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Effect of dietary replacement soybean meal by defatted flaxseed meal on growth performance, digestibility coefficient, carcass characteristics and some blood parameters in growing rabbits.

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Total number of 60 male White New Zealand rabbits (WNZ) after weaning are used to study the effect of the three different replacement levels 25, 50 and 75% of soybean meal (SBM) by a substitute of defatted flax seeds meal (DFM) in rabbit diets. Rabbits were classified into 4 equal groups divided to 3 replicates, 5 rabbits each. The 1st group received the basal diet without replacement level. The other three groups (2nd – 4th) received the basal diet with the replacement by DFM at 25, 50 and 75% levels respectively, till age 8 wks. Flaxseed was partly defatted by cold-pressing. Feeding rabbits at 75% level replacement significantly decreased the final body weight by 10% and the daily body weight gain by 22% with significant non-desirable feed conversion compared to the control group. Feeding rabbits at 25% replacement level significantly decreased the daily feed intake by 15% improved the feed conversion by 13.8 % and increased the digestibility coefficient of CF by 23.9%, EE by 10.3% and NFE by 10.6%, respectively, compared to the control group. Rabbits group at 75% level replacement significantly decreased the TDN by 8.1% and DCP by 12 % compared to the control group. Rabbits group at 25% level replacement significantly increased the dressing percent body weight / the final body weight by 2.6 %, while rabbits received 75% level replacement significantly increased the percent ratio of digestive tract weight / the final body weight by 22 % compared to the control group. Feeding rabbits at 25, 50 and 75% levels replacement significantly decreased the total lipids by 55, 11 and 24 %, the total cholesterol by 3, 7.4 and 14.5%, the HDL by 3.7, 9.1 and 17.1%, the LDL by 4.7, 7.5 and 12.7% and the triglycerides by7.4, 17.7 and 15.4% respectively, compared to the control group with no significant effects of DFM replacement on the other blood parameters. Rabbits at 50 and 75% levels replacement significantly decreased the total protein by 12.3 and 24.7%, respectively, compared to the control group. In conclusion, rabbits group at 25% level replacement showed the significant and best values of the digestibility coefficient and the dressing weight with the lowest feed intake and feed conversion.

Keywords: White New Zealand rabbits, Soybean meal, Defatted flaxseeds meal, Growth performance, Digestibility, Carcass characteristics and Blood parameters

INTRODUCTION

While feeding is the main cost of animal production, protein is an essential key ingredient of animal feed and it is necessary for mass rabbit growth performance, soybean meal is becoming the chiefly protein source, most reliable and at the same time the greatest single item determines profit margins in meat production. On the other hand, the capability of different feedstuffs to meet the protein requirements of rabbits depends on the nitrogen unit used. Our theoretical hypothesis that rabbits require high amounts of fiber in their diet to provide a substrate for fermentation in the caecum to produce bacterial cells as another source of protein and vitamins B which has beneficial health effects (Peterson et al.2010)

Flaxseed *Linum usitatissimum L*. (Linaceae), is the richest known source of plant lignans (Thompson et al. 1991). Flaxseed exists in several main forms such as whole seed, ground seed and partially defatted flax seed meal which contains the highest content of a good source of soluble and insoluble fibers (Bassett *et al.* 2009). The DFM contains biologically active substances as lignans secoisolariciresinol diglucoside (SDG) which represents about 95% of the total lignans in flaxseed plant which converted by colon bacteria to the mammalian lignans enterodiol and enterolactone (Liu et al. 2006). Numerous studies confirmed the antioxidant activity not only of flaxseed lignans in different experimental model systems (Lorenc et al.2005) but also of non-lignan phenolic compounds present in flaxseed that contribute to its antioxidant potential (Struijs et al. 2007).

Lignans, flavonoids and phenolic acids in DFM may prevent degradation of many molecules; lipids, DNA, proteins being significant to the metabolism and provide protection to biologically-active substances contained in seeds; e.g., essential fatty acids (Żuk et al. 2011). Polyphenols remain in the flaxseed cake even after the cold-extraction of oil (Magdalena et al. 2015). The colon bacterial strain can transform secoisolariciresinol diglucoside (SDG) to secoisolariciresinol under less stringent anaerobic culture conditions due to its preventive effects against breast or colon cancers, atherosclerosis and diabetes **(**Li et al. 2012).

This study aimed to evaluate the effects of the graded replacement of soybean meal by defatted flax seeds meal on the performance, digestibility and some blood parameters in growing white New-Zealand rabbits.

MATERIALS AND METHODS

This experiment was carried in Nubaria research and production station, National Research Centre and was conducted to study the substitute replacement effect of three different levels of SBM by a substitute of DFM in growing rabbit diets. Sixty male NZW rabbits after weaning with an average body weight of 650 ± 70 g. Rabbit housed in individual wire cages and divided into 4 equal groups divided to 3 replicates, 5 rabbits each. The basal experimental diet was formulated and pelleted to cover the nutrient requirements of rabbits as a basal diet according to t69o as shown in Table (1). The feeding period was extended for 56 days, and the experimental groups were classified as follow: Group 1 basal diet without any replacement and served as (G1), group 2 basal diet with 25% replacement of SBM by DFM (G2), group 3 basal diet with 50% replacement of SBM by DFM (G3) and group 4 basal diet with 75% replacement of SBM by DFM (G4) Flaxseed was partly defatted by cold-pressing and grinded which contained approximately 10% of flaxseed oil. The DFM used the following chemical composition: 22.8% protein, 15.6 % total fat, 6.5% carbohydrates, 12.6% ash and 42.5 % dietary fiber, giving a total caloric value of 1048.1 kcal/100g meal.

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

All rabbits were used in digestibility trials over period of 7 days to determine the nutrient digestibility coefficients and nutritive values of the tested diets. Feed intake of experimental rations and weight of feces were recorded daily. Representative samples of feces were dried at 60ºC for 48 hrs, grinded and stored for chemical analysis later.

Chemical analysis of experimental rations and feces were analyzed according to AOAC (2000) methods. Gross energy (mega calories per kilogram DM) was calculated according to Blaxter (1968), where, each g of crude protein (CP) = 5.65 kcal, each g of ether extract (EE) = 9.40 kcal, and each g crude fiber (CF) and nitrogen-free extract (NFE) = 4.15 kcal. Digestible energy (DE) was calculated according to Fekete and Gippert (1986) using the following equation: DE (kcal/ kg DM) = 4253 – 32.6(CF %) – 144.4 (total ash). To determine the carcass measurements, three representative rabbits from each treatment were randomly chosen and fasted for 12 hours before slaughtering according to Blasco *et al.* (1993). These were removed and individually weighed.

Table (1): Composition of the experimental diets (kg/ton) with different levels (DFM).

Item	Control	Replacement SBM by DFM		
		25%	50%	75%
Ingredients				
Clover hay	18	20	26.9	26.9
Yellow corn	32.9	30.9	23	20
Barley grain	20	20	20	20
Wheat bran	10	10	8	11
Soybean meal (44% CP)	16	12	8	4
Defatted flax seeds meal (DFM)	-	4	8	12
Sunflower oil	-	-	3	3
Lime stone	1.7	1.7	1.7	1.7
Di-Ca-phosphate	0.7	0.7	0.7	0.7
DL-methionine	0.1	0.1	0.1	0.1
Vit. & min. mixture*	0.2	0.2	0.2	0.2
Sodium chloride	0.3	0.3	0.3	0.3
Anti-fungal agent	0.1	0.1	0.1	0.1
Total	100	100	100	100
Chemical composition of the experimental diets %				
DM	91.88	91.94	93.08	91.64
OM	91.36	90.87	91.41	91.86
CP	16.72	16.62	16.36	16.17
CF	13.00	13.40	13.75	13.96
EE	4.00	5.00	5.50	5.40
NFE	57.64	55.85	55.80	56.33
Ash	8.64	9.13	8.59	8.14
Calculated analysis DE** (Kcal/Kg DM)	2889	2882	2888	2800

* Vit. & Min. mixture: Each kilogram of Vit. & Min. mixture contains: 2000.000 IU Vit. A, 150.000 IU Vit. D, 8.33 g Vit. E, 0.33 g Vit. K, 0.33 g Vit. B1, 1.0 g Vit. B2, 0.33g Vit. B6, 8.33 g Vit.B5, 1.7 mg Vit. B12, 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Follic 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. **DE (Kcal/Kg DM))= 4253-32.6 (CF%) – 144.4 (ash%), according to Fekete and Gippert (1986)

Table (2): Effect of replacement different levels of DFM on on rabbit's rabbit's digestibility.

Digestibility coefficient	Control	Replacement SBM by DFM		
		25%	50%	75%
Dry matter (DM)	72.0 ±10.0[a]	74.1 ± 0.4[a]	75.0 ± 4.5[a]	54.7 ± 3.2[b]
Organic matter (OM)	73.0 ± 9.2[ab]	76.1 ± 0.3[a]	76.0 ± 2.8[a]	64.4 ± 25.0[b]
Crude protein (CP)	72.6 ±11.5[ab]	81.0 ± 3.8[a]	77.3 ± 4.7[ab]	69.3 ± 24.0[b]
Crude fiber (CF)	34.7 ±2.2[bc]	43.0 ± 3.6[a]	36.6 ± 1.6[b]	32.1 ± 4.0[c]
Ether extract (EE)	78.0 ± 2.7[c]	86.0 ± 2.0[a]	81.5 ± 2.3[b]	75.0 ± 7.8[c]
Nitrogen free extract (NFE)	79.3 ± 2.0[bc]	87.7 ± 4.0[a]	82.3 ± 2.7[b]	76.6 ± 4.1[c]
Total digestible nutrients (TDN)	74.0 ± 6.8[a]	75.6 ± 0.9[a]	74.1 ± 2.4[a]	68.0 ± 12.2[b]
Digestible crude protein (DCP)	11.8 ± 1.9[a]	13.2 ± 0.6[a]	12.6 ± 0.9[a]	10.4 ± 0.9[b]

.a, b& c Means within each row in each parameter which have different superscripts differ significantly (P<0.05)

Table (3): Effect of replacement different levels of DFM on on rabbit's growth performance.

Item	Control	Replacement SBM by DFM		
		25%	50%	75%
Initial weight (kg)	0.651±0.82	0.671±0.10	0.660±0.51	0.629±0.82
Final weight (kg)	2.44±0.27[a]	2.50±0.24[a]	2.47±0.35[a]	2.12±0.18[b]
Feed intake (kg)	6.04±055[ab]	5.14±2.06[c]	5.97±0.84[b]	6.54±0.36[a]
Daily feed intake (g)	107.8±9.78[ab]	91.7±36.7[c]	106.6±15.0[b]	116.8±6.49[a]
Total weight gain (kg)	1.79±0.35[a]	1.83±0.29[a]	1.81±0.29[a]	1.49±1.42[b]
Daily weight gain (g)	32.7±2.30[a]	32.3±5.23[a]	32.0±5.22[a]	25.4±2.95[b]
Feed conversion (ratio)	3.33±0.88[b]	2.87±1.27[c]	3.36±0.81[b]	4.61± 0.48[a]

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a,b & c Means within each row in each parameter which have different superscripts differ significantly (P<0.05).

Full and empty weights of digestive tract were recorded and digestive tract contents were calculated by differences between full and empty digestive tract. Weights of edible and external offal's were calculated as percentages of slaughter weight (SW). Hot carcass was weighed and divided after head separation into front and hind parts.

Blood samples were collected in heparinized tubes from the brachial vein (3 rabbits /group), and centrifuged at 3000 rpm for 15 minutes to separate clear serum which stored at -20ºC for determination of some blood constituents as total lipids (TL), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), triglyceride (TG), total protein (TP), aspartate transaminases (AST) and alanine transaminas

(ALT) by spectrophotometer using available commercial kits.Collected data were subjected to statistical analysis as one way classification analysis of variance using the general linear model procedure of SPSS (1998). Duncan's Multiple Range Test (1955) was used to separate means when the dietary treatment effect was significant

RESULTS AND DISCUSSION

Effect of DFM replacement on rabbit's performance

Feeding rabbits at 75% level replacement of SBM by DFM significantly decreased the final body weight by 10%, the body weight gain by 22% and the significant non-desirable value of feed conversion by 38% compared to the control group (Table 3). Feeding rabbits at 25% level replacement significantly decreased the daily feed intake by 15% and improved the feed conversion ratio by 14% compared to the control group (Table 2).

These negative effects of the replacement by 75% DFM on the performance parameters was probably attributed to the shortage of sulfur amino acids associated with decreasing SBM especially without using other protein sources or synthetic amino acids (Rezaei and Hafezian 2007), which reflect the positive effects by the replacement of 25% level. In other words decreasing these performance values at 75% replacement may be due the presence of anti-nutrients, such as flaxseed mucilage, which modify and other anti-nutritional factors such as linatine and cyanogenic glycosides (Alzueta et al. 2003) that have a negative impact on the growth and development of young animals (Batterham et al. 1991).

Effect of defatted flaxseed meal replacement on rabbit's digestibility

Feeding rabbits at 25% level replacement significantly increased the digestibility coefficient of the CF by 23.9%, the EE by 10.1% and the NFE by 9.6%, respectively, compared to the control group (Table 2). These results may be attributed to the effect of DFM in healthy improvement associated with the reduction of transit time, and improved the fiber bacterial fermentation into short-chain fatty acids **(**Gomides et al. 2013). Feeding rabbits at 75% level replacement significantly decreased the digestibility coefficient of DM by 24 %, the TDN by 8% and the DCP by 12%, respectively, compared to the control group (Table 3). These results may be attributed to the lignans, flavonoids and phenolic acids in DFM that may prevent degradation of many molecules; lipids, DNA, proteins being significant to the metabolism and provide protection to biologically-active substances contained in seeds **(**Żuk et al. 2011), or may be due to that DFM reduces aberrant crypt foci in rabbit caecum by increasing the Bifidobacterium spp. (Gomides et al. 2015). In other words, flavonoids impair the bioavailability of phosphorus, zinc, manganese, magnesium and calcium which form compounds with proteins, may affect the activity of enzymes (hydrolytic ones in particular) in the gastrointestinal tract and, thereby, reduce digestibility of dietary constituents (Magdalena et al. 2015).

Effect of DFM replacement on carcass characteristics

Feeding rabbits at 25% level replacement by DFM significantly increased the carcass percent body weight/the final body weight by 2.6 % compared to the control group (Table 4). This result may be attributed to increasing the protein level at the form of SBM that may be induce frequently small improvements in carcass quality, measured as increased protein and decreased fiber content. Similar results showed that flaxseed can effectively alter composition of carcass tissues to yield meat (La Brune et al. 2008). Feeding rabbits at 75% level replacement significantly increased the percent of digestive tract weight/the final body weight by 22 % compared to the control group (Table 4). This result may be attributed to that fibre the main component in the rabbit caecum represent component about 70% of total DM while nitrogen the second in importance represent about 15% of total DM (Szendrő et al. 2011). In other words, some tissues are converted faster than others as the intestinal epithelium and liver that lead to little or no net accumulation (Jha et al. 2013).

Effect of DFM replacement on blood parameters.

Feeding rabbits at 25, 50 and 75% levels replacement by DFM significantly decreased the total lipids by 5, 11 and 24 %, the total cholesterol by 3, 7.4 and 14.5%, the HDL by 3.7, 9.1 and 17.1%, the LDL by 4.7, 7.5 and 12.7% and the triglycerides by 7.4, 17.7 and 15.4%, respectively, compared to the control group (Table 5).

Table (4): Effect of replacement different levels of DFM on rabbit's carcass characteristics.

Item*	Control	Replacement SBM by DFM		
		25%	50%	75%
Live body weight (g)	2135± 26.5[b]	2159± 45.5[b]	2221±25.2[a]	2131±56.9[b]
***Carcass wt / live wt %**	69.4±0.59[b]	71.2± 1.1[a]	70.2±1.9[ab]	67.6±2.97[c]
Digestive tract wt / live wt %	12.4±3.36[b]	12.0±2.08[b]	12.8±0.24[b]	15.1±0.31[a]
Head wt / live wt %	5.98± 0.95	5.85±1.00	5.73±1.68	5.79±1.36
Fur wt / live wt %	12.2± 4.13	11.0±1.55	11.3±3.52	11.5±4.37

a, b, c & d, Means within each row in each parameter which have different superscripts differ significantly (P<0.05).

*Carcass %: Weighed and calculated on the basis of the proportion of carcass weight to 100 grams of live body weight.

Table (5): Effect of replacement different levels of DFM on rabbit's blood parameters.

Item	Control	Replacement SBM by DFM		
		25%	50%	75%
Total lipids mg/dl	3.8±0.2[a]	3.6 ± 0.2[b]	3.4 ± 0.12[b]	2.9 ± 0.2[c]
Total cholesterol mg/dl	242± 5.3[a]	234± 8.1[b]	224± 8.1[c]	207±12.2[d]
HDL mg/dl	24.1± 0.3[a]	23.2± 0.7[b]	21.9± 1.1[c]	20.0±0.3[d]
LDL mg/dl	95.6± 1.4[a]	91.1±1.8[b]	88.4±1.5[c]	83.5±3.2[d]
Total glycerides mg/dl	136±6.1[a]	126±11.1[b]	112±5.0[c]	115±5.0[c]
Total protein mg/dl	7.3± 0.9 [a]	6.8±0.5[ab]	6.4±0.8[b]	5.5±0.8[c]
AST IU/L	73.2±7.8	73.7±4.6	76.2±8.5	74.3±7.8
ALT IU/L	35.5±5.9	37.7±2.1	37.6±1.5	38.3±1.1

a, b ,c & d Means within each row in each parameter which have different superscripts differ significantly (P<0.05).

These results may be attributed to the DFM gum is likely the major active ingredient responsible for the lipid-lowering action (Babu et al. 2000) or limit cholesterol-induced atherogenesis and abnormalities (Dupasquier et al. 2006). Therefore, DFM may be regarded as a useful therapeutic diet for reducing hyperlipidemia (Torkan et al. 2015). Feeding rabbits at 50 and 75% levels replacement significantly decreased the total protein by 12.3% and 24.7, respectively, compared to the control group (Table 5). This result may be due to the high level of DFM and the long-term feeding experiment (56 days) lead to the undesirable effects on the assayed hematological and biochemical blood markers (Magdalena et al. 2015)..

CONCLUSION

In conclusion, as gradually decreasing the dietary replacement of soybean meal by defatted flaxseeds meal from 75 to 25% levels significantly improved the growth performance, the digestibility coefficient, carcass characteristics and all lipids blood parameters. Therefore it's important to be recommended that may be adequate energy must be supplied by the diet to make efficient use of dietary protein because of the sufficient nitrogen and caecum degradable protein must be supplied to maximize bacterial fermentation, energy digestibility and feed intake**.**

CONFLICT OF INTEREST

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

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AUTHOR CONTRIBUTIONS

Bakry, A. B, planted this type of flaxseed in the field and separated the meal from the seeds, El-Nomeary, Y.A.A, designed the experience of digestion and performed the chemical analysis, El Allawy, Hewida M, performed the carcass characteristics and rabbit blood parameters and Ibrahim, Sh. A. M, performed the rabbit experiment, the statistical analysis, reviewed the manuscript and approved the final version..

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