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Response of Growing New Zealand White Rabbits to Diets Containing Different Levels of Energy and Mixture of Some Medicinal Plants

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Abstract: A total number of 54 male growing New Zealand White rabbits were used to study the effect of two different levels of energy supplemented with herbs mixture at level of (1:1:1) of *Artemisia herba-alba, Matricaria recutita* L. *and Chrysanthemum coronarium*. Rabbits were classified into six equal groups (G_1-G_6). The 1st and 4th groups received basal ration with 100% and 90% of energy requirement. The 2nd and the 3rd groups received basal ration with 100% of energy requirement supplemented with herbs mixture at the level of 1.0 and 2.0%, respectively. The 5th and 6th groups received basal ration with 90% of energy requirement with herb mixture at the level of 1.0% and 2.0%, respectively. Supplementation of herbs mixture used at 1% significantly ($P<0.05$) improved DM, OM, CP, CF, EE, NFE and TDN digestibility values, compared to the control group. The significantly ($P<0.05$) interaction between the energy and supplementation levels on nutrient digestibility and nutritive values was noticed. Rabbits that received 100% of energy requirement+1% herbs mixture (G_2) showed the best digestion coefficients and nutritive values, however DCP value significantly ($P<0.05$) decreased compared to the control group. Rabbits fed on diet containing 90% of energy requirement+2% herbs mixture diet (G_6) recorded the best DM and CF digestibilities. The 90% of energy level significantly ($P<0.05$) increased feed intake, final weight and weight gain compared to the control group. Adding 1% of herb mixture significantly ($P<0.05$) improved the ratio of feed conversion compared to the control group. Rabbits that received 90% of energy and 2% supplementation (G_6) recorded the best values of final weight, weight gain and average daily gain, while, rabbits fed diet containing 90% of energy and 1% supplementation (G_5) recorded the best feed conversion Rabbits fed diet containing 90% of energy requirements with or without supplementation showed the high values of total revenue, net revenue, economical efficiency and relative economic efficiency. From the results of this work it noticed that using low level of energy (90% of energy requirements of growing rabbits) is considered the sufficient requirements of energy as well as the effect of these herb mixtures on energy complement.

Key words: Rabbits · *Artemisia herba-alba* · *Matricaria recutita* L · *Chrysanthemum coronarium* · Digestibility · Performance · Economics evaluation

INTRODUCTION

Recently, it has found that some medicinal plants or herbs have some properties as growth promoter. These additives are given to animals or birds to improve the physiological and productive performance as well as the general health. Some essential oils lowered circulating glucose levels and systolic blood pressure, suggesting that these natural products are enhancing insulin sensitivity [1].Wormwood (shih) used as the dried leaves of *Artemisia herba-alba*. *Artemisia herba-alba* oil was rich in monoterpenes that constitute 71.6%, beta-myrcene (29.27%) as the major constituent followed by (+)-limonene (13.3%), (Z)-beta-ocimene (13.37%) and gamma-terpinene (9.51%) [2]. Artemisinin is currently the only available drug that is globally effective and used as a remedy for more than two thousand years [3].

Chamomile used as the dried herb of *(Matricaria recutita* L.*)* The active substances in chamomile *(Matricaria recutita* L.*)* forming the essential oils are primarily chamazulene, (-)-alpha-bisabolol, bisabololoxides, bisabolonoxide A, trans-beta-farnesene, alpha-farnesene, spathulenol and the cistransen-in-dicycloethers. Flavonoids, coumarins, mucilages, mono- and oligosaccharides also have pharmacological effects [4]. Chamomile oil seems to be a promising

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candidate for topical therapeutic application as virucidal agents for treatment of herpes genitalis [5]. Crown daisy *(Oqhowan)* used as the dried herb of *(Chrysanthemum coronarium* L.*)*. The effective component of *Chrysanthemum coronarium* L. are camphor (22.1%) and cis-chrysanthenyl acetate (19.9%) were the main constituents of the oil from flowers, whereas the oil from the leaves contained mainly (Z)-ocimene (45.4%) and myrcene (28.2%) [6]. Campesterol isolated from an ethylacetate fraction of *Chrysanthemum coronarium* L. showed a weak cytotoxicity in non-proliferating umbilical vein endothelial cells [7]. *Chrysanthemum coronarium* L. inhibited low-density lipoprotein (LDL) oxidation with an IC (50) value of 7.7 micro m [2].

This work aimed to evaluate the efficacy of the mixture of *Artemisia herba-alba*, *Matricaria recutita* L. and *Chrysanthemum coronarium* as feed additives in improving the utilization of low energy rabbit diets.

MATERIALS AND METHODS

A total of 54 male New Zealand White rabbits aged 6 weeks with an average body weight of 825±5 g, were divided into six equal groups. The basal experimental diet was formulated and pelleted to cover the nutrient requirements of rabbits as a basal diet according to NRC [8] as shown in Table 1. Additives mixture used in this study are composed of *chamomilla, Artenisia herbo-alba* and *Chrysanthemum* at ratio of (1:1:1), respectively. The feeding period was extended for 84 days and the experimental groups were classified as follow:

Group 1 basal diet with 100 % of energy requirement and served as control (G1)
Group 2 basal diet with 100 % of energy requirement + 1% additives mixture (G2)
Group 3 basal diet with 100 % of energy requirement + 2% additives mixture (G3)
Group 4 basal diet with 90 % of energy requirement and served as control (G4)
Group 5 basal diet with 90 % of energy requirement + 1% additives mixture (G5)
Group 6 basal diet with 90 % of energy requirement + 2% additives mixture (G6)

Rabbits individually housed in galvanized wire cages. Stainless steel nipples for drinking and feeders allowing to record individual feed intake for each rabbit, were supplied for each cage (30 x 35 x 40) cm. Feed and water were offered *ad-libitum.* Rabbits of all groups were kept under the same managerial conditions and were individually weighed and feed consumption was individually recorded biweekly during the experimental period.

Table 1: Composition of the experimental diets (kg/ton)

	100% Energy requirements			90% Energy requirements		
Item	G_1	G_2	G_3	G_4	G_5	G_6
Yellow corn	230	230	230	-	-	-
Barley grain	50	50	50	140	140	140
Wheat bran	270	270	270	270	270	270
Soybean meal 44% CP	150	150	150	150	150	150
Alfalfa hay	270	260	250	260	250	240
:Berseem straw	-	-	-	150	150	150
:Di-Ca-Phosphate	10	10	10	10	10	10
:Limestone	10	10	10	10	10	10
:Sodium chloride	5	5	5	5	5	5
Vit. & Min. mixture*	3	3	3	3	3	3
DL-Methionine	1	1	1	1	1	1
Anti fungal agent	1	1	1	1	1	1
Supplement	-	10	20	-	10	20
Price, L.E/Ton	2094	2147	2201	1848	1913	1978

1978* Vit. & Min. mixture: Each kilogram of Vit. & Min. mixture contains: 2000.000 IU Vit. :A, 150.000 IU Vita. D, 8.33 g Vit. :E, 0.33 g Vit. K, 0.33 g Vit. B_1, 1.0 g Vit. B_2, 0.33g Vit. B_6, 8.33 g Vit.B_5, 1.7 mg Vit. B_{12}, 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Folic acid, 200 g Choline chloride, 11.7 g Zn, 12.5 g Fe, 16.6 mg Se, 16.6 mg Co, 66.7 g Mg and 5 g Mn.

At the end of the experimental period six rabbits from each group were used in digestibility trials over period of 7 days to determine the nutrient digestibility coefficients and nutritive values of the tested diets. Feces were daily collected quantitatively. Feed intake of experimental rations and weight of feces were daily recorded. Representative samples of 10% of total fresh weight of feces was sprayed with solution of 10% sulfuric acid and 10% formaldehyde and oven dried at 60°C for 48 hrs and composite samples of dried feces were ground and stored for later chemical analysis. Chemical analysis of experimental rations and feces were analyzed according to AOAC [9] methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL)} were also determined in the experimental rations according to Goering and Van Soest [10] and Van Soest *et al.* [11]. Hemicellulose was calculated as the difference between NDF and ADF, while cellulose was calculated as the difference between ADF and ADL. Digestible energy (DE) was calculated according to Cheek [12] as following:

$$DE\ (MJ/\ kg\ DM) = 4.36-0.04 \times NDF\%.$$

Non fibrous carbohydrates (NFC), calculated according to Calsamiglia *et al.* [13] using the following equation: NFC = 100-{CP + EE + Ash + NDF}.

Compositions of the experimental rations have been done according to the NRC [8] requirements as shown in Table 1. Diets were offered pelleted and the diameter of the pellets was 4 mm. Economical efficiency of experimental diets was calculated according to the local market price of ingredients and rabbit live body weight as following:

Net revenue = total revenue-total feed cost.

Economical efficiency (%) = net revenue/ total feed cost %.

Collected data were subjected to statistical analysis as one way analysis of variance according to SAS [14]. Duncan's Multiple Range Test [15] was used to separate means when the dietary treatment effect was significant.

RESULTS AND DISCUSSION

Chemical Analysis and Cell Wall Constituents of the Experimental Diets: Chemical analysis and cell wall constituents of the experimental diets are presented in Table 2.The results showed that the experimental rations were formulated to be almost iso nitrogenous to meet the rabbit's nutrient requirements for growth NRC [8]. On the other hand, the experimental rations were differing in

Table 2: Chemical analysis and cell wall constituents of the experimental diets

	100% Energy requirements			90% Energy requirements		
Item	G_1	G_2	G_3	G_4	G_5	G_6
Dry matter	91.74	91.55	91.59	91.29	92.10	91.92
Organic matter	88.19	89.57	90.24	90.11	89.58	89.28
Crude protein	16.69	16.53	16.26	16.18	16.17	16.14
Crude fiber	9.18	9.71	10.16	11.17	13.93	14.20
Ether extract	3.36	3.07	3.50	3.07	2.62	2.58
Nitrogen free extract	58.96	60.26	60.32	59.69	56.86	56.36
Ash	11.81	10.43	9.76	9.89	10.42	10.72
NFC*	28.57	30.89	31.89	27.23	27.70	28.00
DE (MJ/kg DM)	2.507	2.505	2.508	2.255	2.250	2.258
Cell wall constituents						
NDF	46.32	46.38	46.29	52.63	52.75	52.56
ADF	18.42	18.20	17.98	19.99	1956	19.13
ADL	6.46	6.35	6.25	7.96	7.83	7.69
Hemicellulose	27.90	28.18	28.31	32.64	33.19	33.43
Cellulose	11.96	11.85	11.73	12.03	11.73	11.44

Digestible energy (DE) was calculated according to Cheek [12] as following: DE (MJ/ kg DM) = 4.36-0.04 x NDF%.

NDF: Neutral detergent fiber. ADF: Acid detergent fiber. ADL: Acid detergent lignin. Hemicellulose = NDF-ADF. Cellulose = ADF-ADL.:

* Non fibrous carbohydrates (NFC), calculated according to Calsamiglia *et al.* [13] using the following equation:
NFC = 100-{CP + EE + Ash + NDF}.

Table 3: Main effects of energy and supplementation levels on nutrient digestibility and nutritive values of the experimental diets

	Experimental diets						
	Energy levels			Supplementation			
Item	100%	90%	SEM	0%	1%	2%	SEM
Digestibility coefficients							
DM	73.19	73.06	0.31	71.64^{b}	73.48^{a}	74.26^{a}	0.31
OM	71.02	70.68	0.28	70.30^{b}	72.01^{a}	70.24^{b}	0.28
CP	77.14^{b}	77.86^{a}	0.49	78.81^{a}	78.13^{a}	75.54^{b}	0.49
CF	30.45^{b}	43.06^{a}	1.32	30.68^{c}	38.93^{b}	40.66^{a}	1.32
EE	80.17^{a}	71.07^{b}	0.97	75.81^{ab}	77.22^{a}	73.84^{b}	0.97
NFE	75.03	74.79	0.29	74.34^{b}	76.35^{a}	74.03^{b}	0.29
Nutritive values							
TDN%	66.73^{a}	65.82^{b}	0.29	65.73^{b}	67.22^{a}	65.88^{b}	0.29
DCP%	12.73	12.59	0.09	12.95^{a}	12.78^{b}	12.24^{c}	0.09

a, b and c: Means in the same row within each treatment having different superscripts differ significantly ($P<0.05$).

SEM, standard error of the mean.

energy contents to study the effect of level energy on growth performance of rabbits. Digestible energy for six tested rations was 2.51, 2.50, 2.501, 2.25, 2.25 and 2.26 (MJ/ kg DM), respectively. The lowest energy rations increased NDF, ADF, ADL and hemicellulose contents while, cellulose content of experimental rations was in the same trend approximately. These variations were related to differ in ingredients that used in ration formulations.

Nutrient Digestibility and Nutritive Values of the Experimental Diets: Data in Table 3 showed that energy levels had no significant effects ($P>0.05$) on DM, OM and NFE digestibility, while lead to significant ($P<0.05$) improvement in CP and CF digestible but, significantly ($P<0.05$) decreased EE digestibility. Also, energy level had no significant effects on DCP, while significantly ($P<0.05$) increased TDN. Regardless to the energy level, the supplementation of herbs mixture used at 1% significantly ($P<0.05$) improved DM, OM, CF, NFE and TDN digestibility values compared to the control group, while DCP value significantly ($P<0.05$) decreased compared to the control group. These improvements in the digestion values may be due to the increased gastrointestinal transit time induce by *Artemisia herba-alba* and/or may be due to the antimicrobial activities of *Matricaria chamomilla* L. as well as may be due to the high content of ascorbic acid and carotenoids in *Chrysanthemum coronarium* that may be useful in preventing vascular weakness. Similar results were observed in Artemisia by Marrif *et al.* [16], in Chamomile [17] and in *Chrysanthemum coronarium* L. by McKay and Blumberg [18]. Marongiu *et al.* [19] reported that, Chrysanthemum flowers have antibacterial and antimycotic activities of volatile fractions. And/or may be due to the cooper content in *Chrysanthemum coronarium* L. that alter the intestinal microbiota as reported by Wei *et al.* [20] and Pang *et al.* [21].

Results in Table 4 recorded significantly ($P<0.05$) interaction between the energy and supplementation levels on nutrient digestibility and nutritive values. Rabbits that received 100% energy requirement + 1% herbs mixture (G_2) showed the best digestion coefficients and nutritive values compared with the control group. This result may be due to *Artemisia herba-alba* in developing better to eradicate the bacteria at the optimum level of energy. This result in agreement with those obtained by Castillo-Juarez *et al.* [22]. And/or may be due to the hyperglycemia effect of chamomile. The consumption of chamomile could contribute to the prevention of the progress of hyperglycemia and diabetic complications [23].

Rabbits that received 90 % energy requirement +2% additives mixture (G_6) recorded the best DM and CF digestibilities. This result may be due to the reaction time to thermal stimuli in digestive tract inducing by *Artemisia herba-alba.* Also, G_2 recorded the best values of CP, EE and NFE digestibilities and nutritive values expressed as TDN and DCP. Similar results observed by Marrif *et al.* [16]. As well as the antipathogenic bacterial effect of *Matricaria chamomilla* L. as reported by Shikov *et al.* [24], who observed that the morphological and fermentative properties of Helicobacter pylori were affected by application of the *Matricaria chamomilla* L. oil extract.

Table 4: Effect of energy and supplementation levels on nutrient digestibility and nutritive values of the experimental diets

	Experimental diets						
	100% Energy requirements			90% Energy requirements			
Item	G_1	G_2	G_3	G_4	G_5	G_6	SEM
Digestibility coefficients							
DM	71.31[d]	75.00[a]	73.25[bc]	71.96[cd]	71.95[d]	75.27[a]	0.31
OM	69.42[d]	73.94[a]	69.69[d]	71.18[b]	70.07[cd]	70.78[bc]	0.28
CP	78.72[b]	80.48[a]	72.21[d]	78.91[b]	75.79[c]	78.87[b]	0.49
CF	24.82[e]	33.14[d]	33.39[d]	36.54[c]	44.73[b]	47.92[a]	1.32
EE	77.99[b]	83.32[a]	79.20[b]	73.62[c]	71.12[cd]	68.48[d]	0.97
NFE	73.24[d]	78.10[a]	74.58[cd]	75.43[b]	74.61[bc]	74.32[c]	0.29
Nutritive values							
TDN%	64.49[d]	69.35[a]	66.35[b]	66.97[b]	65.10[cd]	65.40[c]	0.29
DCP%	13.14[a]	13.30[a]	11.74[d]	12.77[b]	12.26[c]	12.73[b]	0.03a,

b, c, d and e: Means in the same row having different superscripts differ significantly (P<0.05).
SEM, standard error of the mean.

Table 5: Main effects of energy and supplementation levels on growth performance of the experimental groups

	Experimental diets						
	Energy levels			Supplementation			
Item	100%	90%	SEM	0%	1%	2%	SEM
Initial weight, g	825	824	4.9	823	826	825	4.9
Final weight, g	2210[b]	2358[a]	17.3	2233[b]	2288[ab]	2331[a]	17.3
Gain, g	1385[b]	1534[a]	16.8	1410[b]	1462[ab]	1506[a]	16.8
ADG, g	16.5[b]	18.3[a]	0.20	16.8[b]	17.4[ab]	17.9[a]	0.20
Feed intake as:							
DM, g/day	84.7	94.1	2.90	90.7	85.1	92.4	2.90
TDN, g/day	56.6	61.8	1.92	59.8	56.8	60.9	1.92
CP, g/day	14.0	15.2	0.47	14.9	13.9	15.0	0.47
DCP, g/day	10.7	11.9	0.37	11.7	10.9	11.3	0.37
Feed conversion (g intake /g gain) of							
DM	5.13	5.16	0.17	5.39	4.89	5.16	0.17
TDN	3.43	3.37	0.11	3.55	3.22	3.40	0.11
CP	0.85	0.83	0.03	0.89	0.80	0.83	0.03
DCP	0.65	0.65	0.02	0.70	0.63	0.63	0.02

a and b: Means in the same row within each treatment having different superscripts differ significantly (P<0.05).
SEM, standard error of the mean.

Growth Performance of the Experimental Groups: Data in Table 5 cleared that the 90% of energy level significantly (P<0.05) increased the final weight by (6.6 %), weight gain by (9.3 %) and average daily gain by (6.5 %) compared to the control group. This result is considered a new sufficient requirement of energy as well as the positive effect of this mixture on energy complement. This result insures that the requirements for rabbit's breeds differed from country circumstances to another. Supplementation of 2% herb mixture significantly (P<0.05) improved the final weight by (4.4%), weight gain by (6.8 %) and average daily gain by (7.4%) compared to the control group. These significant results may be due to the developing therapeutic regime by *Artemisia herba-alba* that eradicates the bacteria that failed in many cases, mainly due to antibiotic resistance. Similar results obtained by Castillo-Juarez *et al.* [22]. On the other hand these results may be due to the protection of *Artemisia herba-alba* against body weight loss of rabbits especially at the low of energy level. Al-Shamaony [25] reported that, *Artemisia herba-alba* has areole in the protection against body weight loss of diabetic animals. And/or may be due to anti stress properties of *Matricaria chamomilla* L. Reis *et al.* [26] reported that *Matricaria chamomilla* L. reduces stress. As well as may be due to the health beneficial effects of *Chrysanthemum coronarium* L.

Table 6: Effect of energy and supplementation levels growth on performance of the experimental groups

Item	Experimental diets						
	100% energy requirements			90% energy requirements			
	G_1	G_2	G_3	G_4	G_5	G_6	SEM
Initial weight, g	823	825	827	824	826	826	4.88
Final weight, g	2164^{d}	2213^{cd}	2252^{cd}	2302^{bc}	2363^{ab}	2363^{ab}	17.3
Gain, g	1341^{d}	1388^{d}	1425^{cd}	1478^{bc}	1537^{ab}	1537^{ab}	16.8
ADG, g	16.0^{d}	16.5^{d}	17.0^{cd}	17.6^{bc}	18.3^{ab}	18.9^{a}	0.20
Feed intake as:							
DM, g/day	83	82	89	99	88	96	2.90
TDN, g/day	54	57	59	66	57	63	1.92
CP, g/day	13.9	13.6	14.5	16.0	14.2	15.5	0.47
DCP, g/day	10.9	10.9	10.4	12.6	10.8	12.2	0.37
Feed conversion (g intake /g gain) of							
DM	5.19	4.97	5.24	5.63	4.81	5.08	0.17
TDN	3.38	3.45	3.47	3.75	3.11	3.33	0.11
CP	0.87	0.82	0.853	0.91	0.78	0.82	0.03
DCP	0.68	0.66	0.612	0.72	0.59	0.65	0.02

a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.05).
SEM, standard error of the mean. SEM, standard error of the mean.

Table 7: Economical evaluation of the experimental groups

Item	Experimental diets					
	100% Energy requirements			90% Energy requirements		
	G_1	G_2	G_3	G_4	G_5	G_6
Marketing weight, Kg	2.164	2.213	2.252	2.302	2.363	2.410
Feed consumed / rabbit, kg	7.577	7.543	8.165	9.047	8.047	8.744
Costing of one kg feed, (LE)[1]	2.094	2.147	2.201	1.848	1.913	1.978
Total feed cost, (LE)	15.866	16.195	17.971	16.719	15.394	17.298
Management/ Rabbit, (LE)[2]	4	4	4	4	4	4
Total cost, (LE)[3]	34.866	35.195	36.971	35.719	34.394	36.296
Total revenue, (LE)[4]	43.28	44.26	45.04	46.04	47.26	48.20
Net revenue	8.414	9.065	8.069	10.321	12.866	11.904
Economical efficiency[5]	0.2413	0.2576	0.2183	0.2889	0.3741	0.3280
Relative economic efficiency[6]	100	106.8	90.5	119.7	155.0	135.9
Feed cost / kg LBW (LE)[7]	7.33	7.32	7.98	7.26	6.51	7.18

[1] Based on prices of year 2008.
[2] Include medication, vaccines, sanitation and workers.
[3] include the feed cost of experimental rabbit which was LE 15/ rabbit + management.
[4] Body weight x price of one kg at selling which was LE 20.
[5] net revenue per unit of total cost.
[6] Assuming that the relative economic efficiency of control diet equal 100.
[7] Feed cost/kg LBW = feed intake * price of kg / Live weight.

Strzelecka *et al.* [27] recorded that the bioactive compounds from *Chrysanthemum coronarium* L. may have health beneficial effects and reduce the risk of chronic inflammatory diseases. Woman recovered from red poultry mites by means of daily washing of chamomile tea [28]. *Matricaria recutita L.* may form the basis to design "functional foods" for the prevention of osteoporosis [29].

Artemisia increased the total antioxidant status [30]. Regardless the feed additives, the 90% of energy level showed significant (P<0.05) increase in feed intake by (11.1 %), compared to the control group. This result explained the actual requirement of energy. Adding 1% of herb mixture improved the ratio of feed conversion by (9.8%) compared to the control group. This result may be due to the better palatability for these herbs or because of its calming, carminative and spasmolytic properties as reported by Koch *et al.* [5].

Rabbits that received 90% energy and 2% supplementation (G_6) recorded the best values of final weight, weight gain and average daily gain. This result may be due to the effective role of *Chrysanthemum coronarium L* as antioxidant. Similar results observed by Takenaka *et al.* [31], who reported that the antioxidants properties of *Chrysanthemum coronarium* L. by reducing aflatoxin production and that may be due to caffeic acid. And/or may be due to the antihyperglycemic effect of *Matricaria chamomilla L* that promote the great useful of energy. Cemek *et al.* [32], showed that *Matricaria chamomilla* L. exhibited significant antihyperglycemic effect and protected beta-cells in diabetic rats and diminished the hyperglycemia-related oxidative stress. Madav *et al.* [4] noted that Chamomile has a sweet, grassy and lightly fruity aroma. The significant interaction values between energy and 1% supplementation levels on feed conversion that shown in G_5 may be due to inhibiting cortisol production and calming and anxiolytic effects of these mixture at 1% supplementation. Reis *et al.* [26] found similar result for *Matricaria chamomilla* L.

Economical Evaluation: The economical efficiency of dietary treatments is presented in Table 7. The profitability of using medicinal plants as supplementation depends on upon the price of tested diets and the growth performance of rabbits fed these diets. Costing of one kg feed, (LE) was decreased by 11.75, 8.64 and 5.54 % in G_4, G_5 and R_6, respectively, compared to control diet G_1. Rabbits fed on diet containing 90% energy requirements with or without supplementation showed the high values of total revenue, net revenue, economical efficiency and relative economic efficiency, while recorded the low value of feed cost/ kg live body weight (LE). Rabbits received G_5 diet recorded the highest value of relative economic efficiency (155%) and the lowest value of feed cost/ kg live body weight (6.51 LE).

CONCLUSION

Under the conditions of this experiment, the results indicated that, decreasing energy level from 100% requirements to 90% of requirements with 1% supplementation realized the best growth performance, digestion coefficients of nutrients, net revenue, relative economic efficiency and the lowest value of feed cost/ kg live body weight.

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