



Effect of Adding Different Levels of Flaxseed Powder as a Source of Omega-3 on the Chemical Characteristics of Karadi Carcass Lambs

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Abstract: The aim of the study is to determine the effect of different levels of Flaxseed powder (FP) as a source of omega-3 on the chemical characteristics of Karadi carcass lambs. Twenty male Karadi lambs aged 4-5 months were used in this study with an average live-weight of 28.00 ± 0.40 kg. The animals were randomly divided into four treatments (FP was added at the levels of 3%, 6% and 9% compared with the control group) for 88 days. At the end of the experiment, twelve lambs were slaughtered. The carcasses were kept at 4°C for 24 h. and subjected to various physio-chemical measurements. The results illustrated significant ($p < 0.05$) differences in percentages of (moisture, protein, fat and ash). T1 was superior than other treatment in moisture percentage and T2 was superior in protein percentage. While, control treatment was superior in fat and ash percentages. The results pointed to significant ($P < 0.05$) increased in Water holding capacity percentage. But concerning pH, there were no significant differences among treatments. Myofibril fragmentation index and protein solubility significantly ($P < 0.05$) increased with FP supplementation in the ration. A significant ($P < 0.05$) decreasing of cholesterol concentration. In contrast to that, myoglobin concentration increase with FP. The results of collagen analysis showed significant ($P < 0.05$) differences among treatments, in soluble part in hydroxyproline concentration and collagen content value, increased but in the insoluble part the value decreased. The results showed improvement in total soluble collagen percentage in FP treatments. The results pointed to improvement ($P < 0.05$) in the sensory evaluation in FP treatments as compared to control treatment.

Keywords: Fax seed powder, Physio-chemical characteristic , Karadi lambs.

Introduction

The lean of red meats are an excellent source of high biological value protein, vitamin B12, niacin, vitamin B6, iron, zinc and phosphorus. Moreover, it is a good source of long-chain

omega-3 polyunsaturated fats, riboflavin, pantothenic acid, selenium and possibly vitamin-D (Williams, 2000). Recent analyses have shown that there has been a significant

trend to leaner cuts of meat over the past two decades (Williams & Burdge, 2006). Therefore, new studies and researches have focused on improving sheep production for better quality and quantity of red meat production through using new techniques in feeding like using medicinal herbs and plants as feed supplementations. Using flaxseed and flax oil in animal rations as they can be used to alter the fatty acid composition of meat products and therefore, provide functional health benefits for the consumer. Marbling were increased when the finishing diet containing ground flaxseed (Alfaia, 2009). Numerous trials have shown that supplementing finishing diets with oilseeds can influence both the n-6/n-3 PUFA ratio and long-chain polyunsaturated fatty acid (LC-PUFA) content (Kronberg *et al.*, 2006; Maddock *et al.*, 2006 & Dawson *et al.*, 2010). Many efforts have been made to improve the nutritional value and quality of ruminant meats by controlling the intramuscular fat (IMF) deposition and its fatty acid composition. Since part of the unsaturated fatty acids may escape via ruminal biohydrogenation, the diet can thus notably affect the fatty acid composition of ruminant tissues and products (Alfaia, 2009). The researches indicate that products, such as eggs and beef, from animals fed flax have increased levels of omega-3 fatty acids (Scheideler *et al.*, 1994; Maddock *et al.*, 2003). Thus, this study aimed to determine the effect of different levels of Flaxseed powder as a source of omega-3 on the chemical characteristics of Karadi carcass lambs.

Materials & Methods

Housing and feeding trail experiment

A total of 20 Karadi male lambs were used in this study. Animals were individually housed

in pens (1×1.5 m²) at the Animal Science Farm, College of Agricultural sciences, University of Sulaimani. The average live weight of lambs was 28±0.398 kg and 4-5-month-old. All lambs were randomly allocated into four experimental treatments. The four treatments were control group without supplement flaxseed powder (FP) into the ration, T2, T3, with inclusion 3%, 6% and 9% FP, respectively. The concentrate feed were given at the rate 3% of animals live body weight. The chemical composition and formulation of the concentrate feed was presented in Table (1). The roughage feed (straw) and clean water were given ad libitum. The change of weighing all lambs were recorded by weighing every week with sensitive balance. The experimental feeding period was 13 weeks except 2 weeks for adaptation.

Slaughtering and carcass characteristics

At the end of the experimental, three lambs from each treatment were slaughtered after overnight fasting. The lambs immediately weighed before slaughtering to achieve slaughter body weight (SBW). The slaughtering process performed according to Islamic law by severing the jugular vessels, esophagus and trachea without stunning. The carcasses were longitudinally split into two equal sides, right and left, after removing the tail fat from the carcasses. The right sides were provided to study chemical characteristics of thoracic limb Infraspinatus (IS), abdominal wall Longissimus dorsi (LD) and pelvic limb Semimembranosus (SM).

The chemical analysis (moisture, protein, fat, ash percentages) for the muscles were determined according to AOAC (2004). The pH of the meat was measured according to Naveena & Mendiratta (2004).

Table (1): Formulation and chemical composition of concentrate diets.

Ingredients (%)	Control	T1	T2	T3
Barley	40	40	40	40
Wheat bran	27	27	27	27
Corn	15	15	15	15
Soybean meal	15	12	9	6
Flaxseed powder	0	3	6	9
Min. & Vit. mix.	2	2	2	2
Salt	1	1	1	1
Urea		0.2	0.4	0.6
Chemical composition				
CP %	15.38	15.31	15.23	15.14
ME (MJ/KG) *	12.77	11.63	11.82	12.01

$$\text{ME (MJ/kg DM)} = 0.012 \text{ CP} + 0.031 \text{ EE} + 0.005 \text{ CF} + 0.014 \text{ NFE (MAFF, 1977)}.$$

Water Holding Capacity (WHC) was estimated by the method of Dolatowski & Stasiak, (1998). The myoglobin concentration (Mb) was measured by the method of Zessin *et al.* (1961). Myofibril Fragmentation Index (MFI) was determined according to the method of Culler *et al.* (1978). To determine myofibril protein solubility, the procedure of DenHertog-Meischke *et al.* (1997) was applied. Collagen analysis soluble and insoluble hydroxyproline were determined according to the procedure of Hill (1966), Taher (1979) and Morgan *et al.* (1991). Cholesterol content was measured as described by Ojiako & Akubugwo (1997). A trained sensory panel of eight members was used to evaluate: flavor, juiciness, tenderness and overall palatability of cooked lamb meat (LD muscle). A judging scale was used as 5 =extremely, 4 = like, 3 = neither like nor

dislike, 2 = dislike, 1= extremely dislike, (Griffin *et al.*, 1985).

Statistical analysis

The data were analyzed by using XL-Stat program, version 7.5, 2005. The significant differences between means were determined using Duncan's Multiple Range Tests under the probability of $P < 0.05$ (Duncan 1955).

Results & Discussions

Proximate analysis (Moisture, Protein, Fat and Ash)

The effect of flaxseed powder supplementation on the proximate analysis (moisture, protein, fat and ash) is presented in table (2). Adding FP to lamb diet led to a significant increase ($p < 0.05$) moisture percentages in IS and LD muscles. However, SM moisture content showed similar values among

different treatments. The highest percentages of moisture (77.360, 76.610 and 74.540%) were found in T1 of IS, SM and LD respectively and the lowest percentages (73.640, 74.990 and 69.085%) were found in group C of IS, SM and LD respectively. FP supplementation significantly ($p < 0.05$) increased protein percentages in SM muscle. There was a mathematical increase in protein percentages as compared with group C in IS and LD protein contents. The IS and LD muscle have no significant differences among treatments. T2 showed protein content of (19.250, 20.405 and 20.530%) of IS, SM and LD respectively and those of control were (17.010, 18.050 and 17.975%) respectively. Fat percentages were significantly ($p < 0.05$) affected by FP supplementation to the diets. Lower fat percentages were achieved by groups of lambs fed the FP supplementation (T1, T2 and T3) as compared with C group in all muscles (IS, SM and LD). The highest percentages of fat (7.560, 5.330 and 11.240%) were found in group C of IS, SM and LD respectively. And the lowest percentages (2.900, 2.510 and 3.895%) were found in T1 in IS, SM and LD respectively. Results of the current study showed that no significant differences were found in ash percentages among all treatments as affected by FP supplementation in all muscles IS, SM and LD. Many studies refer to the effect of diets supplemented with oilseeds on dry matter, protein, and fat percentages in lamb meat (Borowiec *et al.*, 2004; Borys & Borys, 2005). On the other hand, it can be concluded the positive effect of supplementation of FP on the mass of meat and enhanced the animals ability to deposit protein and thus increased the percentages of protein that led to increase of percentages of moisture and decreased the percentages of fat. This positive impact is

considered desirable by the producers of meat animals and consumers.

Water holding capacity (WHC) and pH value

The effect of flaxseed powder supplementation on WHC and pH value are presented in (Table 3). FP supplementation significantly ($P < 0.05$) increased WHC. The highest WHC percentages were observed in T2 (54.700, 63.730 and 67.100) % for IS, SM and LD respectively. Whereas, the lowest WHC percentages (47.200, 49.350 and 51.800%) were recorded by group C of IS, SM and LD respectively. The values in other treatments are distributed between these two values. In relation to pH value no significant changes were found among treatments, but the results indicated that there was a mathematical increase in pH of T1, T2 and T3 as compared with group C in IS, SM and LD muscles. WHC considered as an important economical aspect which attributes to the quality of meat and the most important of tenderness and juiciness and the increase of WHC in the meat of lambs fed powder flax seed.

Cholesterol and myoglobin concentration (Mb)

The effect of FP supplementation on cholesterol content and myoglobin concentration is revealed in Table (4). FP supplementation significantly ($P < 0.05$) decreased in cholesterol content and increased myoglobin concentration in all IS, SM and LD muscles. T2 had recorded the lowest cholesterol content (55.190, 54.880 and 60.150 $\text{mg} \cdot 100\text{g}^{-1}$) in IS, SM and LD respectively, and group C had recorded the highest cholesterol content (63.460, 61.520 and 68.200 $\text{mg} \cdot 100\text{g}^{-1}$) in IS, SM and LD respectively. In other treatments cholesterol

Table (2): Effect of flaxseed powder supplementation on proximate analysis (moisture, protein, fat and ash) (Mean± SD).

Treatment	Moisture %			Protein %			Fat %			Ash %		
	IS	SM	LD	IS	SM	LD	IS	SM	LD	IS	SM	LD
C	73.640 ^b	74.990 ^a	69.085 ^b	17.010 ^a	18.050 ^b	17.975 ^a	7.560 ^a	5.330 ^a	11.240 ^a	1.115 ^a	1.110 ^a	1.100 ^a
	± 0.600	± 0.180	± 1.685	± 0.590	± 0.460	± 0.595	± 0.150	± 0.850	± 0.990	± 0.135	± 0.050	± 0.020
T1	77.360 ^a	76.610 ^a	74.540 ^a	18.505 ^a	19.350 ^{ab}	20.065 ^a	2.900 ^b	2.510 ^b	3.895 ^b	0.990 ^a	1.055 ^a	0.970 ^a
	± 0.460	± 0.470	± 0.680	± 0.035	± 0.390	± 0.185	± 0.480	± 0.410	± 0.625	± 0.010	± 0.035	± 0.030
T2	76.500 ^a	75.830 ^a	73.280 ^a	19.250 ^a	20.405 ^a	20.530 ^a	2.930 ^b	2.780 ^b	4.605 ^b	0.965 ^a	1.040 ^a	0.965 ^a
	± 0.070	± 0.420	± 0.410	± 0.610	± 0.325	± 0.110	± 0.570	± 0.080	± 0.585	± 0.055	± 0.020	± 0.085
T3	76.785 ^a	75.210 ^a	74.345 ^a	17.960 ^a	19.860 ^a	18.130 ^a	3.590 ^b	2.750 ^b	5.490 ^b	1.015 ^a	1.095 ^a	0.980 ^a
	± 0.605	± 0.510	± 0.585	± 1.520	± 0.230	± 1.740	± 0.780	± 0.020	± 0.830	± 0.045	± 0.045	± 0.100

Different letters at the same column are significantly different (P<0.05).

Table (3): Effect of flaxseed powder supplementation on Water holding capacity (WHC) and pH value (Mean \pm SE).

Treatments	% WHC			pH		
	IS	SM	LD	IS	SM	LD
C	47.200 ^b	49.350 ^d	51.800 ^c	6.041 ^a	5.876 ^a	5.769 ^a
	\pm	\pm	\pm	\pm	\pm	\pm
	2.810	0.150	0.300	0.098	0.068	0.241
T1	53.620 ^a	57.280 ^b	61.500 ^b	6.078 ^a	5.908 ^a	5.860 ^a
	\pm	\pm	\pm	\pm	\pm	\pm
	0.150	0.350	0.250	0.104	0.011	0.014
T2	54.700 ^a	63.730 ^a	67.100 ^a	6.045 ^a	5.946 ^a	5.881 ^a
	\pm	\pm	\pm	\pm	\pm	\pm
	0.210	0.110	0.130	0.045	0.048	0.009
T3	54.510 ^a	55.920 ^c	61.180 ^b	6.012 ^a	6.034 ^a	5.891 ^a
	\pm	\pm	\pm	\pm	\pm	\pm
	0.150	0.260	0.260	0.011	0.083	0.091

Different letters at the same column are significantly different ($P < 0.05$).

content (60.870, 57.110 and 62.740 mg100g⁻¹) and (57.920, 56.790 and 61.650 mg.100g⁻¹) which were observed in T1 and T3 in IS, SM and LD, respectively. Results of the current study observed that significant ($p < 0.05$) differences were found in myoglobin concentration among all treatments as affected by FP supplementation in all muscles IS, SM and LD. The highest myoglobin concentration (4.360, 5.180 and 3.940 mg.g⁻¹) was observed in T2 in IS, SM and LD respectively, while the lowest myoglobin concentration (3.550, 4.220 and 3.290 mg.g⁻¹) was found in group C of IS, SM and LD, respectively. Other treatments have values of myoglobin concentration (3.920, 5.070 and 3.750) mg.g⁻¹ and (4.120, 5.100 and 3.860 mg.g⁻¹) were observed in T1 and T3 in IS, SM and LD respectively. In the present study, the cholesterol content has been decreased in all treatments response to FP supplementation while the myoglobin concentration increased in all treatments as compared with group C as a result of dietary supplementation with FP. These results identical with Borys *et al.* (2004)

who observed larger responses to addition rapeseed and linseed on diets in reduced cholesterol content in the muscles of all experimental lambs as compared with control lambs, by 7.9% on average. Similar finding was found by Borys *et al.* (2005) who reported in his study when crushed rapeseed and linseed added to the diet mixture fed to fattened lambs, the cholesterol content in muscle tissue was about 16% lower than the present study. Borys *et al.* (2004) reported that no statistical differences of meat colour, however, there was a tendency towards darker meat colour in lambs fattened with the 1:1 rapeseed and linseed diets. Myoglobin concentration is a very important economical attribute and has a close relation with meat quality because it limits meat color as a result of the coordination of myoglobin concentration and its chemical condition (Young & West, 2001). Increase in the Mb in meat lambs fed on powdered flaxseed in diets may be due to the effectiveness of flaxseed in reducing the oxidative stress and thereby protect cell membranes and this led to maintain the content within them and this

needs to be studied for a deeper knowledge of mechanical effect to this subject.

Myofibril fragmentation Index (MFI) and protein solubility

The mean values of (MFI) and protein solubility are demonstrated in (Table 5). Results of the current study observed that there were no significant changes in MFI among treatments except SM muscle which was significantly ($P < 0.05$) different. However, the results observed that there was a mathematical increase in MFI of T1, T2 and T3 as compared with group C in IS and LD muscles. T2 had the highest MFI (53.000, 55.350 and 59.500 %) in IS, SM and LD, respectively and group C had the lowest (49.000, 49.500 and 55.500 %) in IS, SM and LD, respectively. The values MFI in other treatments are distributed between these two values. However, there are significant ($P < 0.05$) differences among treatments concerning in protein solubility. The highest value of protein solubility concentration (64.200, 68.150 and 69.500 mg.g^{-1}) was observed in T2 in IS, SM and

LD, respectively and the lowest value of protein solubility concentration (62.180, 64.110 and 65.595 mg.g^{-1}) was found in group C of IS, SM and LD respectively. The values protein solubility concentrations in other treatments are distributed between these two values. MFI value has a strong association with tenderness and carcass maturity (Veiseth *et al.*, 2001). In the current study, it is noticed that increasing of MFI is the reflection of an increase of protein percent and then leads to increasing WHC. So, this is the indication to meat tenderness (softness) in animals meat fed on FP that reflects on the MFI subsequently increasing and then reflected on increasing PS.

Collagen content

The effect of feeding flaxseed powder on collagen content are presented in table (6). In all treatment's significant differences ($P < 0.05$) were observed in relation to hydroxyproline concentration of each soluble and insoluble parts except LD

Table (4): Effect of flaxseed powder supplementation on cholesterol content and myoglobin concentration (Mean \pm SE).

Treatments	Cholesterol (mg.100g^{-1})			Mb (mg.g^{-1})		
	IS	SM	LD	IS	SM	LD
C	63.460 ^a	61.520 ^a	68.200 ^a	3.550 ^c	4.220 ^b	3.290 ^b
	\pm 0.490	\pm 0.490	\pm 0.700	\pm 0.130	\pm 0.030	\pm 0.060
T1	60.870 ^b	57.110 ^b	62.740 ^b	3.920 ^b	5.070 ^a	3.750 ^a
	\pm 0.310	\pm 0.140	\pm 0.360	\pm 0.070	\pm 0.030	\pm 0.050
T2	55.190 ^d	54.880 ^c	60.150 ^c	4.360 ^a	5.180 ^a	3.940 ^a
	\pm 0.290	\pm 0.270	\pm 0.250	\pm 0.050	\pm 0.020	\pm 0.060
T3	57.920 ^c	56.790 ^b	61.650 ^{bc}	4.120 ^{ab}	5.100 ^a	3.860 ^a
	\pm 0.300	\pm 0.240	\pm 0.230	\pm 0.030	\pm 0.030	\pm 0.040

Different letters at the same column are significantly different ($P < 0.05$).

Table (5): Effect of flaxseed powder supplementation on myofibril Fragmentation Index (MFI) and protein solubility (Mean \pm SE).

Treatments	M.F.I (%)			Ps (mg.g ⁻¹)		
	IS	SM	LD	IS	SM	LD
C	49.000 ^a \pm 0.000	49.500 ^b \pm 0.500	55.500 ^a \pm 3.500	62.180 ^b \pm 0.260	64.110 ^c \pm 0.190	65.595 ^c \pm 0.705
T1	51.000 ^a \pm 0.000	53.100 ^a \pm 0.510	56.750 ^a \pm 0.550	63.720 ^{ab} \pm 0.750	64.430 ^{bc} \pm 0.160	66.700 ^{bc} \pm 0.150
T2	53.000 ^a \pm 2.000	55.350 ^a \pm 0.650	59.500 ^a \pm 0.700	64.200 ^a \pm 0.390	68.150 ^a \pm 0.220	69.500 ^a \pm 0.550
T3	52.000 ^a \pm 0.500	54.180 ^a \pm 1.080	57.440 ^a \pm 0.540	62.900 ^{ab} \pm 0.210	65.500 ^b \pm 0.600	67.500 ^b \pm 0.270

Different letters at the same column are significantly different (P<0.05).

muscle of insoluble hydroxyproline.

In the soluble part, hydroxyproline concentration increased with FP supplementing. T2 had the highest hydroxyproline concentration (0.037, 0.036 and 0.038 mg.g⁻¹) in IS, SM and LD respectively, and group C had the lowest hydroxyproline concentration (0.030, 0.026 and 0.034 mg.g⁻¹) in IS, SM and LD respectively. In the insoluble part, the direction of results was reverse, hydroxyproline concentration decreased significantly (p<0.05) with FP supplementation, C group had the highest hydroxyproline concentration (0.319, 0.329 and 0.291 mg.g⁻¹) in IS, SM and LD respectively and T2 group has the lowest hydroxyproline concentration (0.294, 0.319 and 0.268 mg.g⁻¹) in IS, SM and LD respectively. While collagen content concerning each soluble and insoluble parts significant differences (P<0.05) were observed between all treatments except LD

muscle of insoluble collagen content. In the soluble part, collagen content increased with FP supplementing. The highest collagen content (0.264, 0.244 and 0.284 mg.g⁻¹) was

observed in T2 group in IS, SM and LD respectively, and the lowest collagen content (0.221, 0.197 and 0.267 mg.g⁻¹) was observed in group C of IS, SM and LD respectively. In the insoluble part, the situation is opposite where the collagen content was significantly (p<0.05) decreased with FP supplementation. The highest collagen content (2.310, 2.386 and 2.112 mg.g⁻¹) was observed in group C of IS, SM and LD respectively, and the lowest collagen content (2.132, 2.312 and 1.578 mg.g⁻¹) was achieved in T2 in IS, SM and LD respectively. From the results, it can be noted the positive correlation between hydroxyl-proline concentration and collagen content in both soluble and insoluble parts. While the highest total collagen content (2.530, 2.582 and 2.375 mg.g⁻¹) was observed in group C of IS, SM and LD respectively, and the lowest collagen content (2.395, 2.553 and 2.214

Table (6): Effect of feeding flaxseed powder on collagen content (Mean ± SE).

Treatments	Hydroxyprolin concentration (mg.g ⁻¹)						collagen content (mg.g ⁻¹)						Total collagen content (mg.g ⁻¹)			Soluble collagen percentage %		
	Soluble			insoluble			Soluble			insoluble			IS	SM	LD	IS	SM	LD
	IS	SM	LD	IS	SM	LD	IS	SM	LD	IS	SM	LD						
C	0.030 ^b ± 5.00	0.026 ^b ± 1.00	0.034 ^a ± 0.000	0.319 ^a ± 0.001	0.329 ^a ± 0.001	0.291 ^a ± 0.001	0.221 ^c ± 0.001	0.197 ^c ± 0.001	0.267 ^c ± 0.002	2.310 ^a ± 0.000	2.386 ^a ± 0.001	2.112 ^a ± 1.50	2.530 ^a ± 0.000	2.582 ^a ± 0.002	2.375 ^a ± 0.001	8.700 ^c ± 0.050	7.590 ^c ± 0.090	11.240 ^b ± 0.280
T1	0.035 ^a ± 2.00	0.032 ^{ab} ± 6.00	0.037 ^a ± 0.001	0.298 ^c ± 0.001	0.320 ^b ± 0.001	0.273 ^b ± 0.002	0.262 ^a ± 0.001	0.240 ^a ± 0.001	0.279 ^{ab} ± 0.001	2.162 ^c ± 0.001	2.319 ^{bc} ± 0.002	1.943 ^a ± 8.00	2.424 ^c ± 0.001	2.558 ^b ± 0.001	2.256 ^b ± 0.001	10.790 ^a ± 0.060	9.370 ^a ± 0.090	12.330 ^a ± 0.080
T2	0.037 ^a ± 9.00	0.036 ^a ± 4.40	0.038 ^a ± 0.001	0.294 ^d ± 0.001	0.319 ^b ± 0.001	0.268 ^b ± 0.003	0.264 ^a ± 0.001	0.244 ^a ± 0.002	0.284 ^a ± 0.002	2.132 ^d ± 0.001	2.312 ^c ± 0.001	1.578 ^a ± 3.99	2.395 ^d ± 0.001	2.553 ^b ± 0.004	2.214 ^d ± 0.003	11.010 ^a ± 0.090	9.560 ^a ± 0.110	12.670 ^a ± 0.060
T3	0.034 ^a ± 2.00	0.030 ^{ab} ± 8.00	0.036 ^a ± 0.001	0.302 ^b ± 0.001	0.321 ^b ± 0.002	0.270 ^b ± 0.001	0.253 ^b ± 0.002	0.226 ^b ± 0.003	0.271 ^{bc} ± 0.002	2.190 ^b ± 0.002	2.327 ^b ± 0.004	1.954 ^a ± 7.00	2.443 ^b ± 0.001	2.556 ^b ± 0.001	2.237 ^c ± 0.002	10.370 ^b ± 0.120	8.830 ^b ± 0.130	12.250 ^a ± 0.080

Means having different letters at the same column are significantly different (P<0.0)

mg.g⁻¹) was observed in T2 in IS, SM and LD respectively. Also, highest Soluble collagen percentage (11.010, 9.560 and 12.670%) was observed in T2 in IS, SM and LD respectively, and the lowest Soluble collagen percentage (8.700, 7.590 and 11.240%) was observed in group C of IS, SM and LD respectively. Messia *et al.* (2008) considered the amount of collagen as the critical factor to determine meat tenderness. It is noticed from the results that decreasing collagen content in all treatments and in the three muscles compared to control. It noticed that the positive impact of the results to supplementation of FP to the diets to increase the concentration of hydroxyproline in the soluble and low concentration in the insoluble and this led to increasing the percentage of soluble collagen in the meat of lambs fed on FP as compared with the control group. Soluble collagen percentage increased in IS muscle (2.09, 2.31, 1.67%) in T1, T2 and T3 while, SM muscle increased (1.78, 1.97 and 1.24) T1, T2 and T3. Then LD muscle

increased (1.09, 1.43 and 1.01) T1, T2 and T3 as compared with group C.

Sensory evaluation of meat

Table (7) revealed the effect of FP supplementation on Sensory evaluation of meat (LD) muscle. From results, it is noticed that the significant (P<0.05) differences in tenderness, juiciness, flavor and palatability are observed. T1 was recorded the highest tenderness, juiciness, flavor and palatability (4.455, 4.285, 4.625 and 4.375) respectively, and group C has recorded the lowest tenderness, juiciness, flavor and palatability (3.120, 3.405, 3.051 and 3.188) respectively. As it was noticed from the table, improving meat tenderness in all treatments which supplementation of FP may be due to the increase in protein solubility and MFI and collagen solubility.

As it was noticed from the table, improving meat tenderness in all treatments which supplementation of FP may be due to the increase in protein solubility and MFI and collagen solubility.

Table (7): Effect of feeding flaxseed powder on Sensory evaluation of meat (Mean ± SD).

Treatments	Traits			
	Tenderness	Juiciness	flavor	Palatability
C	3.120± 0.256 ^c	3.405± 0.035 ^b	3.051± 0.075 ^d	3.188± 0.063 ^b
T1	4.455± 0.105 ^a	4.285± 0.188 ^a	4.625± 0.000 ^a	4.375± 0.250 ^a
T2	3.755± 0.135 ^{bc}	4.170± 0.040 ^a	4.063± 0.063 ^c	4.006± 0.121 ^a
T3	4.020± 0.105 ^{ab}	4.188± 0.188 ^a	4.375± 0.000 ^b	4.133± 0.153 ^a

Means having different letters at the same column are significantly different (P<0.05).

But in relation to juiciness this improvement may be due to increasing moisture percentage which reflects on WHC value led to an improvement in juiciness. As for the good flavor added in treatments may be due to the low percentage of fat within the muscle, which reduces the occurrence of the process of oxidation and rancidity, which produces undesirable flavor in the meat, consequently palatability (overall acceptability) has been improved.

Conclusions

According to the experimental results of this study, the most important conclusions can be expressed as follows: Supplementing ration of lambs with different levels of Flaxseed powder resulted in significant enhancement with relation to general chemical and physical characteristics of lambs as indicated by significant increases in myoglobin concentration, myofibril fragmentation index (MFI), protein solubility (Ps), and water holding capacity (WHC). There are no significant differences in pH value. As in significant improvements were noticed regarding proximate analysis (moisture, protein, fat and ash), sensory evaluation, cholesterol concentration and soluble collagen content with different level of Flaxseed powder supplementation, while cholesterol concentration decreased and soluble collagen percentage increased.

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