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THE EFFECTS OF DIETARY INCLUSION OF DIFFERENT LEVELS OF FLAXSEED ON THE DIGESTIBILITY, GROWTH PERFORMANCE, BLOOD PARAMETERS AND FATTY ACID PROFILE IN GROWING NEW-ZEALAND WHITE (NZW) RABBITS

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SUMMARY

A total number of 60 male New-Zealand White (NZW) rabbits post-weaning was used to study the effect of the inclusion of three levels (4, 6 and 8%) of flaxseed (FS) in the rabbit diet on nutrients digestibility, growth performance, blood parameters and fatty acid profile. Rabbits were distributed among 4 equal groups (3 replicates, 5 rabbits each). The1st group received the basal diet without FS. The other three groups (2nd, 3rd and 4th) received the basal diet with FS at levels 4, 6 and 8%, respectively. Rabbits were fed experimental diets for 8 weeks. Feeding diet contains FS at 6% level significantly ($P<0.05$) decreased the digestion coefficients as DM and OM compared to the control group while, feeding FS at the 8% level significantly decreased the digestion coefficients of DM, OM, CF and NFE compared to the control group. Feeding FS at the 6 or 8% level in rabbits significantly decreased the daily feed intake compared to the control group. Feeding flaxseed at the three levels 4, 6 and 8% in rabbits significantly ($P<0.05$) decreased the long dorsal fat and pre-renal fat weight compared to the control group. Feeding the experimental diets contain flaxseed at different levels (4, 6 and 8 %) significantly ($P<0.05$) decreased triglycerides, total cholesterol and total alkaline phosphatase compared to those of the control group. Feeding diets contain flaxseed at the level 6 and 8% in rabbit rations significantly ($P<0.05$) increased the α-linolenic acid, eicosapentaenoic acid and palmitic acid levels as well as reduced the arachidonic acid. Comparing these results to the literature, it was found that inclusion of dietary flaxseed at 6 and 8% of total ration considered high levels which significantly improved the blood parameters and profile fatty acids meanwhile a slightly decreased the growth performances and digestibility. Our suggestion under these circumstances is to use the lower level of 4% in rabbit feeding, flaxseeds are used to increase the diet content in omega-3 fatty acids, mostly alpha-linolenic acid.

Keywords: *Flaxseeds, rabbits, growth performance, digestibility, carcass characteristics and blood parameters.*

INTRODUCTION

Flaxseed *Linumusita tissimum* L. (Linaceae) is one of the most important field crops for industrial food and feed which relatively rich in protein about 25%, oil about 37% and crude fibre about 10% of DM(Singh *et al.*, 2011). Flaxseed (FS) contains about 10% saturated fatty acids (palmitic and stearic), about 20% monounsaturated fatty acids (mainly oleic acid), more than 55% is α-linolenic acid (ω-3 fatty acid) and about 18% linoleic acid (Prasad *et al.*,1999) which effectively increase the concentration of polyunsaturated fatty acids and reduce the concentration of saturated fatty acids (Benatman *et al.*,2011). Flaxseed is one of the best sources of n-3 fatty acids (El-Beltagi *et al.*, 2007) and therefore used as a source of protein and energy in livestock diets as well as a good source of sulphur amino acids (methionine and cysteine) and a branched chain of amino acids (isoleucine, leucine and valine) (Oomah *et al.*, 2007) as well as more lysine (Beaulieu *et al.*, 2010). Flaxseed lignins are transformed into bioactive endogenous lignin' senterodiol and enterolactone as the health-promoting properties due to the impact on the hormonal activity of the organism and the antioxidative potential and cell protection against oxidative stress (Mitchell *et al*., 1998). The strong effects of antioxidative properties of lignin's, flavonoids and phenolic acids prevent the degradation of many lipids, DNA, proteins molecules being significant to the metabolism (Prasad *et al*., 2000) considered as a curative agent (Akhtar *et al*., 2013) and characterized functional properties (Martinchik *et al*., 2012). Several studies have demonstrated that the use of flaxseeds up to 20% in feedlot diets does not affect performance and may reduce the incidence of disease (Newkirk, 2008).

Our hypotheses to examine the pros and cons of a direct effect of feeding flaxseeds on digestibility coefficient, growth performance, meat quality, blood parameters and some fatty acids. Therefore, the present study was carried out by using growing New-Zealand White (NZW) rabbits.

MATERIALS AND METHODS

Experimental design and dietary treatment:

This work was carried out at Research and Production Station, National Research Centre (NRC) located in El-Emam Malik Village, El-Bostan, west of Nubaria and at laboratories of Animal Production Department, NRC. Sixty male NZW rabbits post-weaning with an average body weight of 698 ± 67 g were used. The basal experimental diet was formulated and pelleted to cover the nutrient requirements of rabbits according to NRC (1977) as shown in Table (1). The experimental groups were classified as follows: the 1st group fed on only basal diet (0.0%FS), the 2nd group fed the basal diet with inclusion 4% FS, the 3rd group fed the basal diet with inclusion 6% FS and the 4th group fed basal diet with inclusion 8% FS.

Table (1): Composition of the experimental diets (kg/100) with different levels of FS.

Item	Diets inclusion FS at the levels of			
	0%	4%	6%	8%
Ingredients:				
Clover hay	24	25	26	26.4
Yellow corn	20	19.4	17	16
Barley grain	15.9	12	10	9
Wheat bran	22.5	23	25.4	26
Soybean meal (44% CP)	14.5	13.5	12.5	11.5
Flaxseeds (FS)	-	4	6	8
Limestone	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

** 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 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.*

Rabbits were housed in individual wire cages (30 x 35 x 40 cm) and divided into 4 equal groups divided into 3 replicates, 5 rabbits each. Stainless steel nipples for drinking and feeders allowing for each cage and 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 as well as average body weight and feed consumption was recorded biweekly during the experimental period.

All rabbits were used in digestibility trials over 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 analysed according to AOAC (2000) methods. To determine the carcass measurements, three representative rabbits from each treatment were at a similar average weight and fasted for 12 hours before slaughtering according to Blasco *et al.* (1993). These were removed and individually weighed.

Full and empty weights of the 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 percentage of slaughter weight (SW). The hot carcass was weighed and divided after head separation into the front and hind parts. The 9th, 10th and 11th ribs were frozen in polyethylene bags for later chemical analysis. The best ribs of samples were lyophilized applying the lyophilizing apparatus to prevent the triggers multiple physiological and biochemical changes in ribs meat samples in the interval (Mato *et al*., 2019). Samples were analysed for DM, EE and ash according to the AOAC (2000) methods, while CP percentage was determined by difference as recommended by O'Mary *et al*. (1979).

Blood samples were collected at the end of the experiment in heparinized tubes at slaughtering time (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), triglyceride (TG), total protein (TP), alkaline phosphatase, aspartate aminotransaminase (AST) and alanine aminotransferase (ALT) by spectrophotometer using available commercial kits. Globulin was calculated by subtracting the albumin from the total protein value (Doumas *et al*., 1971). The serum fatty acids were measured using gas chromatography according to the method described by Frakas *et al*. (1980). No feed was supplied for 18 hours before the withdrawal of blood samples.

Statistical analysis:

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

RESULTS AND DISCUSSION

Chemical analysis of flaxseed and the experimental rations:

Chemical analysis of the experimental rations is presented in Table (2).The results showed that flaxseed has high contents of CP and EE while low content of NFE. Variation in these results may show that the structure of flaxseed species can vary based on planting process, analysis, environmental factors

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

Item	flaxseed whole	Diets inclusion FS at the levels of			
Chemical composition of (DM %)		0%	4%	6%	8%
DM	90.50	91.55	91.00	92.06	91.54
OM	93.60	91.20	91.33	91.11	91.01
CP	23.50	16.33	16.58	16.66	16.63
CF	11.60	12.17	12.70	13.21	13.48
EE	31.00	3.50	4.14	4.68	5.21
NFE	27.50	59.20	57.91	56.56	55.69
Ash	6.40	8.80	8.67	8.89	8.99
GE** (Kcal/KgDM)	5864	4214	4256	4277	4299
DE*** (Kcal/KgDM)	2950	2586	2587	2539	2515

*** Gross energy (GE) was 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) using the following equation: DE (kcal/ kg DM) = 4253 – 32.6 (CF %) – 144.4 (total ash %).*

and diversity (Daun *et al*., 2003;Morris, 2008 and Maddock *et al*., 2005). All flaxseed treatments at the different levels used 4, 6 and 8 % in rabbit rations are almost in iso-caloric and iso-nitrogenous, but the EE and NFE percentage increased as the proportion of flaxseed in the diets increases (Table 2). These results showed that as the level of flaxseed in ration increased, the proportion of EE and CF tend to increase while its content of nitrogen-free extract decreased.

Effect of FS levels on rabbit's digestibility:

Feeding FS at the 8% level significantly decreased the digestion coefficients as DM, OM and CF while significantly increased the digestion coefficients as EE and NFE compared to the control group (Table 3). These results may be due to the high levels of mucilage that modifies the enteric microflora activity (Martinchik *et al*., 2012). The significant decrease of dry matter, organic matter and crude fibre digestibility may be due to the effect of FS mucilage on the proliferation of epithelial cells which have a direct impact on the digestive and absorptive function of the small intestine (Wang *et al*., 2019). Decreasing the digestion coefficients at the 8% level of FS probably due to the viscous nature of the linseed and its interference with the digestion and absorption of fat (Kristensen *et al*., 2013).

The significant ($P<0.05$) increase of EE and NFE digestibility at the 8% level may be due to the polyphenols in FS (Singh *et al*., 2011) which can induce the alteration in the microbial composition of the intestine as a contributing this effect (Fiesel *et al*., 2014). In other words, the flavonoids in FS (Żuk *et al*., 2011) may be affecting to increase the EE digestibility in ruminants (Hassan *et al*., 2020). The significant ($P<0.05$) increase of EE and NFE digestibility at the 8% level may be due to the formula that as the fat intake in FS increased the excretion of internal fats in the stool decreased in less effect on the calculated apparent digestibility (Van Manen *et al*., 1989). With increasing the dietary linseed percentage the digestibility of EE increased (Peiretti *et al*., 2007). This discrepancy between different studies may be not only due to the utilized lipid sources and the level of rabbit's digestibility, but could also be attributed to animal species (Huo *et al*., 2019). In other words, increased EE and NFE digestibility with higher supplemented fat diets 8% FS in this study may be a result of the reduced DM intake observed with the added more FS diets as showed in ruminant by Haddad and Younis (2003). A similar result is consistent with El Hag *et al*. (1985), who observed an increase in EE digestion when 10% tallow was added to sheep diets.

Table (3): Digestibility coefficient of nutrients in growing rabbits fed different levels of flaxseed.

	Diets inclusion FS at the levels of					
Item	0%	4%	6%	8%	±SE	Sig
Dry matter intake, g/h/d	95.97^{a}	91.61^{a}	82.76^{b}	61.39^{b}	1.86	*
Nutrients digestibility,%:						
DM	78.38^{a}	73.18^{ab}	61.72^{b}	61.39^{b}	3.07	*
OM	80.27^{a}	74.75^{ab}	64.35^{b}	63.81^{b}	3.27	*
CP	78.89	78.84	69.24	66.21	3.66	NS
CF	49.30^{a}	41.04^{ab}	40.45^{ab}	32.12^{b}	2.72	*
EE	72.43^{b}	75.00^{ab}	82.51^{ab}	85.95^{a}	2.74	*
NFE	69.56^{b}	79.70^{a}	81.06^{a}	83.89^{a}	2.09	*
Feeding value,%:						
TDN	74.41^{a}	72.72^{a}	67.98^{ab}	63.96^{b}	2.00	*
DCP	13.00	12.94	11.44	11.10	0.64	NS

*a and b: means in the same row within each treatment having different superscripts differ significantly at $P<0.05$. SE: standard error of the mean. NS: non-significant. *: $P<0.05$.*

Effect of FS levels on the rabbit's growth performance:

Feeding FS at the 6 or 8% level in rabbit rations significantly ($P<0.05$) decreased the daily feed intake compared to the control group (Table 4). This result may be due to the FS gel may be slowing down the emptying of the stomach and slightly effect on appetite (Kristensen *et al*., 2011). The gradual decrease of the daily feed intake at the three levels used of FS probably due to the secoisolariciresinol diglucoside (SDG) which enhances the production of leptin enzyme that reduces the feed intake (Orzechowski *et al*., 2002). As well as the protease inhibitors (e.g., trypsin inhibitors) as anti-nutritional compounds in FS may decrease the protein absorption and consequently diminish the growth performance (Cardoso *et al*., 2012). A similar result showed that supplementation of different types of fats did not influence animal performance in Dorper sheep (Behan *et al*., 2019).

Feeding FS at the 6 or 8% level in rabbit rations decreased the daily weight gain compared to the control group (Table 4). The reduction in growth performance may be due to the phytic acid effect in FS that binds proteins and minerals decreasing the bioavailability (Robert *et al*., 2017). On the other hand, the flaxseed lignin may have a direct relation to health improvement via both pangs of hunger suppressed (Martinchik *et al*., 2012). Also, probably due to the FS mucilage that absorbs water that increases the intestinal viscosity causing a laxative effect result in reduced performance (Alzueta *et al*., 2003). Some authors have linked the presence of toxins in whole flaxseeds with reduced energy use and thus poor growth rates (Bianchi *et al*., 2006). Similar studies showed that rabbits fed diets containing whole flaxseed and fully extruded flaxseed had a low growth rate (Colin *et al*., 2005 and Bianchi *et al*., 2006).

The reduction in growth performance probably due to the mucilage percentage that modifies the enteric microflora activity producing several unfavourable changes in the gastrointestinal tract which slows down the emptying of the stomach, slightly affected appetite, palatability and feed intake (Martinchik *et al*., 2012). In other words, these results may be due to the flaxseed characterize within fibre crops by a genotype for heavy metal tolerance or accumulation (Saleem *et al*., 2020). Also, the reduction in growth performance probably due to the B6 deficiency in FS as observed in broilers by Newkirk (2008). The performance reduction may be due to the FS constipation effect as shown in sows (Lawrence *et al*., 2004).

Table (4): Growth performance as affected by different levels of FS in ration of rabbits.

	Diets inclusion FS at the levels of					
Item	0%	4%	6%	8%	±SE	Sig
Initial weight (kg)	0.696	0.699	0.688	0.706	0.18	NS
Final weight (kg)	2.140	2.110	1.998	1.866	0.81	NS
Final gain weight (kg)	1.444	1.411	1.310	1.160	0.73	NS
Daily weight gain (g)	25.8	25.2	23.4	20.7	3.05	NS
Feed intake (kg)	4.66^{a}	4.55^{a}	4.24^{b}	4.20^{b}	0.89	*
Daily feed intake (g)	83.2^{a}	81.3^{a}	75.7^{b}	75.0^{b}	5.82	*
Feed conversion ratio g DMI/g gain	3.23	3.23	3.24	3.62	2.66	NS

[a and b:] *means in the same row within each treatment having different superscripts differ significantly at P<0.05. SE: standard error of the mean. NS: non-significant. *: P<0.05.*

Effect of FS levels on the rabbit's carcass characteristics:

Feeding flaxseed at the three levels (4, 6 and 8 %) in rabbit rations significantly (P<0.05) decreased the long dorsal fat and pre-renal fat weight compared to the control group (Table 5). These results may be due to the high proportion of lignin fibres "secoisolariciresinol diglycoside" which are responsible for the reduction of visceral fat mass (Fukumitsu *et al*., 2008 and Park and Velasquez, 2012). On the contrary, some results showed that the fat thickness of the FS groups was greater (P<0.05) than the other groups

Table (5): Carcass characteristics as affected by different levels of FS in ration of rabbits.

	Diets inclusion FS at the levels of					
Item	0%	4%	6%	8%	±SE	Sig
Live body weight (g)	2032	2031	2034	2036	19.5	NS
Slaughter wt (g)	1228	1256	1261	1290	70.50	NS
Digestive tract wt (g)	234	227	225	222	5.70	NS
Long dorsal fat wt (g)	55.3^{a}	50.3^{b}	49.3^{b}	45.3^{c}	3.85	*
Prerenal fat wt (g)	21.7^{a}	19.0^{b}	16.0^{c}	13.7^{d}	2.85	*
Head (g)	165.0	165.7	165.7	164.3	2.01	NS
Heart (g)	7.3^{c}	8.4^{b}	8.9^{b}	9.8^{a}	0.70	*
Liver (g)	74.7^{b}	76.7^{b}	79.0^{ab}	82.3^{a}	3.92	*

[a, b, c and d:] *means in the same row within each treatment having different superscripts differ significantly at P<0.05. SE: standard error of the mean. NS: non-significant.*: P<0.05.*

(Whetsell *et al*., 2003). Feeding flaxseed at the three levels used (4, 6 and 8 %) in rabbit rations significantly (P<0.05) increased the heart weight (Table 5). This result probably due to the biologically active substances in FS, such as lignin, fibres and linoleic acid which provide the cardioprotective effects (Prim *et al*., 2012). Feeding FS at the three levels used in rabbit rations slightly increases the liver weight (Table 5). This result probably due to that the oil in FS which can increase the concentrations of the n-3 fatty acid ALA in liver tissue (Barceló and Murphy, 2009). In other words, the essential amino acids in FS are of great importance in the synthesis of protein which contributes to the repair and maintenance of cells, tissues and organs (Omoni and Aluko, 2006).

Chemical analysis of the 9th, 10th and 11th ribs fed the experimental ration:

Feeding FS at 6 or 8% level significantly (P<0.05) increased the chemical analysis on DM basis of CP while significantly (P<0.05) decreased the EE in the meat ribs compared to the control group (Table 6). These results probably due to the changes in the lipid composition of the diet being able to alter the protein content of meat (Bourre, 2004). We can conclude that FS in rabbit diets improved the nutrition value of rabbit meat. On the contrary, flaxseed at 5% or 7.5%, did not affect the total lipid content in thigh tissues (Roth-Maier *et al*., 1998). In general, feeding flaxseed tends to increase meat quality parameters such as the marbling score (Maddock *et al*., 2005 and 2006).

Table (6): Chemical analysis of 9th, 10th and 11th ribs as affected by different levels of FS in ration of rabbits.

	Diets inclusion FS at the levels of					
Item	0%	4%	6%	8%	±SE	Sig
Chemical analysis on DM basis:						
CP	57.17^{b}	60.07^{b}	64.60^{a}	64.97^{a}	2.05	*
EE	35.37^{a}	32.46^{a}	25.27^{b}	25.06^{b}	1.93	*
Ash	7.46^{b}	7.47^{b}	10.13^{a}	9.97^{a}	0.28	*

*a and b: means in the same row within each treatment having different superscripts differ significantly at P<0.05. SE: standard error of the mean. NS: non-significant *: P<0.05.*

Effect of FS levels on the rabbit's blood parameters:

Feeding flaxseed at different levels (4, 6 and 8 %) in rabbits significantly (P<0.05) decreased triglycerides, total cholesterol and total alkaline phosphatase compared to the control group (Table7). The decreased value of triglycerides probably due to the high soluble mucilage fibre lignin content of FS (about 28% by weight) may have yielded the reduction attenuated cholesterol values (Pan *et al*., 2009).

Table (7): Blood serum constituents as affected by different levels of FS in ration of rabbits.

	Diets inclusion FS at the levels of					
Item	0%	4%	6%	8%	±SE	Sig
Albumin (g/dl)	3.37	3.22	3.01	3.48	0.42	NS
Globulin (g/dl)	2.26	2.10	2.79	2.62	0.43	NS
Total protein (g/dl)	5.63	5.32	5.80	6.10	0.35	NS
Triglycerides (mmol/l)	2.36^{a}	1.47^{b}	1.39^{b}	1.35^{b}	0.56	*
Total cholesterol (mmol/l)	16.8^{a}	14.5^{a}	12.6^{b}	11.4^{b}	1.87	*
Alkaline phosphatase (U/I)	66.6^{a}	52.7^{b}	53.8^{b}	55.4^{b}	2.33	*
AST (U/l)	94.7^{a}	86.4^{a}	69.6^{b}	65.2^{b}	3.51	*
ALT (U/l)	33.7	33.6	32.9	32.7	1.35	NS

a and b : means in the same row within each treatment having different superscripts differ significantly atP<0.05. SE: standard error of the mean. NS: non-significant.: P<0.05.*

While, the reduction of cholesterol concentrations may be attributed to the essential omega-3 fatty acid (Dupasquier *et al*., 2007). Similar results showed a significant reduction in triglycerides, total cholesterol and low-density lipoprotein-cholesterol (LDL-C) levels were observed (Saxena and Katare, 2014) when feeding on FS. It is more likely that soluble mucilage fibre resulting from flaxseed lignin extracts (Fukumitsu *et al*., 2008) may have yielded the attenuated cholesterol values observed in our study. Feeding flaxseed at different levels (6 and 8 %) in rabbits significantly (P<0.05) decreased the serum AST and total alkaline phosphatase compared to the 0% flaxseed group (Table 7). These results may be due to the ability of flaxseed oil to attenuate liver injury by reducing ALT and AST levels (Chen *et al*., 2015) as well as altered gut microbiota and the decrease of liver inflammation (Zhang *et al*., 2017) as well as may due to the lack of inflammation (Chen *et al*., 2015).

Effect of FS levels on the rabbit's serum fatty acid:

Feeding on flaxseed at the 6 and 8 % levels in rabbit rations significantly (P<0.05) increased the α-linolenic acid (ALA), eicosapentaenoic acid and palmitic acid levels (Table 8). These results showed that FS enriched diets with free fatty acids expression in the rabbit serum blood. This result probably due to the long period (56 days) of an experiment is more efficient at increasing ALA content in rabbit meat. A similar result showed that feeding higher levels of flaxseeds for shorter periods versus lower levels for longer periods is more efficient at increasing ALA content in pig meat (Juarez *et al*., 2010). Feeding ground flaxseeds slightly modifies the long-chain fatty acid profile in the rib eye, by increasing both linoleic (C18:2) and alpha-linolenic (C18:3) acids (LaBrune *et al*., 2008), as well as the unsaturated fatty acids in the muscle (Maddock *et al*., 2005). A similar result showed that both raw and processed flaxseed increased fatty acids (saturated or unsaturated) content but decreased or had no effect on short to medium-chain fatty acids and on longer chain fatty acids in milk (Glasser *et al*., 2008). Feeding on flaxseed at the 6 and 8 % levels in rabbit rations significantly (P<0.05) reduced the arachidonic acid (Table 8). Similar results in blood and tissues are reported by Gotoh *et al*. (2007). Our results showed that feeding FS in rabbit ration improved the nutritional value of rabbit meat as showed by Kouba *et al*. (2008). This study confirmed that dietary FS could be considered as a way of enriching the n-3 PUFA in a rabbit. Similar results showed that most of the saturated fatty acids decreased with increasing flaxseed levels except C18:0 while unsaturated fatty acids increased (Hurtaud *et al*., 2010).

Table (8): Serum fatty acids profiles as affected by different levels of FS in ration of rabbits.

		Diets inclusion FS at the levels of					
Item	Lipid numbers	0%	4%	6%	8%	±SE	Sig
Arachidonic acid	C20:4n-6	3.14[a]	3.03[a]	2.72[b]	2.08[c]	0.15	*
Eicosapentaenoic acid	C20:5n-3	0.18[c]	0. 62[b]	0.78[ab]	0.84[a]	0.10	*
Palmitic acid	C16:1n-7	0.44[d]	0.56[c]	0.74[a]	0.66[b]	0.13	*
Stearic acid	C18:1n-9	42.51	43.8	42.6	42.5	4.50	NS
Linoleic acid	C18:2n-6	9.99	10.26	9.95	9.95	0.64	NS
Alpha- linolenic acid	C18:3n-3	0.92[d]	2.86[c]	3.91[b]	4.87[a]	0.15	*

[a, b, c and d:] *means in the same row within each treatment having different superscripts differ significantly at P<0.05. SE: standard error of the mean. NS: non-significant.*: P<0.05.*

CONCLUSION

Feeding flaxseeds at 6 and 8% of the total rabbit ration was considered to be of high levels, leading to a decrease in growth performance and digestion coefficient, while slightly improving the fatty acid profile. Our suggestion under these circumstances is to use the lower level of 4% in rabbit feeding, flaxseeds are used to increase the diet content in omega-3 fatty acids, mostly alpha-linolenic acid.

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تأثير إدخال مستويات مختلفة من بذور الكتان فى العلائق على قابلية الهضم وآداء النمو ومقاييس الدم وخصائص الأحماض الدهنية فى الأرانب النيوزيلندى البيضاء النامية

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يهدف هذا البحث الى دراسة تأثير إدخال مستويات مختلفة من بذور الكتان في علائق الارانب النامية وتأثير إدراج هذه المستويات علي معاملات الهضم والاداء الانتاجي وبعض مقاييس الدم وخصائص الذبيحة.

- تم استخدام عدد 60 من ذكورالأرانب النيوزيلندية البيضاء(NZW) بعد الفطام لدراسة تأثير ادراج او تضمين ثلاثة مستويات مختلفة من بذور الكتان بنسبة 4 و 6 و 8٪ من العليقة في النظام الغذائي للأرانب النامية. تم تقسيم الأرانب إلى 4 مجموعات متساوية مقسمة إلى 3 مكررات كل منها تحتوى على 5 أرانب وقسمت المجموعات عشوائيا في تجربة نمو استمرت لمدة 8 اسابيع وكانت العلائق كالاتي:

- المجموعة الاولي: غذيت علي العليقة الأساسية.

- المجموعة الثانية: غذيت علي العليقة الاساسية مع إدراج بذور الكتان في العليقة بمستوي 4%.

- المجموعة الثالثة: غذيت علي العليقة الاساسية مع إدراج بذور الكتان في العليقة بنسبة 6%.

- المجموعة الرابعة: غذيت علي العليقة الاساسية مع إدراج بذور الكتان في العليقة بنسبة 8%.

وكانت النتائج كما يلى:

* ادي إدخال بذور الكتان في العليقة بمستوي 6% الي انخفاض في معاملات هضم المادة الجافة والمادة العضوية مقارنة بالمجموعة الاولي المغذاه علي العليقة الاساسية.

* ادي إدخال بذور الكتان في العليقة بنسبة 8% الي انخفاض في معاملات هضم الالياف والمستخلص الخالي من الازوت مقارنة بالمجموعة المغذاه علي العليقة الضابطة.

* ادت التغذية بإدخال بذور الكتان بنسبة 6 و8% الي انخفاض كبير في كمية المأكول اليومي ومتوسط النمو اليومى مقارنة بالمجموعة الضابطة.

* سجلت المجموعات الثلاثة المحتوية علائقها على بذور الكتان بنسبة 4، 6، 8% من العليقة لإنخفاض معنوي في محتواها من الدهون الظهرية ووزن الدهون المحيطة بالجسم والدهون الثلاثية والكولستيرول الكلى مقارنة بالمجموعة الضابطة.

* أدت التغذية بإدخال بذور الكتان فى علائق الارانب بمستوى 6 و 8٪ إلى زيادة معنوية في مستويات حمض اللينوليك (اوميجا6) والالفا لينولينك (اوميجا3) وحمض إيكوسابنتاينويك وحمض البالمتيك وكذلك خفض حمض الأراشيدونيك .

* ادت تغذية بذور الكتان بنسبة 6، 8% من عليقة الارانب الي زيادة معنوية في الاحماض الدهنية المشبعة .

نستخلص من هذه الدراسة أن إضافة بذور الكتان بنسبة 6 و 8٪ من العليقة الإجمالية للأرانب تعتبر مستويات عالية، مما أدى إلى انخفاض معاملات الهضم ومقاييس النمو، مع تحسن طفيف في صورة الأحماض الدهنية. وتوصى هذه الدراسة بإستخدام المستوى الأدنى من إضافة بذور الكتان فى عليقة الارانب بمستوى 4٪ وهو مايعنى من الناحية التطبيقية عدم تجاوز هذه النسبة من بذور الكتان فى علائق الأرانب.