Utilization of Flaxseeds *(Linum usitatissimum L.)* in Rabbit Rations. 1. Response of Growing Rabbits to Diets Containing Different Levels of Flaxseeds.

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Abstract: A 70-day feeding trial was conducted to determine the response of growing rabbits to diets containing graded levels of flaxseeds. Forty five male New Zealand White rabbits aged 5-6 weeks with an average body weight of 598 ± 16.22 g were divided into five equal groups (9 rabbit in each). Flaxseed was incorporation in rabbit rations at levels of 0, 2.50, 5.00, 7.50 and 10.00% for rations from R_1 to R_5, respectively. Weight gain, feed intake, feed conversion, digestion coefficients and economic efficiency were determined. Tested rations were almost isocaloric and isonitrogenous. The results showed that chemical composition of the experimental rations was formulated to have a similar CP that ranged from 15.55 to 15.76% and digestible energy that ranged from 2517 to 2561 kcal/ kg DM for the experimental rations. Increasing level of flaxseeds in the rabbit rations lead to increase the ether extract and acid detergent fiber (ADF) contents, while, it decreased the hemicellulose content. Except DM and hemicellulose digestibilities, dietary treatment had significant effect ($P<0.05$) on all the other nutrient digestibility of (OM, CP, CF, EE, NFE, NDF, ADF and cellulose); nutritive values (TDN and DCP). Rabbits received 10% flaxseeds containing diet recorded the highest digestion coefficient values of (OM, CP, CF, NFE, NDF, ADF and cellulose) and nutritive value as (TDN). Dietary treatments had no significant effect ($P>0.05$) on final live body weight (FLBW), total body weight gain (TBWG) and average daily gain (ADG) among the different experimental groups. FLBW, TBWG and ADG ranged from 2458 to 2628 g; from 1866 to 2030g and from 26.7 to 29.0 g, respectively. With increasing the levels of flaxseed in rabbit rations the increasing in FLBW, TBWG and ADG was realized. Rabbit received 10% flaxseed containing ration recorded the best values of FLBW, TBWG and ADG. Feed conversion was improved by inclusion flaxseed in rabbit rations at different levels (2.5, 5.0, 7.5 and 10%) compared to the control ration. Rabbit received 10% flaxseed containing ration recorded the best values of feed conversion that expressed as (g feed intake of DM, CP, DCP and TDN/ g gain) and digestible energy (kcal/ g. gain). Increasing levels of flaxseed in rabbit rations, both net revenue and relative economic efficiency were increased. Net revenue was improved by 8.15%, 15.29%, 19.97% and 27.41% for tested rations (2-5), respectively compared to control ration, while, relative economic efficiency was improved by 9.7%, 18.4%, 25.1% and 35.4%. Feed cost/ kg live body weight gain was decreased when rations contained different levels of flaxseed compared to control rations. The corresponding values of feed cost/ kg live body weight gain were decreased by 5.10%, 9.16%, 12.83% and 17.67% for rations contained 2.5, 5.0, 7.5 and 10.0% flaxseed, respectively, in comparison with the control ration. It could be mentioned that incorporation flaxseed in rabbit rations give the best results in terms of growth performance with a positive effect on digestion coefficients and realizing high net revenue.

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1. Introduction:

Historically, flaxseed has been used for food and feed for animals for several thousand years in Europe, Asia and Africa, and more recently in Canada and United States. Oil pressed from flaxseed also has been basic cooking oil in China and other countries for centuries **(Steven's farm, 2013).**

The revival of interest in flaxseed is due to the oil content, which is about 40%on a dry matter basis (**Budin *et al.*, 1995**). This oil is a rich source of the following unsaturated fatty acids: oleic (C18:1n−9; 12–20%), linoleic (C18:2n−6; 20–24%), and linolenic acid (C18:3n−3; 36–42%) (**Flachowsky *et al.*, 1997**) and it has a relatively low glucosinolate content (**Schuster and Friedt, 1998**). The protein and fiber content in the seed are also important nutritional parameters: the crude protein content in the seed ranges from 25% to 45%, while the crude fiber content is about 10% (**Korsrud *et al.*, 1978**).

Ground flaxseed is a source of Alpha-linolenic acid (ALA) and lignans that exhibit a number of properties that are essential to good health. Alpha-linolenic acid (ALA) is both an essential fatty acid and an omega 3 fatty acid that can aid in regulating

cholesterol, triglycerides and blood pressure. Controlling immune and inflammatory disorders **(Stevens's farm, 2013).**

Flaxseed contains lignan, which is a type of photo estrogen that serves as an antioxidant. Lignan may help to prevent certain types of cancer, especially breast cancer, report doctors at the Mayo Clinic. Lignan metabolites may bind to estrogen receptors and inhibit the growth of breast cancer cells (**Ray, 2011**).

Ground flaxseed is also rich in protein, B vitamins, vitamin E, beta-carotene, calcium, potassium, magnesium, manganese and zinc **(Steven's farm, 2013).**

Flaxseed is a good source of soluble and insoluble dietary fiber and is the richest plant source of α-linolenic acid (ALA; C18:3 n-3, omega-3 [n-3] fatty acid), as well as the lignan secoisolariciresinol diglucoside (**Liggins *et al.*, 2000; Prasad 2000** and **Simopoulos, 2002)**.

Prasad (2000) noted that flaxseed contains 32-45% of its mass as oil, of which 51-55% is alpha linolenic acid (n-3 fatty acids, omega 3 fatty acids). Flaxseed lignan (secoisolariciresinol diglucoside; SDG) is isolated from defatted flaxseed.

Golden variety of flaxseed (GFS) can be given to rabbits at levels of up to 16% in the diet without any adverse effects on growth performance and with a better digestibility than the control diet (**Peiretti and Meineri**, **2008**).

The main objective of this work was carried out to study the effects of inclusion flaxseeds at different levels in rabbit rations on their growth performance, digestion coefficients, and economic evaluation.

2. Materials and Methods

Forty five male New Zealand White rabbits aged 5-6 weeks with an average body weight of 598 ± 16.22 g were divided into five equal groups, 9 rabbit in each group. Flaxseed was incorporation in rabbit rations at levels of 0, 2.50, 5.00, 7.50 and 10.00% for rations from R_1 to R_5, respectively.

The experimental rations were formulated and pelleted to cover the nutrient requirements of rabbits according to (**NRC, 1977**).

Rabbits individually housed in galvanized wire cages (30 x 35 x 40 cm). Stainless steel nipples for drinking and feeders allowing recording individual feed intake for each rabbit were supplied for each cage (*ad libitum).* Rabbits of all groups were kept under the same managerial conditions and rations were offered pelleted and diameter of the pellets was 4 mm. Feeding trial lasted for 70 days.

At the end of the experimental period, all rabbits were used in digestibility trials over period of 7 days to determine the nutrient digestibility and nutritive values of the tested rations. Feed intake of experimental rations and weight of feces were daily recorded. Representative samples of feces was dried at 60°C for 48 hrs, ground and stored for later chemical analysis. Composition of the experimental rations (kg/ton) is presented in Table (1).

Table 1. Composition of the experimental rations (kg/ton)

Item	Experimental rations				
	0% Flaxseed	2.5% Flaxseed	5% Flaxseed	7.5% Flaxseed	10% Flaxseed
Yellow corn	230.0	205.0	130.0	90.0	70.0
Barley grain	50.0	50.0	70.0	75.0	50.0
Wheat bran	270.0	270.0	300.0	320.0	300.0
Soybean meal	150.0	140.0	120.0	110.0	100.0
Flaxseed	---	25.0	50.0	75.0	100.0
Alfalfa hay	270.0	280.0	300.0	300.0	350.0
Di-Ca-Phosphate	10.0	10.0	10.0	10.0	10.0
Limestone	10.0	10.0	10.0	10.0	10.0
Sodium chloride	5.0	5.0	5.0	5.0	5.0
Vit. & Min. mixture*	3.0	3.0	3.0	3.0	3.0
DL-Methionine	1.0	1.0	1.0	1.0	1.0
Anti fungal agent	1.0	1.0	1.0	1.0	1.0
Price, L.E/Ton	1986	2066	2152	2236	2293

* 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.

Chemical analysis of flaxseeds, experimental rations and feces were analyzed according to **A.O.A.C (2000)** methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were also determined in flaxseeds, experimental rations and feces according to **Goering and Van Soest (1970)** and **Van Soest *et al.* (1991).**

Economic 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.
Economic 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 **Fekete and Gippert (1986)** by applying the following equation:
DE (kcal/ kg DM) = 4253 – 32.6 (CF %) – 144.4 (total ash %).

Collected data were subjected to statistical analysis as one way analysis of variance using the general linear model procedure of **SPSS (2008). Duncan's Multiple Range Test (1955)** was used to separate means when the dietary treatment effect was significant.

3. Results and Discussion

Chemical analysis of Flaxseeds and the experimental rations

Chemical analysis of flaxseeds and the experimental rations are presented in Table (2). Flaxseed used in our study contained 20.93% CP, 12.23% CF, 29.14% EE, 15.94% NFE, 5091 kcal/ kg DM of gross energy and 1107 kcal/kg DM digestible energy.

Table 2. Chemical analysis (%) of flaxseeds and the experimental rations

Item	Flax seed	Experimental rations				
		0% Flax seed	2.5% Flax seed	5% Flax seed	7.5% Flax seed	10% Flax seed
Dry matter (DM)	92.46	89.57	90.38	90.24	90.30	90.83
Chemical analysis on dry matter basis						
Organic matter (OM)	78.24	90.64	90.57	90.70	90.62	90.75
Crude protein (CP)	20.93	15.71	15.76	15.56	15.75	15.55
Crude fiber (CF)	12.23	10.45	10.56	11.72	11.56	11.64
Ether extract (EE)	29.14	3.45	4.08	4.91	5.85	5.52
Nitrogen–free extract (NFE)	15.94	61.03	60.17	58.51	57.46	58.04
Ash	21.76	9.36	9.43	9.30	9.38	9.25
Growth energy (Kcal/kg DM)[1]	5091	4178	4209	4255	4304	4289
Digestible energy (kcal/kg DM)[2]	1107	2561	2547	2528	2517	2538
Cell wall constituents						
Neutral detergent fiber (NDF)	36.96	35.79	35.86	36.62	36.52	36.57
Acid detergent fiber (ADF)	25.36	17.43	18.46	18.88	19.82	20.74
Acid detergent lignin (ADL)	4.00	4.20	4.07	5.49	4.40	4.21
Hemicellulose[3]	11.60	18.36	17.40	17.74	16.70	15.83
Cellulose[4]	21.36	13.23	14.39	13.39	15.42	16.53

[1]Gross energy (kcal/kg DM) was calculated according to **Blaxter (1968)**. Each g CP = 5.65 kcal, g EE = 9.40 kcal and g (CF & NFE) = 4.15 kcal.
[2] Digestible energy (DE) was calculated using the following equation:
DE (kcal/ kg DM) = 4253 – 32.6 (CF %) – 144.4 (total ash %).
[3] Hemicellulose = NDF – ADF.
[4] Cellulose = ADF – ADL.

Similar to most grains and oilseeds, the composition of flax can vary based on variety, environmental factors and method of analysis (**Daun *et al.*, 2003; Maddock *et al.*, 2005** and **Morris, 2008**). Limited data are available regarding proximate (nutritive) analysis of flax. Values most commonly used were 41% oil, 20% protein and 28% dietary fiber (**Canadian Grain Commission, 2001**; DM basis). Protein values range from 18.8% to 24.4% (**Daun and Pryzbylski, 2000**).

Peiretti and Meineri (2007) noted that flaxseed contained 93.20% DM; 24.5% CP; 30.2% EE; 41.0% NDF; 29.4% ADF; and 4.2% Lignin.

Also, data of Table (2) showed that chemical composition of the experimental rations were formulated to have a similar CP that ranged from 15.55 to 15.76% and digestible energy that ranged from 2517 to 2561 kcal/ kg DM for the rations contained flaxseeds at levels (0, 2.5, 5, 7.5 and 10%). The inclusion flaxseeds in the rations lead to increase the ether extract and acid detergent fiber (ADF) contents, while, it decreased the hemicellulose content. These results in agreement with those obtained by **Peiretti *et al.* (2007a)** who used false flax (Camelina sativa L.) seeds (FFS) at different levels 0, 10 or 15% in crossbred rabbit diets.

Digestion coefficients and nutritive values of the experimental rations

Data of Table (3) cleared that except for DM and hemicellulose digestibilities, dietary treatment had significant effect (P<0.05) on all the other nutrient digestibility of (OM, CP, CF, EE, NFE, NDF, ADF and cellulose); nutritive values (TDN and DCP).

Rabbits received ration containing 10% flaxseeds recorded the highest digestion coefficient of (OM, CP, CF, NFE, NDF, ADF and cellulose) and nutritive value as (TDN).

Table 3. Digestion coefficients and nutritive values of the experimental rations

Item	Experimental rations					SEM
	0% Flax seed	2.5% Flax seed	5% Flax seed	7.5% Flax seed	10% Flax seed	
Digestion coefficients (%)						
DM	77.24	77.83	80.51	76.56	78.79	0.93
OM	64.61^{b}	68.25^{ab}	69.42^{ab}	63.83^{b}	70.35^{a}	0.97
CP	73.72^{ab}	78.00^{a}	78.00^{a}	72.76^{b}	78.04^{a}	0.86
CF	10.27^{b}	12.66^{ab}	20.98^{ab}	11.34^{b}	23.61^{a}	1.97
EE	71.76^{ab}	71.34^{ab}	77.57^{a}	77.47^{a}	68.52^{b}	1.35
NFE	72.71^{bc}	75.25^{ab}	76.16^{ab}	70.55^{c}	77.84^{a}	0.87
Nutritive values (%)						
TDN	62.60^{c}	65.46^{abc}	67.73^{ab}	63.51^{bc}	68.56^{a}	0.84
DCP	11.58^{ab}	12.29^{a}	12.14^{ab}	11.46^{b}	12.13^{ab}	0.13
Cell wall constituents (%)						
Neutral detergent fiber (NDF)	40.80^{b}	50.32^{ab}	48.23^{ab}	42.82^{ab}	55.04^{a}	2.17
Acid detergent fiber (ADF)	20.52^{c}	32.90^{b}	35.77^{b}	33.44^{b}	45.36^{a}	2.34
Hemicellulose	60.05	68.80	72.34	63.96	67.71	2.76
Cellulose	21.40^{d}	43.84^{ab}	31.41^{cd}	37.97^{bc}	49.83^{a}	2.95

a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.5).
SEM: Standard error means

Peiretti *et al.* (2007a) studied the effect of levels of false flaxseeds (*Camelina sativa L.*) (FFS) at 0, 10 or 15% on nutrient and cell wall constituent's digestibilities of crossbred rabbits**.** They found that digestibility of DM, OM, NFE and EE significantly increased as the proportion of the FFS increased. Digestibility of CP decreased (69.5% to 66.2%) when FFS levels were increased from 10 to 15%, while digestibility of the diet without FFS was intermediate. This is probably due to the different digestibility of the protein sources in the three experimental diets. Conversely, ADF digestibility decreased as the proportion of the FFS increased, while the CF and NDF digestibilities showed the same trend, but without any statistical differences.

Peiretti and Meineri (2008) showed that feeding rabbits golden flaxseeds (*Linus usitatissimun* L.) (GFS) at different levels (0, 8 and 16%) containing diets to evaluate its effect on nutrients digestibility. Apparent digestibility of the mixed feed with GFS inclusion level of 16% was higher than those of other 2 diets (0 or 8% GFS). They also concluded that golden flax can be given to rabbits at levels up to 16% in the diet caused better digestibility than the control diet.

Peiretti *et al.* (2010) determined the effects of three levels (0, 5 and 10%) of perilla (*Perilla frutescens L.*) seeds (PFS) on the apparent digestibility in rabbits aged. The measured parameters were digestibility of dry matter, organic matter, crude protein, ether extract, neutral detergent fiber, acid detergent fiber and gross energy. The only parameter that was modified by the inclusion of PFS was the ether extract digestibility; it resulted higher in the 10% PFS diet (83.9%) than in the other two diets. Perilla seed may be used satisfactorily as a nutrient

supplement for rabbits at levels up to 10% in the diet with a better digestibility of ether extract than in the other two diets.

Fernández *et al.* (1994) observed an increase in ADF digestibility when fat was added to the diet, but most authors do not find significant differences in fiber digestibility (**Xiccato *et al.*, 1995**; **Pérez *et al.*, 1996**). In fact, in most of the works the differences seem to be attributed more to changes in dietary fiber content and nature than to the addition of fat itself (**Peiretti *et al.*, 2010**).

Van Manen *et al.* (1989) described an increase in EE digestibility when fat was added to the diet and this could be due to the fact that with increasing fat intake the fecal excretion of endogenous fat had a diminishing effect on the calculated apparent digestibility.

There are some differences of digestibility, depending on the unsaturation degree of fats used; in fact, the higher EE digestibility of unsaturated fatty acids diet seems to be related to its richness in polyunsaturated fatty acids, which are easier emulsified in the digestive tract than saturated fatty acids (**Pascual *et al.*, 2002**), and a negative relationship has been reported between the degree of saturation and fat digestibility in rabbits (**Xiccato, 2010**).

Obaa *et al.* (2009) estimated the effect of unprocessed whole flaxseed (WF) or dry-rolled flaxseed (RF) at 100 g kg^{-1} of dietary dry matter on nutrients digestibility of Holstein cows. They found that apparent total tract digestibility of ether extract was lower for WF compared with RF (486 vs. 624 gkg^{-1}). Moreover, excretion of α-linolenic acid in feces was greater for WF compared with RF treatment (259 vs.129gd^{-1}). They also, reported that although some intact whole flaxseed appeared in the feces of cows fed unprocessed flaxseed, the EE content was quite low, indicating that the fats present in flaxseed were available to cattle even in the absence of any visible damage to the seed coat.

Petit *et al.* (2005) noted that digestibility of DM, CP, ADF, and NDF was generally reduced when diets contained flaxseed and lower protein concentration. Also they noted that dietary protein had no effect while dietary flaxseed increased fecal N excretion. Retention of N was lower in cows fed flaxseed compared with cows fed the control ration.

Growth performance of the experimental groups

Growth performance of the experimental groups is presented in Fig. (1) and Table (4). The results cleared that, dietary treatments had no significant effect (P>0.05) on final live body weight (FLBW), total body weight gain (TBWG) and average daily gain (ADG) among the different experimental groups. FLBW, TBWG and ADG ranged from 2458 to 2628 g; from 1866 to 2030g and from 26.7 to 29.0 g, respectively. Present data showed that with increasing the levels of flaxseed in rabbit rations the increasing in FLBW, TBWG and ADG were realized. Rabbit received 10% flaxseed containing rations recorded the best values of FLBW, TBWG and ADG.

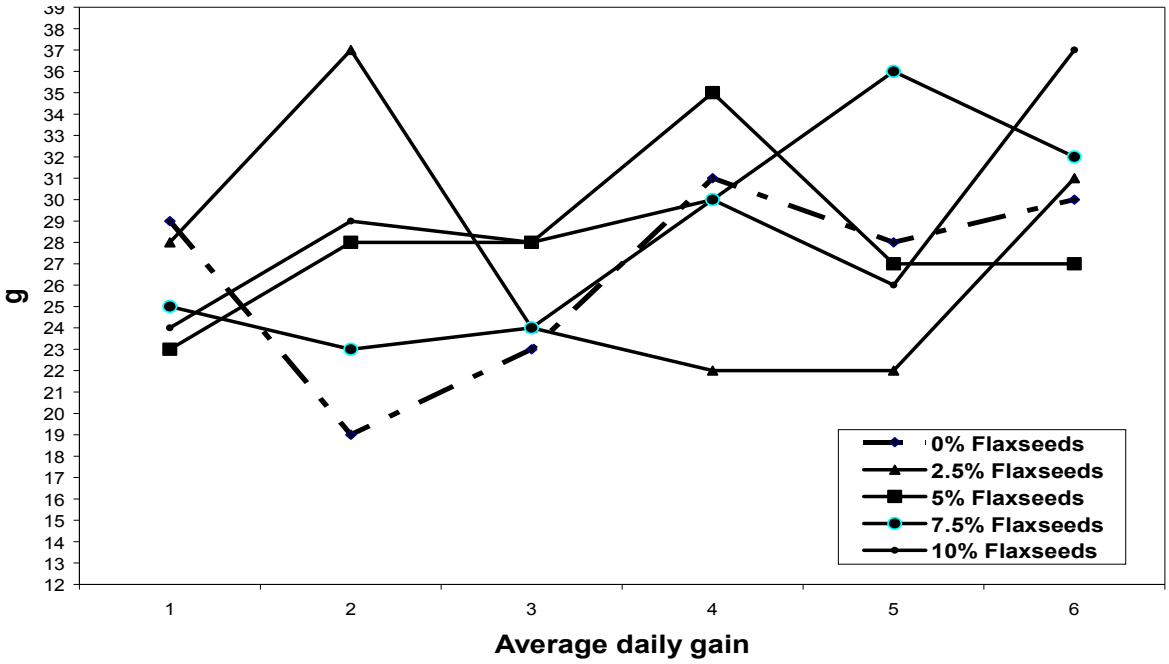

Fig. 1. Effect of flaxseed levels on average daily gain of the experimental group rabbits.

Table 4. Growth performance of the experimental groups

Item	Experimental rations					SEM
	0% Flax seed	2.5% Flax seed	5% Flax seed	7.5% Flax seed	10% Flax seed	
Initial weight, g	592	599	601	600	598	16.22
Final live body weight, g (FLBW)	2458	2513	2563	2585	2628	52.78
Total Body weight gain, g (TBWG)	1866	1914	1962	1985	2030	59.28
Duration period, days	70 days					
Average daily gain, g (ADG)	26.7	27.3	28.0	28.4	29.0	0.84
Daily feed intakes, g as						
Dry matter (DMI)	121^{a}	114^{ab}	106^{bc}	99^{cd}	94^{d}	2.45
Crude protein (CPI)	19.01^{a}	17.97^{ab}	16.49^{bc}	15.59^{cd}	14.62^{d}	0.39
Digestible Crude protein (DCPI)	14.01^{a}	14.01^{a}	12.87^{a}	11.35^{b}	11.40^{b}	0.30
Total digestible nutrients (TDNI)	75.75^{a}	74.62^{a}	71.79^{a}	62.87^{b}	64.45^{b}	1.42
Digestible energy (DEI)	310^{a}	290^{ab}	268^{bc}	249^{cd}	239^{d}	6.40
Feed conversion (g. intake/ g. gain) of						
Dry matter (DMI)	4.53^{c}	4.18^{c}	3.79^{b}	3.49^{ab}	3.24^{a}	0.11
Crude protein (CPI)	0.71^{c}	0.66^{c}	0.59^{b}	0.55^{ab}	0.50^{a}	0.01
Digestible Crude protein (DCPI)	0.52^{c}	0.51^{c}	0.46^{b}	0.40^{a}	0.39^{a}	0.01
Total digestible nutrients (TDNI)	2.84^{c}	2.73^{bc}	2.56^{b}	2.21^{a}	2.22^{a}	0.06
Digestible energy (kcal/ g. gain)	11.61^{d}	10.62^{c}	9.57^{b}	8.77^{ab}	8.24^{a}	0.28

a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.5).
SEM: Standard error means.

Bernardini *et al.* (1999); **Dal Bosco *et al.* (2004)** and **Bianchi *et al.* (2009)** not observed any detrimental effect of whole flaxseed on the productive performance of rabbits. No significant effects of diets with different dietary ratios of flaxseed and sunflower oils were found on the litter or doe performances and the body weight of the fattening rabbits (**Eiben *et al.*, 2010**). Also, **Maertens *et al.* (2005)** reported beneficial effects of flaxseed on the performance, milk composition and viability of the progeny in rabbit does. Similarly, growth was unaffected when the rabbits were fed 3% flaxseed oil or 3% sunflower oil diet from 17 to 44 days of age (**Casado *et al.*, 2006).**

In a study made by (**Verdelhan *et al.*, 2005**) pointed a decrease in the growth rate of rabbits fed diets containing flaxseed oil, (**Colin *et al.*, 2005**) with extruded flaxseed and with whole flaxseed (**Bianchi *et al.*, 2006**).

Some authors associated the poorer growth rate to the presence of toxic substances in raw whole flaxseed, which may depress energy utilization. A correct pelletting procedure may have a good effect on reducing the anti-nutritional factor content, as reported by **Shen *et al.* (2005)**, who found a satisfactory growth performance in broilers fed diets containing 12% of pellet-processed flaxseed.

Peiretti *et al.* (2007a) formulated three diets with increasing levels (0, 10 or 15%) of false flax (*Camelina sativa L.*) seeds (FFS) to study its effect on growth performance of crossbred rabbits**.** They found that the weekly live weight and weight gain did not differ significantly (P>0.05) for among the dietary treatments. Nevertheless, the growth curves of rabbits showed a major difference between the diet without FFS and the diets with supplementary FFS; the inclusion of 10 and 15% FFS in the rabbit diets decreased the total weight gain by 3.6 and 2.7% compared to the control group, respectively.

Peiretti *et al.* (2007b) conducted an experiment to study the effects of various levels of false flax (*Camelina sativa L.*) seed (FFS) in rabbit rations on the growth performance. Three levels (0%, 10% or 15%) of FFS were included in isonitrogenous and isocaloric rations. There were no significant differences among the groups in live weight, live weight gain, feed consumption and feed efficiency.

Peiretti and Meineri (2008) studied the effect of inclusion golden flax (*Linus usitatissimun* L.) seeds (GFS) at levels (0, 8 and 16%) in rabbit rations to study its effect on growth performance. They reported that the weight gain and feed intake did not differ significantly (P>0.05) among dietary treatment. They also concluded that golden flax can be given to rabbits at levels up to 16% in the diet without any adverse effect on growth performance.

Bas *et al.* (2007) studied the effects of inclusion linseed at (0%, 3%, 6%, and 9%) on growth performance of male or female lambs. No effects of

linseed contents in the diet on growth performance either in male or female lambs were observed.

Incorporation flaxseed in rabbit rations at levels (5, 7.5 and 10%) significantly (P<0.05) decreased dry matter intake (DMI); crude protein intake (CPI) and digestible energy intake (DEI) compared to control ration, however, introduce flaxseed at level of 2.5% in significantly decreased (P>0.05) DMI, CPI and DEI in comparison with the control ration. **Obaa *et al.* (2009)** fed Holstein cows on diets contained either unprocessed whole flaxseed (WF) or dry-rolled flaxseed (RF) at 100 g kg^{-1} of dietary dry matter. They noted that dry matter intake was not affected by treatments.

Also, the data of feed conversion expressed as (g feed intake of DM, CP, DCP and TDN/ g gain) and digestible energy (kcal/ g. gain) are shown in Table (5) showed that, feed conversion was improved by inclusion flaxseed in rabbit rations at different levels (2.5, 5.0, 7.5 and 10%) compared to the control ration. Rabbit received 10% flaxseed containing ration recorded the best values of feed conversion that expressed as (g feed intake of DM, CP, DCP and TDN/ g gain) and digestible energy (kcal/ g. gain). This improvement in feed conversion may be related to increasing in daily gain with decreasing in daily feed intake. By another method the superior feed conversion ratios for the flaxseeds containing rations might have also contributed to the superior growth rate and weight gain by the rabbits fed rations contained flaxseeds compared to control ration. The inclusion of 0 and 8% of flaxseed in rabbit diets had no significant effect on weight gain or feed conversion rate ((**Dal Bosco *et al.*, 2004**).

Economic evaluation of the experimental rations

The economic efficiency of dietary treatments is presented in Table (5). The profitability of using rations containing flaxseed depends on upon their prices and the growth performance of rabbits fed this rations. Costing of one kg feed increased by 4.03%, 8.36%, 12.59 and 15.46%, respectively for tested rations that contained 2.5, 5.0, 7.5 and 10.0% flaxseed in comparison with the control ration (0% flaxseed).

Present data cleared that with increasing levels of flaxseed in rabbit rations both net revenue and relative economic efficiency were increased.

Net revenue was improved by 8.15%, 15.29%, 19.97% and 27.41% for tested rations compared to the control diet. While, relative economic efficiency was improved by 9.7%, 18.4%, 25.1% and 36.4%.

Feed cost/ kg live body weight gain was decreased when rations contained different levels of flaxseed compared to control ration. The corresponding values of feed cost/ kg live body weight gain were decreased by 5.10%, 9.16%, 12.83% and 17.67% for rations contained 2.5, 5.0, 7.5 and 10.0% flaxseed, respectively in comparison with the control ration. These results were in agreement with those obtained by **Adeniji *et al.* (2010)**; **Nuhu (2010)** and **Adeniji and Lawal (2012)** who noted that the feed cost was increased as the level of supplementation inclusion increased in rabbit rations. Also, they noted that there was significant effect for treatment (P<0.05) on the cost of feed per kg.

Table 5. Economic evaluation of the experimental rations

Item	Experimental rations				
	0% Flaxseed	2.5% Flaxseed	5% Flaxseed	7.5% Flaxseed	10% Flaxseed
Marketing weight, Kg	2.458	2.513	2.563	2.585	2.628
Feed consumed/ rabbit, kg (as it is)	9.450	8.820	8.260	7.700	7.210
Costing of one kg feed, (LE)[1]	1.986	2.066	2.152	2.236	2.293
Total feed cost, (LE)	18.77	18.22	17.78	17.22	16.53
Management/ Rabbit, (LE)[2]	4	4	4	4	4
Total cost, (LE)[3]	37.77	37.22	36.78	36.22	35.53
Total revenue, (LE)[4]	61.45	62.83	64.08	64.63	65.70
Net revenue	23.68	25.61	27.30	28.41	30.17
Economic efficiency[5]	0.6270	0.6881	0.7423	0.7844	0.8491
Relative economic efficiency[6]	100	109.7	118.4	125.1	135.4
Feed cost / kg LBW (LE)[7]	7.64	7.25	6.94	6.66	6.29

[1] *Based on prices of year 2013.* [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 25.* [5] *net revenue per unit of total cost* ***(Khial, 1997).***
[6] *Assuming that the relative economic efficiency of control diet equal 100.*
[7] *Feed cost/kg LBW = feed intake * price of kg / live weight. LE = Egyptian pound equals 0.15 USS approximately.*

4. Conclusion

From the results obtained and under the conditions of this study it could be mentioned that incorporation flaxseed in rabbit rations give the best results in terms of growth performance with a positive effect on digestion coefficients, feed conversion and relative economic efficiency. So, it could be used flaxseed until the level of 10% in rabbit rations without any adverse effect on their growth performance, digestion, feed conversion with improvement the economic and realizing high net revenue.

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