 and 3.

The carcass and internal organ weights obtained from the animals that cut at the end of the study are shown in Table 4. There was no difference in the weights of hot carcass, carcass yield, heart, liver, gizzard and spleen in the control and experiment groups.

Table 2. The effect of mixture of essential oil and organic acid at different levels in rations on body weight (BW) and body weight gain (BWG) in broilers.

	Control	1. Trial	2. Trial	3. Trial	p
Initial	48,38±0,50	48,48±0,39	47,83±0,49	47,95±0,47	0,70
7. Day	146,48±2,61	147,32±2,68	148,43±3,00	146,81±3,03	0,97
14. Day	504,76±12,25^{b}	502,84±10,69^{b}	540,65±12,52^{a}	553,46±13,60^{a}	0,006
21. Day	1023±18,66	10,10±27,37	1022±18,45	1038,81±20,76	0,84
28. Day	1629,11±31,19	1620,84±35,16	1645,18±36,79	1664,34±30,17	0,80
35. Day	2084,50±33,02	2113,95±37,16	2152,09±37,32	2159,19±26,94	0,36
42. Day	2371,93±26,09^{b}	2448,32±23,69^{a}	2461,40±27,02^{a}	2510,13±25,09^{a}	0,002
	Control	**1. Trial**	**2. Trial**	**3. Trial**	**p**
BWG 1	98,10±2,59	98,83±2,72	100,60±3,11	98,86±3,01	0,94
BWG 2	357,56±12,43^{b}	355,52±10,83^{b}	392,29±13,58^{ab}	409,30±13,71^{a}	0,005
BWG 3	519,42±22,39	508,09±29,47	482,87±25,79	484,68±25,83	0,70
BWG 4	607,14±36,01	611,67±45,64	618,98±36,77	629,30±33,15	0,98
BWG 5	459,84±43,43	476,97±47,07	491,34±40,85	478,23±33,87	0,96
BWG 6	287,39±37,76	334,33±32,23	310,46±31,56	350,96±29,04	0,54
BWG	2323,53±26,04^{b}	2399,91±23,73^{a}	2418,27±27,50^{a}	2462,36±25,05^{a}	0,002

a,b: Means in the same column with different superscripts differ significantly (P<0.05)

Table 3. The effect of a mixture of essential oils and organic acids in rations at different levels on feed consumption (FC) and feed conversion ratio (FCR) in broilers.

	Control	1. Trial	2. Trial	3. Trial	p
FC. 1-7 day (gr)	111,88±5,07	119,78±1,78	118,88±2,92	115,12±3,31	0,39
FCR. 1-7 day	1,18±0,02	1,21±0,006	1,18±0,02	1,16±0,03	0,43
FC. 8-14 day (gr)	467,18±22,07	475,37±16,07	510,61±11,17	531,08±27,28	0,14
FCR. 8-14 day	1,37±0,01^{a}	1,34±0,006^{ab}	1,30±0,01^{b}	1,31±0,02^{b}	0,017
FC 15-21 day (gr)	815,98±97,21	812,06±25,22	763,69±33,37	767,93±61,03	0,89
FCR. 15-21 day	1,61±0,009^{a}	1,61±0,005^{a}	1,58±0,017^{ab}	1,57±0,02^{b}	0,045
FC. 22-28 day (gr)	1089,23±1,06	1162,03±1,37	1125,16±1,23	1162,53±1,25	0,96
FCR. 22-28 day	1,86±0,05	1,90±0,01	1,86±0,02	1,88±0,006	0,68
FC. 29-35 day (gr)	935,95±1,65	1015,88±1,58	993,80±3,34	977,04±1,79	0,99
FCR. 29-35 day	2,13±0,01^{a}	2,09±0,04^{ab}	2,05±0,03^{ab}	2,01±0,02^{b}	0,049
FC. 36-42 day (gr)	691,70±1,67	791,92±1,77	702,15±2,46	763,82±1,21	0,97
FCR. 36-42 day	2,44±0,05^{a}	2,36±0,04^{a}	2,30±0,03^{ab}	2,21±0,05^{b}	0,017
FC. 0-42	4111,93±4,21	4376,04±3,43	4214,29±6,33	4317,51±2,96	0,98
FCR. 0-42	1,81±0,04	1,82±0,02	1,73±0,04	1,75±0,01	0,25

a,b: Means in the same column with different superscripts differ significantly (P<0.05)

Tablo 4. The effect of mixture of essential oil and organic acid in rations at different levels on carcass and internal organ parameters in broilers.

	Control	1. Trial	2. Trial	3. Trial	p
Slaughter BW (gr)	2463,00±42,7	2480,80±25,72	2489,55±30,15	2487,45±31,8	0,94
Hot carcass (gr)	1868,30±28,9	1883,00±23,79	1891,10±20,76	1903,52±32,6	0,83
Carcass yield (%)	75,93±0,009	75,91±0,006	75,98±0,003	76,51±0,007	0,92
Heart weight (gr)	14,55±0,72	15,80±0,68	15,65±0,52	14,75±0,66	0,44
Liver weight (gr)	45,05±1,38	47,90±1,49	47,35±2,09	48,70±2,03	0,52
Gizzard weight (gr)	42,95±1,81	41,90±1,12	42,55±2,26	42,10±1,52	0,97
Spleen weight (gr)	2,40±0,16	2,45±0,23	2,75±0,37	2,35±0,22	0,70

The difference between groups is statistically insignificant.

This study was designed to investigate the effects of the supplementation of different levels of essential oil and organic acid in broiler chicks rations on fattening performance, feed utilization, carcass yield and some internal organ weights.

Discussion and Conclusion

In this study, the effect of addition of essential oil and organic acid at different levels (1g / kg, 2g / kg, 3g / kg) on broiler body weight, body weight gain, feed consumption, feed utilization rate and carcass parameters and some internal organ weights were investigated.

On days 0, 7, 14, 21, 28, 35 and 42 of the study, all animals in the control and experimental groups were weighed and recorded. The body weights of the groups at the end of the experiment were 2371 g in the control group and 2448 g, 2461 g and 2510 g in the experimental groups respectively. The mean body weight values of the experimental groups were significantly higher than the control group (P <0.05). At the end of the study, the total weight gain (TWG) averages was 2323 g in the control group and 2399 g, 2418 g and 2462 g in the experimental groups, respectively. The total body weight gain in the experimental groups were higher (P <0.05) than the control group. These data are consistent with the study of Alçiçek et al. (2003). Also similar results were reported by Jang et al., (2004), who observed that; the supplementation of essential oil mixture in broiler rations on the days of the trial 0-21; had any effect on body weight and body weight gain but on the days of the trial 22-35; had significant effects on the increasing in the body weight and the body weight gain averages. However, some researchers [6, 9, 16, 20] reported no beneficial effects in body weight and body weight gain from supplementing of essential oil and/or organic acids to broiler rations. Buğdaycı and Ergün (2011) reported that the addition of essential oil and probiotics to broiler rations did not affect body weight and body weight gain. In another similar study, Köksal and Küçükersan (2012) reported that humate and plant extracts

participating in broiler rations had no positive effect on body weight and body weight gain. Lee et al., (2003) reported that essential oils added to rations did not affect body weight and body weight gain in broilers. Celik and Sahin (2015) reported that essential oil mixtures (mint + thyme + juniper + rosemary) supplementation at different levels to drinking water had any effect on body weight and body weight gain in broilers. It is thought that; the difference between the studies resulting from using the different races and different forms with dozens of the mixture of essential oil and organic acids.

Although there was a statistically significant difference ($P < 0.05$) between the groups in the second, fifth and sixth weeks of the experiment, the statistical difference was not statistically significant when the average of all the work (6 weeks) was taken. Feed utilization rates were calculated as 1.81 in the control group and 1.82, 1.73 and 1.75 in the experimental groups, respectively. It is seen that the lowest fertility rates are in the second and third experimental groups. Feed consumption and feed utilization rates in our study seem to be in harmony with other studies [6, 8, 9, 21]. On the other hand; in similar studies [4, 5], statistical significance was found in the rate of feed utilization with the supplementation of essential essential oils, which is contradictory to the study we conducted. This is thought to be due to the work done in different environmental conditions, the availability of the essential oil involved in the ration, the amount of content and rationality, and the number of animals used in the study.

At the end of the study, there was no difference between hot carcass, carcass yield, heart liver, stomach and spleen weights of the slaughtered animals ($P > 0.05$). In some similar studies have reported that there is no difference between the carcass and internal organ weights and are consistent with the work we have done [6, 9, 16]. On the other hand, Küçükyilmaz et al. (2012) reported that carcass yield was positively affected by the addition of essential oil mixture to broiler chickens.

In conclusion, this study showed that the mixture of essential oils and organic acids added to the broiler rations at different levels significantly improved the live weight and live weight gain and although statistically not important but improved the feed utilization rate positively. This shows that the use of a mixture of essential oils and organic acids in broiler rations as a feed additive for performance improves.

References

1. Alçiçek A, Bozkurt M, Çabuk M (2003): The effect of an essential oil combination derived from sellected herbs growing wild in Turkey on Broiler performance. S. Afr. J Anim Sci, 33: 89-94.
2. Bassett R (2000): Oregano's positive impact on poultry production. World Poultry, 16 (9):31-34.
3. Botsoglou NA, Florou-paner P, Christaki E (2002): Fletouris DJ, Spais AB. Effect of dietary oregano essential oil on performance of chickens and on ironinduced lipid oxidation of breast, thigh and abdominal fat tissues. Br Poult Sci, 43: 223-230.
4. Bozkurt M, Kücükyilmaz K, Çatli AU, Çinar M, Bintaj E (2007): Etlik piliç yemlerine organik asit ve esansiyel yag karışımı ile kombinasyonlarının ilave edilmesinin besi performansı üzerine etkileri. IV. Hayvan Besleme Kongresi, 24-28 Haziran 2007, Bursa. 217-220.
5. Bozkurt M, Küçükyılmaz K, Çatlı AU, Çinar M, Çabuk M (2009): Mısır ve bugday esasli karma yemlere esansiyel yag karışımı ilavesinin erkek ve dişi etlik piliçlerin performansı üzerine etkileri. Hayvan Besleme Kongresi, 30 Eylül-03 Ekim 2009, Çorlu. 261-265
6. Buğdaycı KE, Ergün A (2011): Esansiyel yağ ve/veya probiyotiğin broylerlerde performans immun sistem ve bazı kan parametreleri üzerine etkisi. Ankara Üniv Vet Fak Derg, 58: 279-284.
7. Carpenter CE (2009): Broadbent JR. External Concentration of Organic Acid Anions and pH: Key Independent Variables for Studying How Organic Acids Inhibit Growth of Bacteria in Mildly Acidic Foods. Journal of Food Science, 74: R12–R15. doi:10.1111/j.1750-3841.2008.00994.x
8. Çabuk M, Bozkurt M, Alcicek A, Akbap Y, Kucukyllmaz K (2006): Effect of a herbal essential oil mixture on growth and internal organ weight of broilers from young and old breeder flocks. South African Journal of Animal Science, 36: 135-141.
9. Çelik R, Şahin T (2015): İçme suyuna farklı düzeylerde ilave edilen esansiyel yağ karışımlarının (nane+ kekik+ardıç+ biberiye) broylerlerde besi performansı, kesim ve karkas özellikleri üzerine etkisi. Vet Hekim Der Derg, 86 (1): 22-35.
10. Çiftçi M, Güler T, Dalkiliç B, Ertaş ON (2005): The effects of anise oil (Pimpineíla anisum L) on broiler performance. IntJ Poult Se, 4 (11): 851- 855.
11. Dawson B, Trapp RG (2001): Basic and Clinical Biostatistics. 3rd ed., Lange Medical Books/McGraw Hill Medical Publishing Division, New York.
12. Hume ME, Clemente-Hernandez S, Oviedo-Rondont EO (2006): Effects of feed additives and mixed Eimeria species infectionon intestinal microbial ecology of broilers. Poult Sci. 85: 2106–2111.
13. Humphrey TJ, Lanning DG (1988): The vertical transmission of salmonellas and formic acid treatment of chicken feed: a possible strategy for control. Epidemiology and infection, 100.01: 43-49.
14. Jang IS, Ko YH, Yang HY, Ha JS, Kim JY, Kim JY, Kang SY, Yoo DH, Nam DS, Kim DH, Lee CY (2004): Influence of Essential Oil Components on Growth Performance and the Functional Activity of the Pancreas and Small Intestine in Broiler Chickens. Asian-Aust. J. Anim. Sci, 17 (3) : 394-400.
15. Kamel C (2001): Tracing modes of action and the roles of plant extracts in non-ruminants. In: Recent advances in animal nutrition.

(Ed. P. C. Garnsworthy and J. Wiseman). Nottingham University Press. Nottingham, 135-150.

16. Köksal BH, Küçükersan MK (2012): Broyler rasyonlarına humat ile bitki ekstraktı karışmı ilavesinin büyüme performansı, bazı bağışıklık ve serum biyokimya değerlerine etkileri. Kafkas Üniv Vet Fak Derg, 18(1): 103-108.
17. Krishan G, Narang A (2014): Use of essential oils in poultry nutrition: A new approach. J. Adv. Vet. Anim. Res, 1(4): 156-162.
18. Küçükyılmaz K, Çatlı AU, Çınar M (2012): Etlik Piliç Yemlerine Esansiyel Yağ Karışımı İlavesinin Büyüme Performansı, Karkas Randımanı Ve Bazı İç Organlar Ağırlıkları Üzerine Etkileri. Kafkas Üniv Vet Fak Derg, 18(2): 291-296.
19. Lambert RJW, Skandamis PN, Coote PJ, Nychas GJE (2001): A Study of The Minimum İnhibitory Concentration and Mode of Action of Oregano Essential Oil, Thymol and Carvacrol. J App Microbiol, 9: 453-462.
20. Lee KW, Everts H, Kappert HJ, Frehner M, Losa,R, Beynen AC (2003): Effects of dietary essential oil components on growth performance, digestive enzymes and lipid methabolism in female chickens. Br. Poult. Sci, 44 (3): 450-457.
21. Rezaei–Moghadam A, Mohajeri D, Rafiei B, Dizaji R, Azhdari A, Yeganehzad M, Shahidi M, Mazani M (2012): Effect of turmeric and carrot seed extracts on serum liver biomarkers and hepatic lipid peroxidation, antioxidant enzymes and total antioxidant status in rats. BioImpacts, 2: 151-57.
22. Svoboda PK, Hampson BJ (1999): Bioactivity of Essential Oils of Selected Temperate Aromatic Plants: Antibacterial, Antioxidant, Antiinflammatory and Other Related Pharmacological Activities. Aromatopia, 35: 50–54.
23. Tiihonen K, Kettunen H, Bento MH, Saarinen M, Lahtinen S, Ouwehand AC, Schulze H, Rautonen N (2010): The effect of feding essential oils on broiler performance and gut microbiota. Br. Poult Sci. 51 (3): 381-92.
24. Van Immerseel F, Russell JB, Flythe MD, Gantois I, Timbermont L, Pasmans F, Haesebrouck F, Ducatelle R (2006): The use of organic acids to combat Salmonella in poultry: a mechanistic explanation of the efficacy, Avian Pathology, 35: 182-188, DOI: 10.1080/03079450600711045.
25. Wenk C (2000): Recent Advances in Animal Feed Additives such as Metabolic Modifiers, Antimicrobial Agents, Probiotics, Enzymes and Highly Available Minerals Review. Asian-Australasian Journal of Animal Sciences, 13 (1): 86-95. doi: https://doi.org/10.5713/ajas.2000.86
26. Young KM, Foegeding, PM (1993): Acetic, Lactic and Citric Acids and pH Inhibition of Listeria Monocytogenes Scott a and the Effect on Intracellular pH. J. Appl. Bacteriol, 74 (5): 515-520.