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Research Article
Effect of Weaning Age and Using Mixture of Cumin, Mentha Extracts with Cow Milk as a Supplementation on Growing Rabbits Performances

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Abstract

Background and Objective: Early weaning seems to be a feasible practice that could have interesting possibilities from a productive point of view. While, the rabbits during weaning period are sensitive to multifactorial digestive disorders. Therefore, the aim of the study was to evaluate the response of early weaning rabbits at 21 days for 6 days supplementation with a mixture of mentha, cumin extracts and cow milk (MCM), compared with rabbits weaned at 2 and 27 days without supplementation. **Materials and Methods:** A total of 288 weaned rabbits were used from four breeds (New Zealand White, California, Chinchilla and Rex). Rabbits were divided into three treated groups, each group containing 96 rabbits. The 1st group was kits weaned at 27 days (G27), the 2nd group at 21 days (G21) and the 3rd group at 21 days (GS21) and supplemented for 6 days with a fresh mixture of MCM. At 27 days of age, blood samples were taken form 36 rabbit (12 from each treatment). During the growth period of rabbits' individual live body weight and feed consumption were recorded weekly and feed conversion efficiency was calculated. At the end of the experiment (70 days of age) 36 male rabbits (12 from each treatment) were slaughtered for carcass traits evaluation and meat analysis. **Results:** The live body weight and the average daily gain were significantly ($p<0.05$) improved when 21 days weaned rabbits were supplemented with MCM mixture (GS21), compared with groups G27 and G21. The MCM mixture was more effective without any adverse effect on the blood biochemical changes at 27 days of age. The supplemented group (GS21) showed lower digestive disorders cases. At 70 days of age, the MCM mixture improved some carcass traits and increased crude protein and ash contents in the rabbit meat (GS21). Moreover, group GS21 showed significantly lower feed cost per kilogram weight gain and higher performance index and economic efficiency values. **Conclusion:** In summary, supplementing with the MCM mixture could improve significantly the early weaned rabbit performance (21 days of age) without any adverse effect.

Key words: Early weaning, mentha, cumin, cow milk, growth performance, meat quality, blood plasma constituents, feed efficiency

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Weaning in rabbits is a complex step causing dietary, environmental and psychological stresses influencing gastro-intestinal tract development, feed intake and adaptation to the weaning diet[1]. The most used rabbits weaning systems are traditional weaning (over 35-42 days post-partum), semi-intensive weaning (at 28-35 days post-partum) and intensive weaning (at 21-28 days post-partum)[2]. Generally, earlier weaning has some advantages for both kits and dams: Specific starter diets could better cover kit nutritional requirements[3-5], improves the health status of the doe and its body condition[3,6,7] and shorter lactation periods could reduce the doe energy output for milk production and consequently, body energy deficit[8]. Up to 18-20 days, rabbits ingest only milk, while from this point onwards they begin to consume solid feed as well, initially in small quantities and subsequently, as their mother's milk yield diminishes in ever increasing quantities[9]. After 20-25 days, the maternal milk production decreases progressively[10]. Therefore, early weaning at 21-25 days seems to be a feasible practice that could have interesting possibilities from a productive point of view[6]. Although, artificial milk feeding for early weaning kits is technically possible and used previously by McNitt and Moody Jr.[11,12] and Ferguson *et al.*[13], despite the potential benefits, these methods had not been accepted by the commercial industry. The high cost of artificial milk and the degree of skill involved are limitations of these methods. However, the period of 10-15 days after weaning is the most critical period when rabbits are most susceptible to gastro-intestinal infections and at greatest risk of a fatal outcome[14,15]. In this period, rabbits are sensitive to multifactorial digestive disorders, which can determine high mortality rate[16], so intensive use of antibiotics occurs. The World Health Organization (WHO) has recently identified antibiotic resistance as a major problem for public health on a global scale[17]. Therefore, there are strategies to reduce antibiotic use in rabbit production include the use of prebiotics, probiotics, organic acids, synbiotics, enzymes, immune modulators and plants and their extracts[18-20]. Regarding medical plants and their extracts, mainly acting as antioxidants, antimicrobial agents, immune and digestion stimulants. Therefore, generally they can improve the productive performances[21]. However, cumin (*Cuminum cyminum* L.) seeds yields 2.5-4.0% essential oil which has reputation as an important economic drug because of their stomach, diuretic, carminative, stimulant, astringent and their biological activities (antimicrobial, antifungal, antiviral, antitumor and anti-inflammatory)[22,23], hypoglycemic agents[24] and rabbit growth promoter[25]. Moreover, *Mentha piperita* is one of the world's oldest medicinal herbs, this plant is containing about 1.2-1.5% essential oils[17]. The principal components of the oil are menthol (35-55%), menthone (20-30%) and menthylacetate (3-10%)[26]. However, evidence about the effect of feeding cumin and mentha extracts mixed with fresh cow milk on early weaning rabbit performance is scarce and not sufficient. Therefore, the aim of this study was to evaluate the response of early weaning rabbits at 21 days for 6 days supplementation with a mixture of mentha, cumin extracts and cow milk (MCM), compared with 21 and 27 days without any supplementation on the growth performance, blood plasma constituents, carcass traits, digestive disorders and meat quality of growing rabbits.

MATERIALS AND METHODS

A total number of 36 female rabbits at 12-15 weeks of age were used in this study from four breeds (New Zealand White, California, Chinchilla, Rex). Does were randomly distributed to 3 groups having nearly similar average weights (12 does each). The study was performed on 288 of kits and subdivided randomly into 3 groups according to weaning age, the 1st group was rabbits weaned at age of 27 days (G27), the 2nd group was weaned at 21 days (G21) and the 3rd group was weaned at 21 days supplemented with the tested mixture (GS21) for 6 days. Weaning rabbits were group housed in galvanized wire cages (4 rabbits/cage), measuring ($33\times50\times25$ cm) until slaughtering and were kept under the same managerial conditions. Each cage was supplied with a feeder and a stainless-steel nipple for drinking. Two liters of the mixture were prepared by soaking dry *Mentha piperita* leaves (4 g) and *Cuminum cyminum* (10 g) for 5 min in 1 L of distilled boiled water. Then the extract was filtered and mixed with 1 L fresh cow milk (MCM mixture) and used at 40°C for the rabbits weaned at 21 days of age once a day (9 am). The chemical composition of the MCM mixture was 1.52% protein, 2.49% fat, 4.06% solid not fat and 2.13% lactose (measured by milk analyzer lactoscan). The MCM mixture provided by using the water system and after recording the MCM consumption the system was cleaned twice by using hot water and then refill with fresh water. Rabbits fed a commercial rabbit pelleted diet once a day from the beginning until the end of the experiment, which was formulated to meet their nutrient requirements[27]. During the growth period of rabbits (70 days of age) individual live body weight and feed consumption were recorded weekly and feed conversion efficiency was calculated. At 27 days of age, blood samples were taken from 36 weaned rabbits by slaughtering 12 rabbits from each group, of 3 replicates for each breed. Blood samples were taken immediately after the slaughter of rabbits, two blood samples from each animal were taken into test tubes and the first tube contained EDTA, while 2nd tube without any addition (non-heparinize). Blood samples in tubes contained EDTA were used to perform complete blood picture. Tubes without any addition (non-heparinized) were centrifuged at 4000 rpm for 10 min to separate clear serum, which were stored at -20°C until determination of blood constituents, liver function enzyme alanine aminotransferase (ALT), red blood cells, white blood cells, total protein, albumin, globulin and hemoglobin by using commercial kits. At the end of the experiment (70 days of age) 36 male rabbits (12 from each treatment) were randomly taken after being fasted for 12 h and slaughtered for carcass traits evaluation and meat analysis. Meat samples were collected from 36 male rabbits of each breed separately and were subjected to analysis for water, crude protein, ether extract (fat) and ash according to AOAC[28]. From these values, the energy value was calculated equation for:

$$\text{EC (kJ/100 g)} = 16.75\times\text{Protein content}+37.68\times\text{Fat content}^{29}$$

Data were statistically analyzed using the general linear model SAS[30] for complete randomized design. The significant differences among means were assigned using Duncan multiple range test method[31].

RESULTS AND DISCUSSION

The average live body weight and average daily gain of growing rabbits are presented in Table 1. Results obtained showed that at 27 days of kits age the live body weight and the average daily gain were significantly (p<0.05) improved when 21 days weaned rabbits were supplemented with MCM mixture (GS21), compared with groups G27 and G21. Generally, all rabbits' breeds used in the study had the same trend of growth performance, since the four breeds in group GS21 had the highest growth values, compared with the same breeds in the other tested groups (G27) and (G21)[32]. However, at 34 days, because of the weaning shock the rabbits supplemented with MCM mixture showed a significant decrease (p<0.05) in daily gain and live body weight. Generally, the final weight of group GS21 was significantly higher than groups G27 and G21 by about 8.43 and 3.02%, respectively. Group GS21 showed the highest significant (p<0.05) total daily gain (29.09 g day^{-1}), compared with other groups G27 and G21 (26.29 and 28.27 g day^{-1}, respectively). Similar result of a higher live weight of the early weaned rabbits was recorded at 35 days of age by Xiccato *et al.*[33], Gidenne and Fortun-Lamothe[34] and Zita *et al.*[35]. While, Tumova *et al.*[36] and Rajeshwari *et al.*[37] did not find any significant differences of early weaning in live weight during the time of fattening. By contrast, the negative effect of early weaning on final live weight was found[5,35,38-40]. On the other hand, researches using artificial milk[11,13] formula reported slower post-weaning growth rates for 14 days weaned kits and artificial milk fed to 21 days versus 28 days weaned kits nursed by dams. Moreover, a number of experiments have provided evidence that young rabbits reach slaughter weight 6-9 days earlier as a result of the rearing by two does[41-45].

Table 1: Effect of rearing systems on body weight and daily gain of growing rabbits

Parameters	G27	G21	GS21	±SEM
Body weight (g)				
21 days	320.05	323.75	316.12	3.48
27 days	362.06^{b}	366.74^{b}	381.49^{a}	4.32
34 days	443.29^{c}	483.11^{a}	460.56^{b}	6.33
41 days	568.65^{b}	647.83^{a}	647.60^{a}	7.46
48 days	750.10^{c}	814.34^{b}	876.14^{a}	8.55
55 days	976.97^{b}	962.13^{b}	1094.50^{a}	8.06
62 days	1201.85^{c}	1253.14^{b}	1362.08^{a}	9.81
Final weight (g)	1467.39^{c}	1554.07^{b}	1602.45^{a}	10.95
Daily weight gain (g day^{-1})				
21-27 days	6.00^{b}	6.23^{b}	9.34^{a}	0.36
27-34 days	11.43^{b}	16.65^{a}	11.42^{b}	0.57
34-41 days	17.91^{c}	23.53^{b}	26.72^{a}	0.73
41-48 days	25.92^{c}	23.79^{b}	32.65^{a}	0.63
48-55 days	32.41^{a}	21.11^{b}	31.19^{a}	0.75
55-62 days	32.12^{c}	41.57^{a}	38.23^{b}	0.86
62-69 days	37.93^{b}	42.99^{a}	34.34^{c}	0.96
Total daily gain (g)	26.29^{c}	28.27^{b}	29.09^{a}	0.25

$^{a-c}$Mean in the same row with different superscripts are significantly different at p<0.05

Table 2: Effect of rearing systems on blood plasma constituents of growing rabbits at 27 days of age

Parameters	G27	G21	GS21	±SEM
Total protein (g dL^{-1})	4.79^{a}	4.13^{b}	4.66^{a}	0.12
Albumin (g dL^{-1})	2.58^{a}	2.21^{b}	2.55^{a}	0.08
Globulin (g dL^{-1})	2.22	2.01	2.08	0.11
A/G ratio (g dL^{-1})	1.16	1.10	1.23	0.02
Hemoglobin (g dL^{-1})	11.10	10.86	11.17	0.25
Red blood cells ($\times10^{6}$ mm^{-3})	4.00	3.97	4.01	0.05
White blood cells ($\times10^{6}$ mm^{-3})	3725.00	3687.50	4037.50	121.57
Alanine aminotransferase (ALT) (U L^{-1})	17.36^{b}	19.94^{a}	20.36^{a}	0.76

^{a,b}Mean in the same row with different superscripts are significantly different at p<0.05

Data presented in Table 2 cleared decreases at 27 days of age in blood protein fractions (total protein, albumin and globulin) and A/G ratio in rabbits weaned at 21 days of age (G21). While, no significant differences (p<0.05) were detected in blood protein fractions between rabbits weaned at 21 days supplemented with MCM mixture (GS21) and that weaned at 27 days (G27). In this way, there were no significant differences in hemoglobin, RBC and WBC concentrations among all

Table 3: Effect of rearing systems on frequency of some digestive disturbances cases in growing rabbits

Parameters (%)	No.	G27	G21	GS21
Diarrhea incidence	24	54.17	33.33	12.50
Bloat incidence	9	55.56	22.22	22.22
Coccidiosis incidence	5	40.00	40.00	20.00

Table 4: Effect of rearing systems on carcass traits of growing rabbits slaughtered at 70 days of age

Parameters	G27	G21	GS21	±SEM
Pre-slaughter weight (g)	1317.92^{c}	1420.42^{b}	1476.25^{a}	8.16
Carcass (g)	713.34^{c}	757.50^{b}	791.67^{a}	7.36
Dressing (%)	54.13	53.33	53.63	1.12
Head (g)	79.17^{b}	81.25^{ab}	85.00^{a}	1.38
Hind legs (g)	170.00^{b}	190.83^{a}	200.42^{a}	3.39
Fore legs (g)	95.83^{c}	102.50^{b}	107.92^{a}	1.38
Liver (g)	46.25^{b}	56.25^{a}	56.25^{a}	1.56
Kidney (g)	12.38^{b}	14.22^{a}	14.08^{a}	0.44
Heart (g)	5.48^{a}	5.04^{b}	5.77^{a}	0.18
Spleen (g)	1.33	1.33	1.43	0.05
Lung (g)	12.50^{b}	17.08^{a}	14.58^{b}	0.80

$^{a-c}$Mean in the same row with different superscripts are significantly different at p<0.05

Table 5: Effect of rearing systems on chemical composition (%) and meat quality of growing rabbits at 70 days of age

Parameters	G27	G21	GS21	±SEM
Dry matter	25.40	24.80	25.50	0.40
Crude protein	78.00^{b}	84.20^{a}	84.00^{a}	1.80
Crude fat	12.40	10.60	11.70	1.00
Ash	3.40^{b}	4.80^{a}	4.30^{a}	0.20
Energy value (kJ/100 g)	450.80	448.30	470.70	11.80
pH	7.21	7.27	7.28	0.03
WHC	32.90	33.19	33.51	2.18
PWC	0.27^{b}	0.28^{a}	0.29^{a}	0.00
PWFC	0.25^{b}	0.27^{a}	0.28^{a}	0.00
Feder value	3.50	3.60	3.50	0.10

^{a,b}Mean in the same row with different superscripts are significantly different at p<0.05, WHC: Water holding capacity, PWC: Protein-water coefficient = (protein%/water%), PWFC: Protein-water-fat coefficient = (protein%/ moisture%+fat%), Feder value = (moisture%/organic not fat%)

studied groups. The liver enzyme (ALT) was increased significantly (p<0.05) in rabbits weaned at 21 days (groups G21 and GS21) when compared with that weaned at 27 days. However, a late weaning used almost to reduce mortality during fattening, probably because of the milk protective role[46,47]. Later weaned rabbits could also present a more mature immune system[2]. Moreover, significant effects of cumin seeds and its essential oil on New Zeland White rabbits growing performance, digestibility and some metabolic enzymes functions were observed[25]. In the present study, supplementing the early weaned rabbits at 21 days of age with the MCM mixture was more effective without any adverse effect on the blood biochemical changes at 27 days of age and animal health in general.

Table 3 showed that supplementing the early weaning rabbits with MCM mixture (GS21) caused lower digestive disorders cases, compared with other groups (G27) and (G21). Generally, during the experiment few digestive troubles and no cases of mortality were observed, an exceptional occurrence in rabbit breeding may be partly explained by the good management and environmental conditions. However, in the present study mortality was not affected by the weaning age. According to Trocino *et al.*[48] and Xiccato *et al.*[33], the weaning age also did not affect the mortality. While, Gidenne and Fortun-Lamothe[34] and Zita *et al.*[35] reported higher mortalities in the early weaned rabbits at 21 days.

Carcass traits of slaughtered rabbits for different groups are shown in Table 4. There were significant differences (p<0.05) in the final slaughter body weight and carcass weight among the different groups. It could be noticed that the supplemented group (GS21) with the MCM mixture showed the highest final slaughter body weight and carcass weight (1476.25 and 706.67 g, respectively), compared with the 21 days weaned rabbits G21 (1420.42 and 676.25 g, respectively) and the 27 days weaned rabbits G27 (1317.92 and 634.17 g, respectively). The MCM mixture increased significant (p<0.0) the carcass fore legs weight of the 21 days weaned rabbits (GS21). In general, the carcass hind legs and the giblets weights (liver and kidney) were significantly affected with the early weaning (G21 and GS21), compared with 27 days weaned rabbits (G27). However, there was no significant effect detected for dressing percentage among tested groups. Generally, little is known about carcass performance of early weaned rabbits. Zita *et al.*[35] found that the weaning age influenced the slaughter and carcass characteristics (except the drip loss percentage and dressing out percentage) and was insignificantly higher in rabbits weaned at 21 days of age in comparison with rabbits weaned at 35 days of age. While, Bivolarski *et al.*[39] indicated a statistically significant lower body mass and dressing percentage in early weaned rabbits at 21 days of age as compared to normally weaned animals at 35 days.

According to the statistical analysis of data in Table 5, it could be noticed that, there was no significant (p<0.05) impact due to the early weaning and the supplementation with MCM mixture on dry matter, crude fat, energy value, pH, WHC and feder value of rabbit's meat at 70 days of age. However, there were significant increases (p<0.05) in crude protein and ash contents in the meat of early weaned groups (G21 and GS21), compared with the 27 days weaned rabbits (G27). Similarly, the same trend was detected in the texture indices (PWC and PWFC). The less value of PWC and PWFC, the

Table 6: Effect of rearing systems on economic efficiency of growing rabbits

Parameters	G27	G21	GS21	±SEM
Total weight gain (g)	1147.34[c]	1230.32[b]	1286.33[a]	14.40
Total MCM intake (mL)	-	-	225.52	2.21
Daily water intake (mL)	8.53[b]	9.04[b]	10.30[a]	0.25
Daily dry matter intake (g)	73.81[c]	79.64[b]	80.48[a]	0.07
Water intake/dry matter (mL g^{-1})	0.116[b]	0.114[b]	0.128[a]	0.02
Feed conversion ratio* (g g^{-1})	2.79[a]	2.82[a]	2.76[b]	0.01
Feed cost/weight gain (LE)	10.13[a]	10.16[a]	9.99[b]	0.03
Performance index[#]	52.59[b]	55.11[b]	58.06[a]	2.14
Economic efficiency[$]	127.05[b]	126.38[b]	130.23[a]	3.02

[a-c]Means in the same row with different superscripts are significantly different at p<0.05. The prevailing price per kilogram at the time of study was 3.60 LE for commercial rabbit diet and 1.45 LE L^{-1} for MCM mixture. While selling prices of 1 kg rabbit live body weight was 23 LE, *Feed conversion ratio = Dry matter/total gain, [#]Performance index = (live body weight/feed conversion)×100, [$]Economic efficiency = ((Price of 1 kg live body weight-feed cost kg^{-1} weight gain)/feed cost kg^{-1} weight gain)×100

more tenderness of the meat is vice versa. The significant increase of the texture indices in G21 and GS21 groups may be due to the increase in protein content and the decrease in fat and moisture content. Generally, the present results clarify that there were no significant differences between the 21 days weaned rabbits, neither supplemented nor non-supplemented with MCM mixture, in the tested meat chemical composition and its quality traits, but they significantly differed with 27 days weaned rabbits for some traits.

Results in Table 6 showed that the daily water intake, dry mater intake and water intake/dry matter intake increased significantly (p<0.05) when supplementing rabbits weaned at 21 days with the MCM mixture (GS21), compared with the other tested groups (G27) and (G21). Additionally, results detected significantly lower values (p<0.05) in the feed conversion ratio and feed cost/weight gain due to the supplementation with MCM mixture (GS21). The performance index and the economic efficiency values of the supplemented group (GS21) surpassed the group (G27) by about 9.42 and 2.44%, respectively. On the other hand, no significant (p<0.05) differences were detected in this aspect between the two groups G27 and G21. Similarly, some studies demonstrated that the early weaned rabbits at 21 days had a higher feed consumption in comparison with rabbits weaned at 28 and 35 days of age[36,40,49,50]. While, some studies reported that early weaning age did not influence feed consumption[5,35].

CONCLUSION

There was a tendency for increasing rabbits live body weight with animals age advanced in all groups. However, such effects were more pronounced with supplementing rabbits weaned at 21 days of age with the tested MCM mixture for 6 days. The MCM mixture improved the 21 days weaned rabbits' growth performance, did not affect the blood biochemical fractions, caused lower digestive disorders and improved some carcass traits. From the economical point of view, supplementing 21 days weaned rabbits with the MCM mixture showed significantly lower feed coast per kilogram gain, higher performance index and economic efficiency, compared with rabbits weaned at 27 and 21 days without supplementation. Generally, as a result of rearing 21 days weaned rabbits with the MCM mixture, rabbits reached the slaughter weight about 6 days earlier than rabbits weaned at 27 days.

REFERENCES

1. Bhatt, R.S., A.R. Agrawal and A. Sahoo, 2017. Effect of probiotic supplementation on growth performance, nutrient utilization and carcass characteristics of growing Chinchilla rabbits. J. Applied Anim. Res., 45: 304-309.
2. Ferrian, S., 2012. Immune response on rabbit does of different genetic types subjected to reproductive, environment and immunologic challenges. Ph.D. Thesis, Production and Animal Health, CEU Cardenal Herrera University, Spain.
3. Gidenne, T. and L. Fortun-Lamothe, 2002. Feeding strategy for young rabbits around weaning: A review of digestive capacity and nutritional needs. Anim. Sci., 75: 169-184.
4. Gutierrez, I., A. Espinosa, J. Garcia, R. Carabano and J.C. de Blas, 2002. Effect of levels of starch, fiber and lactose on digestion and growth performance of early-weaned rabbits. J. Anim. Sci., 80: 1029-1037.
5. Kovacs, M., A. Bonai, Z. Szendro, G. Milisits and H. Lukacs *et al*., 2012. Effect of different weaning ages (21, 28 or 35 days) on production, growth and certain parameters of the digestive tract in rabbits. Animal, 6: 894-901.
6. Pascual, J.J., 2001. Early weaning of young rabbits: A review. World Rabbit Sci., 4: 165-170.
7. Xiccato, G., A. Trocino, A. Sartori and P.I. Queaque, 2001. Influence de lage, du sevrage precoce et de laliment sur le developpement des organes digest ferme caecales chez le jeune lapin. Proceedings of the 9th Journees Recherche Cunicoles, November 2001, Paris, France, pp: 199-202.
8. Parigi-Bini, R. and G. Xiccato, 1998. Energy Metabolism and Requirements. In: The Nutrition of the Rabbit, De Blas, C. and J. Wiseman (Eds.). CABI Publishing, Wallingford, UK., pp: 103-132.
9. Nizza, A., G. Stanco, M.L. Di Meo, C. Marongiu, S. Taranto, M.I. Cutrignelli and L. Juliano, 2002. Effect of pre-weaning solid feed and milk intake on caecal content characteristics and performance of rabbits around weaning. Ital. J. Anim. Sci., 2: 95-101.
10. Gidenne, T., F. Lebas and L. Fortun-Lamothe, 2010. Feeding Behaviour of Rabbits. In: The Nutrition of the Rabbit, De Blas, C. and J. Wiseman (Eds.). CABI Publishing, Wallingford, UK., pp: 233-252.

11. McNitt, J.I. and G.L. Moody Jr., 1992. A method for weaning rabbit kits at 14 days. J. Applied Rabbit Res., 15: 661-665.
12. McNitt, J.I. and G.L. Moody Jr., 1993. Effects of early weaning on rabbit doe productivity. Profess. Anim. Sci., 9: 6-9.
13. Ferguson, F.A., S.D. Lukefahr and J.I. McNitt, 1997. A technical note on artificial milk feeding of rabbit kits weaned at 14 days. World Rabbit Sci., 5: 65-70.
14. Gallois, M., I. Le Huerou-Luron, L. Fortun-Lamothe, J.P. Lalle and T. Gidenne, 2008. Adaptability of the digestive function according to age at weaning in the rabbit: I. Effect on feed intake and digestive functionality. Animal, 2: 525-535.
15. Bivolarski, B.L. and E.G. Vachkova, 2014. Morphological and functional events associated to weaning in rabbits. J. Anim. Physiol. Anim. Nutr., 98: 9-18.
16. Cesari, V., I. Toschi, V. Ferrazzi, N. Cesari, G. Grilli and A. Lavazza, 2007. Effect of weaning age and diet on growth performance, caecal characteristics and potential pathogenetic microflora in rabbits. Ital. J. Anim. Sci., 6: 755-757.
17. Fallah, R., A. Kiani and A. Azarfar, 2013. Effect of artichoke leaves meal and mentha extract (*Mentha piperita*) on immune cells and blood biochemical parameters of broilers. Global Veterinaria, 10: 99-102.
18. Falcao-e-Cunha, L., L. Castro-Solla, L. Maertens, M. Marounek, V. Pinheiro, J. Freire and J.L. Moura, 2007. Alternatives to antibiotic growth promoters in rabbit feeding: A review. World Rabbit Sci., 15: 127-140.
19. Maertens, L.L.C., 2011. Strategies to reduce antibiotic use in rabbit production. J. Agric. Sci. Technol. A, 1: 783-792.
20. Bovera, F., A. Lestingi, F. Iannaccone, A. Tateo and A. Nizza, 2012. Use of dietary mannanoligosaccharides during rabbit fattening period: Effects on growth performance, feed nutrient digestibility, carcass traits and meat quality. J. Anim. Sci., 90: 3858-3866.
21. Lee, J.H., S. Cho, H.D. Paik, C.W. Choi, K.T. Nam, S.G. Hwang and S.K. Kim, 2014. Investigation on antibacterial and antioxidant activities, phenolic and flavonoid contents of some Thai edible plants as an alternative for antibiotics. Asian-Australasian J. Anim. Sci., 27: 1461-1468.
22. Nalini, N., K. Sabitha, P. Viswanathan and V.P. Menon, 1998. Influence of spices on the bacterial (enzyme) activity in experimental colon cancer. J. Ethnopharmacol., 62: 15-24.
23. Kalemba, D. and A. Kunicka, 2003. Antibacterial and antifungal properties of essential oils. Curr. Med. Chem., 10: 813-829.
24. Ali, F.M.H., 2001. Hypoglycemic activity of methylchavicol and cuminaldehyde as major components of basil, cumin essential oil. Proceedings of the 1st International Conference of Role of Biochemistry in Environment and Agriculture, February 6-8, 2001, Cairo University, Giza, Egypt, pp: 1-9.
25. El-Manylawi, M.A. and H.F.M. Ali, 2009. Gas chromatography-mass spectroscopy analysis and evaluate cumin seeds and their essential oil as growth promoters of New Zeland white rabbits. Int. J. Agric. Res., 4: 107-115.
26. ESCOP., 2003. Thymi herba monographs on the medicinal uses of plant drugs. European Scientific Cooperative on Phytotherapy (ESCOP), Exeter, UK.
27. NRC., 1977. Nutrients Requirements of Rabbits. 2nd Edn., National Academies Press, Washington, DC., USA., ISBN: 9780309598774, Pages: 30.
28. AOAC., 2000. Official Methods of Analysis. 17th Edn., Association of Official Analytical Chemistry, Arlington, Virginia, USA.
29. Simonova, M.P, L. Chrastinova, J. Mojto, A. Laukova, R. Szabova and J. Rafay, 2010. Quality of rabbit meat and phyto-additives. Czech J. Food Sci., 28: 161-167.
30. SAS., 2008. SAS/STAT Software for Windows 9.2. SAS Institute Inc., Cary, NC., USA.
31. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
32. Rahma, H.M., 2016. Studies on rabbits rearing systems. Ph.D. Thesis, Animal Production Department, Faculty of Agriculture, Mansoura University, Egypt.
33. Xiccato, G., A. Trocino, A. Sartori and P.I. Queaque, 2003. Effect of weaning diet and weaning age on growth, body composition and caecal fermentation of young rabbits. Animal Sci., 77: 101-111.
34. Gidenne, T. and L. Fortun-Lamothe, 2004. Growth, health status and digestion of rabbits weaned at 23 or 32 days of age. Proceedings of the 8th World Rabbit Congress, September 7-10, 2004, Mexico, pp: 846-852.
35. Zita, L., Z. Ledvinka, K. Mach, J. Kocar, L. Klesalova, A. Fucikova and H. Hartlova, 2012. The effect of different weaning ages on performance in Hyla rabbits. Proceedings of the 10th World Rabbit Congress, September 3-6, 2012, Sharm El-Sheikh, Egypt, pp: 61-64.
36. Tumova, E., L. Zita, M. Marounek, V. Skrivanova and A. Berladyn, 2006. The effect of weaning age on performance, nutrient digestibility and lipase activity in broiler rabbits. Proceedings of the 3rd Rabbit Congress of the Americas, August 21-23, 2006, Maringa, Parana, Brazil.
37. Rajeshwari, Y.B., R. Guruprasad and K. Sathyanarayana, 2010. Effect of weaning at different age intervals on the growth rate of broiler rabbits. Vet. World, 3: 171-172.
38. Vachkova, E.G., I.P. Georgiev, B.L. Bivolarski and R. Konakchieva, 2010. Relationships between plasma concentrations of epidermal growth factor, insulin and iodated thyroid hormones in early and normal weaned rabbits. Revue Medecine Veterinaire, 161: 30-36.

39. Bivolarski, B., G. Beev, S. Denev, E. Vachkova, G. Kostadinova and T. Slavov, 2011. Development of the caecal microbiota in rabbits weaned at different age. Agric. Sci. Technol., 3: 212-219.
40. Andras, B., 2014. Examination of the effects of certain factors influencing caecal fermentation in rabbits. Ph.D. Thesis, Faculty of Agricultural and Environmental Sciences, University of Kaposvar, Hungary.
41. McNitt, J.I. and G.L. Moody Jr., 1988. Milk intake and growth rates of suckling rabbits. J. Applied Rabbit Res., 11: 117-119.
42. Szendro, Z., G. Milisits, G. Papp, T. Gyarmati, A. Levai, I. Radnai and E. Biro-Nemeth, 1998. Milk intake and weight gain of rabbits suckled twice a day. 10 Nyultenyesztesi Tudomanyos Nap, Kaposvar, pp: 35-41.
43. Gyarmati, T., Z. Szendro, E. Biro-Nemeth, I. Radnai, G. Papp and G. Milisits, 1999. Effect of double suckling on the production of kits. 11. Arbeitstagung uber Pelztier-, Kaninchenund Heimtierproduction und Krankenheiten, Celle, Ed. Deutsche Vet. Med. Gesellschaft e.V., Giessen, pp: 18-24.
44. Gyarmati, T., Z. Szendro, L. Maertens, E. Biro-Nemeth, I. Radnai, G. Milisits and Z. Matics, 2000. Effect of suckling twice a day on the performance of suckling and growing rabbits. Proceedings of the 7th World Rabbit Congress, July 4-7, 2000, Valencia, Spain.
45. Szendro, Z., T. Gyarmati, L. Maertens, I. Radnai, E. Biro-Nemeth and Z. Matics, 2000. Production of rabbits nursed with two does. 1. Milk production of does and milk intake of young. Proceedings of the 7th World Rabbit Congress, July 4-7, 2000, Valencia, Spain.
46. Fortun-Lamothe, L. and S. Boullier, 2007. A review on the interactions between gut microflora and digestive mucosal immunity. Possible ways to improve the health of rabbits. Livestock Sci., 107: 1-18.
47. Gallois, M., T. Gidenne, C. Tasca, C. Caubet, C. Coudert, A. Milon and S. Boullier, 2007. Maternal milk contains antimicrobial factors that protect young rabbits from enteropathogenic *Escherichia coli* infection. Clin. Vaccine Immunol., 14: 585-592.
48. Trocino, A., G. Xiccato, A. Satori and P.I. Queaque, 2001. Effect of starter diet and weaning age on growth, caecal fermentation and body composition of young rabbits. Proceedings of the 2nd Meetings of Workgroup 3rd and 4th COST Action 848, June 29-30, 2001, Hungary, pp: 52-53.
49. Gallois, M., T. Gidenne, L. Fortun-Lamothe, I. Le Huerou-Luron and J.P. Lalles, 2005. An early stimulation of solid feed intake slightly influences the morphological gut maturation in the rabbit. Reprod. Nutr. Dev., 45: 109-122.
50. Kovacs, M., G. Milisits, Z. Szendro, H. Lukacs and A. Bonai *et al*., 2008. Effect of different weaning age (days 21, 28 and 35) on caecal microflora and fermentation in rabbits. Proceedings of the 9th World Rabbit Congress, June 10-13, 2008, Verona, Italy, pp: 701-704.