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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2017 14(2): 224-233. **OPEN ACCESS**

Using field crop by-products for feeding rabbits

Hamed Abdel-Aziz Ali Omer[1], Mohamed Farouk El Karamany [2], Sawsan Mansour Ahmed[1], Soha Sayed Abdel-Magid[1] and Bakry Ahmed Bakry[2*]

[1]Animal Production Department and National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Giza**, Egypt.**
[2]Field Crops research Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Giza**, Egypt**.

***Correspondence: bakry_ahmed2004@yahoo.com** **Accepted: 16** April. 2017 **Published online:** 28 May 2017

This work was carried out to study the impact of replacing 50% of Berseem hay (BH) content in basal ration of rabbits that incorporation at portion of 23% of rabbit ration formulation by alternative sources of field crop residues such as Mung bean husks (MBH), soybean vein hay (SBVH) or peanut vein hay (PVH). Feeding trial lasted 70 days, thirty six growing New Zealand White (NZW) rabbits (583.5±25 g) divided into four groups, 9 rabbits. Control (R_1) contained 23% BH and the three experimental rations replaced 50% of BH by MBH, SBVH or PVH for (R_2, R_3 and R_4), respectively. Results showed that both PVH and SBVH recorded the high content of crude protein (15.56 and 15.12%, respectively) that nearly from BH (16.86% CP). Meanwhile, MBH contained 9.94% CP. Soybean vein hay showed the highest content of crude fiber (CF), 51.67%, followed by PVH contained 39.71% CF and MBH contained 32.31%. Peanut vein hay contains the highest values of neutral detergent fiber (47.30%), acid detergent fiber (32.50%), hemicellulose (14.80%) and cellulose (26.73) in comparison with the other tested sources of roughage. Different experimental rations was almost iso-caloric and iso-nitrogenous. Inclusion alternative sources of roughage insignificantly (P>0.05) improved daily gain feed intake and feed conversion. Dressing percentages that expressed as carcass weight/ slaughter weight or carcass weight/ empty body weight was insignificantly (P>0.05) improved. Costing of one kg decreased by 1.00%, 2.67% and 2.67%, net revenue improved by 214%, 194% and 179%, relative economic efficiency were improved by 221.1%, 207.2% and 188% more than the control that assuming that equal 100%. The present results mentioned that, under conditions similar to those available in this work, it can be replaced 50% of Berseem hay used in rabbit ration with alternative sources of roughage (Mung bean husks, soybean vein hay or peanut vein hay) without any adverse effect on their health and gain with improvement in relative economic efficiency; feed cost per kg live body weight and depressing price of ration formulation costing.

Keywords: Berseem hay, field crop residues, rabbits, performance, economic evaluation.

INTRODUCTION

Feeding cost represents about 60-70 % or more of total production cost.. Minimizing the feed cost could be achieved through the use of unconventional cheaper feed ingredients or through out improving the utilization of common feeds (Maertens et al. 2002).Statistics of crop residues and agro-industrial by-products was determined by 25.626 million tones as described by Shoukry (2013). On the other hand, Sadek (2013) reported that agriculture volume by-products reached to 35 million tons annually, 23 million tons of which were plant wastes (7 million tons of them are used as fodders; 4 million tons

were used as organic fertilizers and the rest of wastes which 12 million tons were left without any use).Peanut and Mung beans, kidney beans are cultivated in the newly reclaimed lands. So, significant amounts of their straws and by-products of these crops are produced annually may be help in solution the shortage of animal feeding (Omer et al. 2012b). Recently, some studies designed to using some agricultural by-products in rabbit feeding, especially as alternatives to Berseem hay, which commonly represents about 30-40% of the complete pelleted diets of rabbits. In addition, the available amount of Berseem hay is usually insufficient for animal feeding which lead to increasing the prices of ration formulation (Abo EL-Maaty et al. 2014).

Rabbits require dietary fiber not only for substrate in cecal microbial fermentation, producing volatile fatty acids and providing microbial proteins to the animal through cecotrophy, but for a scabrous and physical effect on the gut mucosa, maintaining normal gut motility and preventing digestive disturbances (Pond et al. 1995). Local available crop residues, such as soybean straws, peanut vein hay or Mung bean husks can be used as unconventional sources of fibrous in feeding rabbits. Although soybean hulls as by-product classified high fiber content it have higher digestibility of DM and NDF than alfalfa and sunflower hulls, thus inclusion of soybean hulls in the diet of rabbits may induce effects similar to those of low dietary fiber levels on digestive disturbances (Garcia et al. 2000). So, This study was designed to investigate the impact of replacement 50% of Berseem hay that considered the main source of rabbit rations formulation with unconventional sources of roughage such as Mung bean husks, soybean vein hay and peanut vein hay on rabbits performance, carcass characteristics and economic.

MATERIALS AND METHODS

This study was carried out at El-Nubaria Experimental and Production Station at El-Imam Malik Village.

A total number of thirty six New Zealand White (NZW) rabbits aged 5-6 weeks with an average body weight of 583.5±25 g were randomly divided into four equal experimental groups (9 rabbits in each treatment).

Three rabbits of each replicate were housed together in galvanized wire cages (50×50×45 cm) and provided with stainless steel nipples for drinking and feeders allowing recording feed intake during the experimental period that lasted to 70 days.

Rabbits of all groups were kept under the same managerial conditions and rations were offered pelleted with diameter 4 mm.

The experimental pelleted rations were formulated (Table 2) to cover the nutrient requirements for rabbits according to NRC (1977). The first one was considered as control (R_1). The 2^{nd}, 3^{rd} and 4^{th} experimental rations were formulated by replacing 50% of Berseem hay by alternative sources of roughage such as Mung bean husks (MBH), soybean vein hay (SBVH) and peanut vein hay (PVH), respectively. Feeds offered *ad libitum.*

Five representative rabbits from each treatment were randomly chosen to determine the carcass parameters according to (Blasco et al. 1993). Rabbits were fasted for 12 hours before slaughter, which was performed according to the Islamic rules. Animals were weighed just before slaughter, slaughter weight (SW) was recorded and as well as after complete bleeding.

Total edible offal's (Giblets) included heart, liver, kidneys, lungs, spleen and testes were weighed.

Full and empty weights of digestive tract were recorded. Hot carcass included head and giblets were weighed to calculate dressing percentages.

Chemical analyses of ingredients were analyzed according to AOAC (2005) methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL)} were also evaluated according to Goering and Van Soest (1970) and Van Soest et al. (1991).

Economical efficiency of experimental rations 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 %.

Gross energy (Kcal/ Kg DM) calculated according to Blaxter (1968). Each g CP= 5.65 Kcal, g EE= 9.40 Kcal and g (CF & NFE) = 4.15 Kcal.

Digestible energy (DE) was calculated according to Cheeke (1987) by applying the following equation:

DE (Mcal/ kg DM) = 4.36 – 0.049 x NDF.

Non fibrous carbohydrates, calculated according to Calsamiglia et al. (1995) using the following equation: NFC = 100 – {CP + EE + Ash + NDF}.

Data collected of feed intake, live body weight; feed conversion and carcass data were subjected to statistical analysis as one way analysis of variance according to SPSS (2008). Duncan's Multiple Range Test Duncan, (1955) was used to

separate means when the dietary treatment effect was significant according to the following model: $Y_{ij} = \mu + T_i + e_{ij}$ Where:
Y_{ij} = observation.
μ = overall mean.
T_i = effect of experimental rations for i = 1–4, 1 = (control ration contained 23% BH), 2 = replacing 50% of BH with MBH, 3 = replacing 50% of BH with SBVH and 4 = replacing 50% of BH in with PVH.
e_{ij} = the experimental error.

RESULTS AND DISCUSSION

Chemical analysis of ingredients

The present results (Table 1) showed that both peanut and soybean vein hays recorded the high content of protein (15.56 and 15.12%, respectively). These values nearly from the main source of good quality roughage used in rabbit rations formulation (Berseem hay 16.86% CP). Meanwhile, Mung bean husks contained 9.94% CP. On the other hand, Mung bean husks recorded the lowest content of crude fiber (32.31) followed by peanut vein hay (39.71%) and soybean vein hay (51.67%). These values of different tested sources of roughage superior in CF values in comparison with Berseem hay (30.62%). Mung bean husks recorded the highest value of the nitrogen free extract (NFE, 49.99%) however showed the lowest value of ether extract (0.95%) and ash content (6.81%). These results in the same range with those found by Ibrahim et al. (2011) and Omer and Badr (2013) for chemical analysis of Berseem hay and peanut vein hay.

Peanut vein hay contents the highest values of NDF (47.30%), ADF (32.50%), hemicellulose (14.80%) and cellulose (26.73%). The present results in agreement with those observed by Omer et al. (2012a & 2012b) for cell wall constituents of Berseem hay and peanut vein hay.

Experimental rations

The data obtained (Table 2) mentioned that, tested roughage sources used Mung bean husks (MBH); soybean vein hay (SBVH) and peanut vein hay (PVH)} were replaced 50% of main source of roughage used in rabbit rations formulations Berseem hay (BH). Also, different experimental rations was almost iso-caloric and iso-nitrogenous. Crude protein content was ranged from 20.69 to 20.89%, ether extract content was also ranged from 2.45 to 2.84%. On the other hand CF contents were slightly varied by percentage 1 to 2% that ranged between 12.17 to 14.59%.

On the other hand NFE content ranged from 51.35 to 54.07% for the different tested rations. Meanwhile, ash content was almost in the same values that ranged from 10.31 to 10.60%. Meanwhile, the present results showed that all cell wall constituents (NDF, ADF, ADL, cellulose and hemicellulose), were almost in the same range for the different tested roughage source used.

Gross energy (kcal/kg DM); digestible energy (Mcal/ kg DM) and non-fibrous carbohydrates (NFC) were ranged between 4163 to 4175; 2.506 to 2.577 and 28.09 to 29.71%, respectively.

Growth performance

Data of Table (3) cleared that, inclusion different sources of roughage in rabbit rations insignificantly ($P>0.05$) improved total body weight gain and daily gain. The present results mentioned that the best source of tested roughage was recorded for Mung bean husks followed by soybean vein hay and peanut vein hay in comparison with the Berseem hay. Omer and Badr (2013) showed that replacing Berseem hay by pea straw in rabbit diets at 0, 25, 50, 75 and 100% had significant effect ($P<0.05$) on daily gain. In addition, Gad Alla (1997), Mohamed (1999); El-Adawy and Borhami (2001); Tag El-Din *et al*. (2002); Abdel-Magid (2005) and Omer et al. (2011) reported that instead of Berseem hay by carrot-tops, strawberry by-products, peanut hay, kidney beans or pea straw significantly improved growth performance of growing rabbits than those fed the control diet. Also, Abo EL-Maaty et al. (2014) observed that rabbits fed diets replaced clover hay with cucumber (*cucumis sativus L*.) vines straw up to 75% resulted in comparable growth performance compared to control group.

Myrie et al. (2008) showed that most feedstuffs contain anti-nutritional factors such as insoluble fibers, ligins, tannins and lectins. Intake of these anti-nutritional factors reduced nutrient digestibility and increased endogenous protein losses, through increasing of intestinal mucus secretion. Also, Muzquize et al. (1999) found that the main toxic components in by-products are lectins, sugar-binding proteins which bind and agglutinate red blood cells. The toxicity of lectins is characterized by growth inhibition and diarrhea.

Dietary treatment had no significantly effect on all parameters of feed intake that calculated as DMI, CPI, NFCI, GEI and DEI (Table 3). Incorporation peanut vines hay in rabbit diets did not affect feed intake (Afifi, 1999; Omara, 2005). However, Galal et al. (2014) found that rabbit

Table: 1. Chemical analysis of the different ingredients.

Item	Berseem hay	Mung bean husks	Soybean vein hay	Peanut vein hay	Yellow corn	Wheat bran	Soybean meal	Barley grain
Moisture	**10.03**	**10.84**	**11.90**	**12.49**	**9.78**	**9.71**	**7.15**	**10.47**
Chemical analysis (%) on DM basis								
Organic matter (OM)	90.13	93.19	90.02	90.96	98.50	87.79	94.38	89.68
Crude protein (CP)	16.86	9.94	15.12	15.56	9.00	13.72	44.00	14.25
Crude fiber (CF)	30.62	32.31	51.67	39.71	4.60	10.25	4.93	8.42
Ether extract (EE)	3.05	0.95	3.08	3.65	4.80	2.81	0.60	4.05
Nitrogen free extract (NFE)	39.60	49.99	20.15	32.04	80.10	61.01	44.85	62.96
Ash	9.87	6.81	9.98	9.04	1.50	12.21	5.62	10.32
Neutral detergent fiber (NDF)	34.6	37.64	40.23	47.30	34.52	43.54	34.77	41.62
Acid detergent fiber (ADF)	20.36	27.12	29.33	32.50	21.38	31.42	26.13	10.33
Acid detergent lignin (ADL)	2.93	5.92	7.82	5.77	2.24	3.98	6.33	6.95
Hemicellulose	14.32	10.52	10.90	14.80	13.14	12.12	8.64	31.29
Cellulose	17.43	21.20	21.51	26.73	19.14	27.44	19.80	3.38
Gross energy (kcal/kg DM)	4153	40.66	4124	4200	4475	3997	4608	4148
Digestible energy (Mcal/kg DM)	2.661	2.516	2.389	2.042	2.669	2.227	2.656	2.321
Nonfibrous carbohydrates (NFC)	35.54	44.66	31.59	24.45	50.18	27.72	15.01	29.76

NFC: Non fibrous carbohydrates were calculated (Calsamiglia et al. 1995).
Gross energy (kcal/kg DM) was calculated (Blaxter, 1986).
Digestible energy: (M cal) was calculated (Cheeke, 1987).

Table: 2. Composition and calculated chemical analysis of the different experimental rations.

Item	Experimental rations			
	Berseem hay (BH)	Mung bean husks (MBH)	Soybean vein hay (SBVH)	Peanut vein hay (PVH)
	R_1	R_2	R_3	R_4
1- Composition (kg/ton)				
Yellow corn	150	130	150	150
Soybean meal	240	260	240	240
Wheat bran	170	170	170	170
Barley grain	180	180	180	180
Berseem hay	230	115	115	115
Mung bean husks	-	115	-	-
Soybean vein hay	-	-	115	-
Peanut vein hay	-	-	-	115
Di-calcium	12	12	12	12
Limestone	12	12	12	12
Sodium chloride	3	3	3	3
Vit. & Min. Mixture[1]	2	2	2	2
D-L-Methionine	1	1	1	1
Price, L.E/Ton	3000	2970	2920	2920
Chemical analysis (%) on DM basis				
Organic matter (OM)	89.42	89.69	89.40	89.51
Crude protein (CP)	20.89	20.79	20.69	20.74
Crude fiber (CF)	12.17	12.38	14.59	13.22
Ether extract (EE)	2.77	2.45	2.77	2.84
Nitrogen free extract (NFE)	53.59	54.07	51.35	52.71
Ash	10.58	10.31	10.60	10.49
Neutral detergent fiber (NDF)	36.39	36.74	37.03	37.84
Acid detergent fiber (ADF)	21.36	22.23	22.39	22.76
Acid detergent lignin (ADL)	4.46	4.89	5.03	4.79
Hemicellulose	15.03	14.51	14.64	15.08
Cellulose	16.90	17.34	17.36	17.97
Gross energy (kcal/kg DM)	**4170**	**4163**	**4166**	**4175**
Digestible energy (Mcal/kg DM)	**2.577**	**2.560**	**2.546**	**2.506**
Non fibrous carbohydrates (NFC)	**29.37**	**29.71**	**28.91**	**28.09**

[1]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. $B1_2$, 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.
NFC: Non fibrous carbohydrates were calculated (Calsamiglia et al. 1995).
Gross energy (kcal/kg DM) was calculated (Blaxter 1986). Digestible energy: (M cal) was calculated (Cheeke 1987)

Table: 3. Growth performance of the experimental groups.

Item	Experimental rations				SEM
	BH (R_1)	MBH (R_2)	SBVH (R_3)	PVH (R_4)	
Live body weight, g					
Rabbits number	9	9	9	9	---
Initial weight (g)	584	580	588	582	24.88
Final weight (FW, g)	2041	2321	2206	2186	70.50
Total body weight gain (TBWG, g)	1457	1741	1618	1604	73.10
Experimental duration period	70 days				
Average daily gain (ADG, g/day)	20.81	24.87	23.11	22.91	1.04
Feed intake of					
Dry matter (DMI), g	119.1	114.4	109.5	112.3	4.20
Crude protein (CPI), g	24.88	23.78	22.66	23.29	0.89
Non fibrous carbohydrates (NFCI), g	34.98	33.99	31.66	31.55	1.24
Gross energy (GEI), kcal	496.6	476.2	456.2	468.9	17.50
Digestible energy (DEI), kcal	306.9	292.9	278.8	281.4	10.77
1- Feed conversion expressed (g intake /g gain) of					
D M	5.72	4.60	4.74	4.90	0.20
CP	1.20^{b}	0.96^{a}	0.98^{ab}	1.02^{ab}	0.04
NFC	1.68	1.37	1.37	1.38	0.06
2- Feed conversion expressed as (kcal intake /g gain) of					
Gross energy	23.86^{b}	19.15^{a}	19.74^{ab}	20.47^{ab}	0.84
Digestible energy	14.75^{b}	11.78^{a}	12.06^{ab}	12.28^{ab}	0.52

a and b: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: Standard error of mean.
BH: Berseem hay.
MBH: Mung bean husks.
SBVH: Soybean vein hay.
PVH: Peanut vein hay.

Table 4: Dressing percentages of the experimental groups.

Item	Experimental rations				SEM
	BH (R_1)	MBH (R_2)	SBVH (R_3)	PVH (R_4)	
Slaughter weight (SW), g	2451	2188	2353	2169	91.94
Non edible offals*	508	460	490	459	19.79
Digestive tract					
Full weight, g	420	331	376	326	18.65
Empty weight, g	166	162	151	181	6.44
Content weight, g	254[a]	169[ab]	225[ab]	145[b]	18.99
Empty body weight (EBW), g	2197	2019	2128	2024	80.08
Edible offals**	141	112	138	116	6.27
Carcass weight (CW)***	1522	1397	1486	1385	63.38
Dressing percentages (DP)%					
DP_1	62.10	63.85	63.15	63.85	0.59
DP_2	69.28	69.19	69.83	68.43	0.63

a and b: Means in the same row having different superscripts differ significantly (P<0.05).
SEM: Standard error of mean.
BH: Berseem hay. MBH: Mung bean husks. SBVH: Soybean vein hay. PVH: Peanut vein hay.
*** Non edible offals included (blood, fur, legs, ears and tail)**
**** Edible offals included (Liver, heart, kidneys, lungs, testes and spleen).**
***** CW: Carcass weight includes head and edible offal's.**
DP_1: Dressing percentages calculated as (CW / SW * 100).
DP_2: Dressing percentages calculated as (CW / EBW * 100).

Table: 5. Economic evaluation of experimental rations.

Item	Experimental rations			
	Berseem hay (BH)	Mung bean husks (MBH)	Soybean vein hay (SBVH)	Peanut vein hay (PVH)
	R_1	R_2	R_3	R_4
Live body weight (LBW), kg	2.041	2.321	2.206	2.186
Total feed consumed for each	9.170	8.813	8.456	8.673
rabbit, kg	3.00	2.97	2.92	2.92
Costing of one kg feed, (LE)[1]	27.51	26.17	24.69	25.33
Total feed cost, (LE)	13.48	11.28	11.19	11.59
Feed cost / kg LBW (LE)[2]	3	3	3	3
Managerial cost / Rabbit, (LE)[3]	45.51	44.17	42.69	43.33
Total cost, (LE)[4]	53.07	60.35	57.36	56.84
Total revenue, (LE)[5]	7.56	16.18	14.67	13.51
Net revenue, (LE)	0.166	0.367	0.344	0.312
Economic efficiency[6]Relative	100	221.1	207.2	188.0
economic efficiency				

[1] Based on prices of year 2016.
[2] Feed cost/kg LBW = feed intake * price of kg / live weight.
[3] Include management, labors and veterinary care.
[4] Include the feed cost of experimental rabbit which was LE 15/ rabbit + management.
[5] Body weight x price of one kg at selling which was LE 26.
[6] Net revenue per unit of total cost (Khial, 1997).
LE = Egyptian pound equals 0.10US$ approximately

received ration containing 40% strawberry vines by-product tended to significant (P<0.05) higher feed intake. Also, Abdel-Magid (2005) and Omer and Bader (2013) noticed that rabbits received diet containing pea straw as alternative source of roughage for Berseem hay had higher daily feed consumption and good feed conversion.

On the other hand, substitution 50% of BH content (R_1) by MBH, SBVH or PVH (R_2, R_3 and R_4) improves feed conversion (g intake of DM, CP or NFC / g gain) or (kcal intake of GE or DE / g gain). The best feed conversion was recorded for R_2 followed by R_3 and R_4.

Dressing percentages

Carcass data is presented in Table (4) revealed that except for digestive tract content weight treatments had no effect (P>0.05) on all other carcass parameters recorded. Replacement 50% of BH with MBH, SBVH or PVH insignificantly (P>0.05) improved dressing percentages that expressed as carcass weight/ slaughter weight (DP_1) or carcass weight/ empty body weight (DP_2). El-Adawy and Borhami (2001); El-Gendy et al. (2002); Abdel-Magid (2005); El-Medany et al. (2008); Omer et al. (2011) who noted that replaced clover hay by pea, chick pea or kidney beans straw, peanut hay, dried carrot processing waste or strawberry by products in rabbit diets had no significant in dressing percentages.

Meanwhile, Galal et al. (2014) noted that substitution 0, 20, 40 and 60% of clover hay by strawberry vines by-product in rabbit rations significantly (P<0.05) increased slaughter weight, (hot carcass weight plus edible offal's) in comparison with those fed control diet.

Economic evaluation

The profitability of instead 50% of Berseem hay content (BH) in control ration (R_1) by different sources of field crop residues such as Mung bean husks (MBH), soybean vein hay (SBVH) or peanut vein hay (PVH) illustrated in (Table 5). The present results cleared that costing of one kg feed decreased by 1.00%, 2.67% and 2.67% for R_2, R_3 and R_4, respectively in comparison with the control ration (R_1).Using alternative sources of BH that considered the main source of good quality roughage in control ration (R_1) by unconventional sources of roughage such as (MBH, SBVH or PVH) occurred improving in their values of net revenue and relative economic efficiency. Net revenue values were improved by 214%, 194% and 179% for rabbits fed (R_2, R_3 or R_4), respectively. On the other hand, relative economic efficiency values were improved by 221.1%, 207.2% and 188% more than the control that assuming that equal 100%. Meanwhile, the present results established that feed cost/ kg live body weight gain were depressed by 16.32%, 16.99% and 14.02% for rabbits received rations contained MBH, SBVH or PVH, respectively. These results in agreement with those obtained by Abdel-Magid (1997); Abdel-Magid (2005); Abou Sekken et al. (2008); El-Medany et al. (2008); Ibrahim et al (2011); Omer et al. (2011); Omer and Badr (2013); Galal et al. (2014) Abo EL-Maaty et al. (2014); they noted that inclusion pea, chick pea or kidney beans straws; peanut hay; fennel and marjoram waste; dried carrot processing waste, broccoli or strawberry by-products and cucumber (*cucumis sativus l*) veins straw to partially or completely replacement of clover hay in rabbit rations reduced total feed cost, improved net revenue and increased relative economic efficiency.

CONCLUSION

It may be said Berseem hay that considered the important source of roughage depend on using it in rabbit rations can be replaced by 50% of different roughages such as soybean vein hay, peanut vein hay and Mung bean husks without any adverse effect on their health and gain with improving in relative economic efficiency; feed cost per kg live body weight and depressing price of ration formulation costing.

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

This work was supported by scientific project section, National Research Centre (P10120202) under title "Forage and fodder crop management production for balanced animal feeding".

with these terms.

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