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Nutritional Impact of Incorporation Sunflower (*Helianthus annuus*) Seed Meal in Growing Barki Sheep Rations on Their Productive Performance, Water Consumption and Economic Evaluation

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Abstract: Twenty five growing male Barki lambs aged 5-6 months with an average weights (21.960±0.175 kg) were randomly distributed into five equal groups each contains 5 lambs to investigate the impact of incorporation sunflower seed meal (SFSM) at different levels (0, 5, 10, 15 and 18%) of total ration formulation, respectively on feed and water intakes, live weight, average daily gain (ADG), feed conversion and economic evaluation. Experimental animals were housed in semi-open pens and fed as group feeding for 112 days. Results showed that SFSM containing 43.01% essential amino acids (EAA) of their protein content, meanwhile, it contains 51.67% of non essential amino acids (NEAA). Also, FSM has a high quantity of potassium (64.90%) of their mineral content and a moderate quantities of calcium, phosphorus and magnesium (9.32, 9.32 and 8.41%), respectively. SFSM suprior in CF, EE, ash, NDF, ADF, ADL, cellulose contents comparing to soybean meal (SBM). Increasing level of SFSM in tested rations from 0 to 18% of total complete feed mixture caused gradully decreasing in the price or cost of ton formulation. Dieferent experemental rations were formulated to be iso caloric and iso nitrogenous. Dietary treatment significantly (P<0.05) increasing final weight, total body weight gain and average daily gain comparing to contol group. Dry matter intake, crude protein intake, total digestible nutrients intake, growth and digestible energy intakes were significantly (P<0.05) decreased when SFSM incorporated in the rations. Meanwhile, feed conversion values were significantly (P<0.05) improved. Dietary treatments significantly (P<0.05) increase drinking water comparing to control. Increasing the level of SFSM in the ration occurred gradually decreasing in daily feed cost per kilogram gain and feed cost/ kg gain, furthermore, daily profit above feeding cost and relative economical efficiency were enhanced. It can be mentioned that sunflower seed meal is a good source of protein and can be successfully used as a traditional source in growing lamb rations without causing any deleterious effect on their performance and realizing a decreasing in feed costing with improving their economic efficiency, so it can incorporate SFSM in sheep rations to improve profitability or net revenue and decrease feed cost/kg gain.

Key words: Sunflower seed meal · Sheep · Performance · Water consumption · Economic evaluation

INTRODUCTION

Shortage and high price of conventional animal feeds such as grains Lucerne and meals in arid and semi arid areas of the world, leads the animal nutrition to effective use of agro-industrial by-products [1, 2]. Developing food industrial factories consequently produced large amount of wastes and by-products which can play an important role in livestock nutrition [3, 4].

The feeding cost is estimated to be as much as 80% of the total production costs [5, 6]. Protein supplements are the most expensive fraction of feedlot rations. In each country of the West Asia and the North Africa, thousands of tons of soybean meal (SBM) are used for different livestock rations annually [7], furthermore the soybean meal cost is 320% more than energy feeds [8].

However, under the governmental legislations in some countries that restrict the use of protein from animal

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sources in feedlot rations, the demand of protein of plant sources is relatively high. The soybean meal (SBM) has been well documented as a main protein source in animal nutrition [9] and its utilization was satisfactory in almost all feeding systems as well as in experimental nutritional research [10]. As a result, soybean was chosen as a reference point for comparison with other feedstuffs [11]. However, high prices of soybean meal in some parts of the world and the fluctuation in yield have raised the interest in alternative protein sources for feeding livestock.

Also, SBM is often referred to as the gold standard compared with other protein sources [12, 13]. The demand for soybean is increasing due to its inclusion in livestock feed and also its use for human consumption [14]

Sunflower (*Helianthus annuus*) is one of the most widely cultivated oil crops in the world [15, 16]. The world-wild production of sunflower seed reached 37.08 million tones and subsequently produced 15.22 million tones of oil [17]. Together with soybeans, cottonseeds and canola (rapeseed), sunflower seeds are one of the major oilseeds produced in the world [18].

Oilseed by-products play an important role in supplying plant protein [19].

In order to satisfy the need for protein resources, other materials such as rapeseed meal [20], cottonseed meal [21] and peanut meal [22, 23] have been used to replace SBM in the feed industry.

Sunflower seed meal (SFSM) is a by-product of the oil extraction of sunflowers and could be an important protein resource for use in animal diets. Solvent extracted sunflower seed meal has an average concentration of crude protein (CP) of 30.7% and a higher concentration of Methionine than solvent extracted SBM, but has less lysine than SBM [24]. Another characteristic of SFSM is that it is not known to have anti-nutritional factors such as those found in soybean, cottonseed and rapeseed meals. Although sunflower seed contains 1.56% chlorogenic acid [25], its concentration in SFSM does not lead to toxicity effects [26].

On the other hand, the importance of sunflower seed meal (SFM) as a high quality feed by-product is increasing. World production of sunflower seed is large and ranked fourth in oil seed production [27]. Recently, the sunflower seed meal is becoming available in the Middle East countries for animal feeding and as a by-product of local extraction of sunflower oil [28].

As a protein supplement, the sunflower seed meal could replace the soybean meal in rations of growing and fattening lambs with similar gain and feed efficiency [29-33].

In addition to, sunflower seeds are high in fat but they're also packed with linoleic acid to help with metabolism of other fats. They are also high in vitamin E, folic acid, calcium, iron, manganese, magnesium, niacin, selenium and zinc. Sprouted seeds contain vitamin C. Comprised of 24-27 percent vegan protein, they are almost equal to the same weight in ground beef but with twice the iron and potassium and almost four times the phosphorus. The oil is often used for frying fast food, though this has been proven to be one of the worst fat sources. It's widely agreed that consuming seeds is the healthiest way to eat sunflowers [34].

The chemical composition of sunflower depends on the weather, variety, soil and how crops are grown [35, 26]. In this context, great variation in the chemical composition of sunflower meal has been observed due to the method for oil processing and extraction [35, 36]. Amino acid composition of sunflower seed is also variable, with levels of lysine and methionine ranging from 0.56% to 0.66% and from 0.33% to 0.50%, respectively [37].

The suitability of sunflower meal proteins for food applications will depend mainly on three factors: antinutritional components, amino acid composition and protein denaturation occurring during oil extraction. Different studies about anti-nutritional factors in sunflower seeds and meals have been carried out regarding the content of several compounds such as chlorogenic acid, saponin, phytic acid, trypsin inhibitors and even fiber which can be found at high levels in sunflower seeds and meals [38-40].

Sunflower meal is as desirable a protein source as cottonseed meal for growing finishing lambs. Lambs fed sunflower meal at 67% of the requirement had increased gains and similar efficiency to lambs fed cottonseed meal at 67% of the requirement, pointing to the fact that methionine is first limiting in lambs. In addition, lambs fed sunflower meal at 67% of the requirement had increased wool growth [41].

So, the objective of this study was aimed to utilization of sunflower seed meal as untraditional source of high quality protein at different levels in sheep rations to study its effects on their productive performance, water consumption and economic evaluation.

MATERIALS AND METHODS

This study was carried out in co-operation work among Animal Production Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo and Field Crops Research Department, National Research Centre, 33 El-Bohouth Street, P.O: 12622, Dokki, Cairo.

The present study was carried out at privet farm for production sheep and goats in a village at Qaliobeya government, meanwhile the chemical analysis were carried out in laboratories of Animal Production and Field Crops Research Departments, National Research Centre, Cairo, Egypt.

The present work aimed to establish the impact of incorporation sunflower seed meal (SFSM) as a conventional source of feed rich in their contents of crude protein and energy, in addition to it chip price comparing to the soybean meal (SBM).

Animals and Feeds: Twenty five of growing male Barki lambs aged 5-6 months with an average weights (21.960 ± 0.175 kg) were randomly distributed into five equal groups each contain 5 animals to investigate the impact of incorporation SFSM at different levels 0, 5, 10, 15 and 18% of total ration formulation, respectively on feed and water intakes, live weight, average daily gain (ADG), feed conversion and economic evaluation.

Experimental animals were housed in semi-open pens and fed as group feeding for 112 days and the experimental rations received would cover the requirements of total digestible nutrients and protein for growing sheep according to the NRC [42].

Lambs were received one of the experimental rations (Complete Feed Mixture) that assigned as follows:

R_1: 1st experimental ration (Complete Feed Mixture) assigned as control and it contained 0% SFSM.
R_2: 2nd experimental ration (Complete Feed Mixture) contained 5% SFSM.
R_3: 3rd experimental ration replace ration (Complete Feed Mixture) contained 10% SFSM.
R_4: 4th experimental ration (Complete Feed Mixture) contained 15% SFSM.
R_5: 5th experimental ration (Complete Feed Mixture) contained 18% SFSM.

Daily amounts of different tested rations were adjusted every 2 weeks according to body weight changes and it were offered twice daily in two equal portions at 800 and 1400 hours, while feed residues were daily collected, sun dried and weekly weighed.

Fresh water was always freely available in plastic containers. Individual body weight change was recorded weekly before receiving the morning ration. chemical analysis (%) of the ingredients are illustrated in (Table 2). Meanwhile, composition and chemical analysis (%) of tested rations are presented in (Table 3).

Analytical Procedures: Chemical analysis of ingredients and tested ration samples were analyzed according to AOAC [43] methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest [44] and Van Soest *et al*. [30]. Meanwhile, hemicellulose and cellulose content were calculated by difference using the following equations:

Hemicellulose = NDF - ADF. Meanwhile, Cellulose =ADF - ADL.

Amino acids composition was analyzed according to the method described by Millipore Cooperative [45] using HPLC and the modification of PICO-TAG methods.

Minerals were determined by digested a part of sample in 10 ml of nitric acid overnight on a steam bath and subsequently digested with 70% perchloric acid. Minerals determined includes Calcium (Ca), Phosphorus (P), Magnesium (Mg), Potassium (K), sodium (Na), Copper (Cu), Manganese (Mn) and Iron (Fe) were analyzed by atomic absorption spectrophotometry using standard procedures of the AOAC [43]. Phosphorus was analyzed using method N-4C according to [46].

Calculations: Non-fibrous carbohydrates (NFC) were calculated according to [47] using the following equation:

$$NFC = 100 - \{CP + EE + Ash + NDF\}.$$

Gross energy (kcal/ kg DM) was calculated according to Blaxter [48]. Each g CP = 5.65 Kcal, g EE = 9.40 kcal and g CF and NFE = 4.15 Kcal.

Digestible energy (DE) was calculated according to NRC [49] by applying the following equation: $DE\ (kcal/kg\ DM) = GE \times 0.76$.

Total digestible nutrient (TDN) was calculated according to NRC [49] by applying the following equation: $TDN\ \% = DE / 44.3$.

Digestible Crude Protein (DCP): Calculated according to NRC [49] by applying the following equation:

$$\text{Digestible crude protein (\%)} = 0.85\ X_1 - 2.5.$$

where X1= Crude Protein % on DM basis.

Economic Evaluation: Economical efficiency for the tested rations used in this study depended on both local market price of ingredients and price of sheep live body weight. Economic evaluation was calculated as follows:

The cost for 1-kg gain = total cost per Egyptian pound (LE) of feed intake/ total gain (kilogram).

Statistical Analysis: Data collected of live weight, average daily gain, feed intake, feed conversion and drinking water were subjected to statistical analysis as one-way analysis of variance according to SPSS [50]. Duncan's Multiple Range Test [51] was used to separate means when the dietary treatment effect was significant according to the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

where: Y_{ij} = observation. ì = overall mean.
T_i = effect of experimental rations for i = 1-5, 1 = {R 1 contained 0% sunflower seed meal (SFSM) and considered as control}, 2 = {R_2 experimental ration contained 5% SFSM}, 3 = {R_3 experimental ration contained 10% SFSM, 4 = {R_4 experimental ration contained 15% SFSM} and 5 = {R_5 experimental ration contained 18% SFSM}.
e_{ij} = the experimental error.

RESULTS AND DISCUSSION

Amino Acids and Minerals Contents (% on DM Basis) of Sunflower Seed Meal: The data presented in Table (1) mentioned that SFSM containing 43.01% approximately of their protein content from essential amino acids (EAA), meanwhile, it contains 51.67% of non essential amino acids (NEAA). On the other hand, SFSM has a high quantity of potassium that reach to 64.90% of their mineral content and it also, containing a moderate quantities of calcium, phosphorus and magnesium, that recorded 9.32, 9.32 and 8.41% of mineral contents for calcium, phosphorus and magnesium, respectively. These values in harmony with those obtained by [41, 42, 16] they found that the different values of amino acids and minerals determined were near from the results recorded in the present study.

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Chemical Analysis, Cell Wall Constituent and Calculated Nutritive Values of Feed Ingredients: Data presented in (Table 2) cleared that when comparing between sunflower seed meal (SFSM) and soybean meeal (SBM) we noticed that SFSM suprior in their contents of CF, EE, ash, NDF, ADF, ADL, cellulose. Meanwhile SBM suprior in their contents of OM, CP, NFE, hemicellulose, cell soluble-NDF, non fiber carbohydrates (NFC), gross energy (GE), digestible energy (DE), total digestible nutrient (TDN) and digestible crude protein.

The quality of sunflower meal depends on the plant characteristics (seed composition, hulls/kernel ratio, dehulling potential, growth and storage conditions) and on the processing (dehulling, mechanical and/or solvent extraction) [53, 54]. While solvent-extracted sunflower meal remains the main type of sunflower meal commercially available, oil-rich sunflower meals obtained by mechanical pressure only have become more popular since the 2000s, with the development of organic farming and on-farm oil production. The present results near from the results that obtained by [55] who noted that sunflower seed meal contains 34.4% protein, 7.2% ash, 26.2% CF, 47.40% NDF and 33.1% ADF. The increased world production of sunflower has increased interest in sunflower seed meal (SFM) as a high quality by-products for ruminants [56, 57]. The SFM, like SBM, is a high-protein supplement, contains 30-46% crude protein, 13-15% crude fiber, 9-12 MJ ME, Neutral Detergent Fiber (NDF) 47% and Ether Extract (EE) 1.5% [33, 56, 57]. Also, chemical analysis of SBM, yellow corn, Berseem hay and wheat bran in the present study were near from the values reported by [55, 58, 59, 60, 61, 62].

Composition and Chemical Analysis of the Different Experimental Rations: Results of (Table 3) showed that with increasing tle level of SFSM in tested rations from 0 to 18% of total complete feed mixture occuerred gradully decreasing in the price or cost of ton formulation from 3615 LE in the ration that not containe SFSM (R_1) to 2480 LE in the ration that contained 18% SFSM (R_5). Dieferent experemental rations were iso caloric and iso nitrogenous. The corresponding values of GE content among the five tested rations ganged from 4180 to 4182 kcal/ kg DM and DE varied from 3177 to 3178. Meanwhile, corresponding values of CP content among the five tested rations ganged from 16.09 to 16.34 %. These results in agreement with those obtained by [62] who reported that when seasmem meal (SM) replaced 50 or 100% of SBM in lamb rations realized decreasing in their costing of formulation from 3090 to 2420 LE / ton, this related to the varince in the price of SBM and un conventional sources of protein such as SM, SFSM, ….etc. Also, when Paengkoum and Wanapat [55] incorporated sunflower seed meal at varying levels (0, 7.3, 14.5 and 22% of total ration

Table 1: Amino acids and Minerals contents (% on DM basis) of sunflower seed meal

Item	Amino acids %	% of CP of SFSM (31.39%)	Minerals Contents	Minerals %	% of ash of SFSM (5.47%)
Essential amino acids (EAA)					
Arginine	2.21	7.04	Calcium	0.510	9.32
Histidine	1.03	3.28	Phosphorus	0.510	9.32
Isoleucine	1.25	3.98	Magnesium	0.460	8.41
Leucine	1.87	5.96	Potassium	3.550	64.90
Lysine	1.34	4.27	Sodium	0.018	0.33
Methionine	0.82	2.61	Copper	0.005	0.91
Phenylalanine	1.44	4.59	Manganese	0.004	0.07
Threonine	1.31	4.17	Iron	0.013	0.24
Tryptophan	0.41	1.31			
Valine	1.82	5.80			
Total	13.50	43.01			
Non essential amino acids (NEAA)					
Alanine	1.73	5.51			
Aspartate	2.70	8.60			
Cystine	0.61	1.94			
Glutamine	5.80	18.48			
Glycine	1.70	5.42			
Proline	1.26	4.01			
Serine	1.53	4.87			
Tyrosine	0.89	2.84			
Total	16.22	51.67			

Table 2: Chemical analysis, cell wall constituent and nutritive values of feed ingredients

	Feed ingredients				
Item	SFSM	SBM	YC	BH	WB
Moisture	6.56	6.43	8.85	9.21	8.72
Chemical analysis on DM basis (%)					
Organic matter (OM)	94.53	95.48	98.27	91.64	89.15
Crude Protein (CP)	31.39	43.12	8.92	15.31	14.20
Crude fiber (CF)	24.33	4.41	3.82	25.18	9.51
Ether extract (EE)	2.84	0.82	3.16	2.86	2.80
Nitrogen free extrct (NFE)	35.97	47.13	82.37	48.29	62.64
Ash	5.47	4.52	1.73	8.36	10.85
Cell wall constituents (%)					
Neutral detergent fiber (NDF)	44.91	31.82	31.43	45.47	35.17
Acid detergent fiber (ADF)	31.62	13.45	12.92	32.40	18.11
Acid detergent lignin (ADL)	5.64	2.27	2.17	5.79	3.13
Hemicellulose[1]	13.29	18.37	18.51	13.07	17.06
Cellulose[2]	25.98	11.18	10.75	26.61	14.98
Cell soluble-NDF[3]	55.09	68.18	68.57	54.53	64.83
Non fiber carbohydrates (NFC)[4]	15.39	19.72	54.76	28.00	36.98
Nutritive values					
Gross energy (GE), kcal/ kg DM	4543	4652	4378	4183	4060
Digestible energy (DE) kcal/ kg DM	3453	3536	3327	3179	3086
Total digestible nutrient (TDN)	77.95	79.82	75.10	71.76	69.66
Digestible crude protein	24.18	34.15	5.08	10.51	9.57

SFSM: sunflower seed meal.
SBM: soybean meal.
YC: yellow corn. BH: Berseem hay.
WB: wheat bran.
[1]Hemicellulos = NDF – ADF.
[2]Cellulose = ADF – ADL.
[3]Cell soluble-NDF = 100 – NDF.
[4]NFC = 100 – {CP + EE + Ash + NDF}.

Table 3: Composition and chemical analysis of the different experimental rations

Item	Experimental rations R_1	R_2	R_3	R_4	R_5	Price of one kg (LE)
Level of sunflower seem meal	0 % SFSM	5% SFSM	10% SFSM	15% SFSM	18% SFSM	
Composition (kg/ ton)						
Yellow corn	380	360	340	330	320	3.750
Soybean meal	140	110	80	40	20	7.500
Sunflower seed meal	-	50	100	150	180	5.500
Wheat bran	150	150	150	150	150	3.500
Berseem hay	300	300	300	300	300	1.750
Lime stone	18	18	18	18	18	0.250
Sodium chloride	7	7	7	7	7	1.000
Anti toxic	4	4	4	4	4	5.000
Vitamin and mineral mixture[1]	1	1	1	1	1	15.000
Price of Ton (LE)	3615	3590	3565	3503	3480	
Chemical analysis (%)						
Moisture	8.42	8.39	8.34	8.32	8.30	
Chemical analysis on DM basis (%)						
Organic matter (OM)	91.66	91.56	91.45	91.38	91.33	
Crude protein (CP)	16.15	16.24	16.34	16.09	16.09	
Crude fiber (CF)	11.05	12.07	13.06	14.07	14.67	
Ether extract (EE)	2.59	2.65	2.70	2.78	2.82	
Nitrogen free extrct (NFE)	61.87	60.60	59.35	58.44	57.75	
Ash	8.34	8.44	8.55	8.62	8.67	
Cell wall constituents (%)						
Neutral detergent fiber (NDF)	36.18	36.85	37.50	38.17	38.56	
Acid detergent fiber (ADF)	19.51	20.44	21.34	22.26	22.81	
Acid detergent lignin (ADL)	3.39	3.57	3.73	3.90	4.01	
Hemicellulose[2]	16.67	16.41	16.16	15.91	15.75	
Cellulose[3]	16.12	16.87	17.61	18.36	18.80	
Cell soluble-NDF[4]	63.82	63.15	62.50	61.83	61.44	
Non fiber carbohydrates (NFC)	36.74	35.82	34.91	34.34	33.86	
Nutritive values						
Gross energy (GE), kcal/ kg DM	4182	4182	4182	4180	4180	
Digestible energy (DE) kcal/ kg DM	3178	3178	3178	3177	3177	

[1]Vitamin & Mineral mixture: Each kilogram of Vit. & Min. mixture contains: 2000.000 IU Vit. A, 150.000 IU Vita. D, 8.33 g Vit. E, 0.33 g Vit. K, 0.33 g Vit. B_1, 1.0 g Vit. B_2, 0.33g Vit. B_6, 8.33 g Vit.B_5, 1.7 mg Vit. $B1_2$, 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Folic acid, 200 g Choline chloride, 11.7 g Zn, 12.5 g Fe, 16.6 mg Se, 16.6 mg Co, 66.7 g Mg and 5 g Mn.

[2]Hemicellulos = NDF – ADF. [3]Cellulose = ADF – ADL. [4]Cell soluble-NDF = 100 – NDF.

R_1: 1st experimental ration (complete feed mixture) assigned as control and it contained 0% SFSM.

R_2: 2nd experimental ration (complete feed mixture) contained 5% SFSM.

R_3: 3rd experimental ration replace ration contained 10% SFSM.

R_4: 4th experimental ration (complete feed mixture) contained 15% SFSM...

R_5: 5th experimental ration (complete feed mixture) contained 18% SFSM.

formulation of growing goats. They observed that the values of chemical analysis were ranged from (15.2 to 15.3% for CP); (4.8 to 5.8% for ash); (9.7 to 12.8 for CF); (16.2 to 25.1% for NDF). In addition to, Irshaid *et al*. [33] replaced soybean meal (SBM) with sunflower seed meal (SFSM) at 50% or 100% in Awassi lamb rations, they showed that CP cotent ranged from 17.6 to 17.9%; CF from 10.1 to 20.8%; NDF from 31.0 to 63.4%; ADF from 7.3 to 17.0%; ash from 6.4 to 7.1% among three experimental group lambs.

Productive Performance of the Experimental Groups: Data illustrated in (Table 4) cleared that incorporation SFSM in lamb rations at different levels occurred significantly ($P<0.05$) increasing in final weight (FW), total body weight gain (TBWG) and average daily gain (ADG) comparing to contol group lambs that received ration cotains 0% SFSM. These parameters (FW, TBWG and ADG) were gradally increase with increasing the level of incorporation of SFSM.

Also, results of (Table 4) showed that values of dry matter intake (DMI), crude protein intake (CPI), total digestible nutrients intake (TDNI), growth energy intake (GEI) and digestible energy intake that expressed as g/h/day, g/kg$W^{0.75}$ or kg/ 100 kg live body weight (LBW) with DMI; g/h/day, g/kg$W^{0.75}$ or g/ 100 kg LBW with CPI; g/h/day, g/kg$W^{0.75}$ or kg/ 100 kg LBW with TDNI and kcal/h/day, kcal /kg$W^{0.75}$ or Mcal/ 100 kg LBW with GEI and DEI were significantly ($P<0.05$) decreased when lambs received rations containing SFSM (R_2, R_3 R_4 and R_5) in comparison with the control (R_1). On the othe hand, values of feed conversion that expressed as (g. intake / g. gain) of DM, CP, DCP and TDN or that expressed as (kcal intake/ g. gain) of GE and DE were significantly ($P<0.05$) improved with incorporation SFSM in the tested rations (R_2, R_3, R_4 and R_5) comparing to the control one (Table 4). The present result of performance were in agreement with those found by [29, 31, 33]. They noted that as a protein supplement, sunflower meal (SFM) could replace soybean meal (SBM) in rations of growing and fattening lambs improved their gain and feed efficiency. In addition to, Economides and Koumas [32] reported that SFM could successfully replace SBM in lamb fattening diets of lambs. When Paengkoum and Wanapat [55] studied the impact of incorporated sunflower seed meal at varying levels (0, 7.3, 14.5 and 22% of total ration formulation that equal replacing 0, 25, 50 and 75% of soybean meal in basal diet of growing goat rations on their growth performance. They noted that dry matter intake based on g/kg $LBW^{0.75}$, increased ($P<0.05$) with the addition of SSM in concentrate up to 14.5% in concentrate, thereafter decreased ($p<0.05$) in goats fed SSM 22% containing ration. Moreover, DMI g/day, g/kg $LBW^{0.75}$) in goats fed 14.5% SSM significantly higher ($P<0.05$) than goats fed the control (SBM). Also, they mentioned that body weight change (g/day) was not significantly ($P>0.05$) differed with replacing SBM by SFSM up to 50% that equal (14.5% SSM containing ration), meanwhile when replaced 75% of SBM by SFSM (22% SSM containing ration) occurred a significantly decreasing in their ADG in comparison with control one (0% SSM). Moreover, Irshaid *et al*. [33] observed that, when Awassi lambs received rations replaced soybean meal (SBM) with sunflower seed meal (SFSM) at partial 50% or complete replacement 100% of SBM their results showed no significant differences among lambs in ADG or in average final BW. However, lambs fed SFM gained numerically less than lambs fed SBM. Values for average daily gain and average total weight gain were not different ($P>0.05$). However, ADG was higher for lambs that fed ration containing SBM. The lack of differences in average feed intake per animal (kg/h/day) among the three rations includes (SBM, SFM and Both) gives an indication that palatability of SFM is as good as or even better than SBM. Feed conversion ratio for lambs fed SBM was better than that for other lambs but these differences were not significant ($P>0.05$). Also, they mentioned that SFM could be incorporated in the ration of growing Awassi lambs without any harmful effect on voluntary intake and growth. no reason restricts the usage of SFM for lambs and. SFM could be used as a protein supplement for feeding lambs and sheep with SBM or instead of SBM according to its availability and price. Feeding SFM for sheep may be encouraged as a replacement for SBM. However, this should be looked at carefully as many factors might affect its composition. On the other hand, Erickson *et al*. [29] showed that lamb performance based on gains and feed efficiencies were similar for SBM and SFM. On the other hand, results for calves and growing cattle that obtained by [10, 63, 31, 64] cleared that SFM could be used successfully as protein supplement in calf starter rations and they not found any significant differences in dry matter intake (DMI), average daily gain (ADG) or feed efficiency in response to SFM. Also, Schingoethe *et al*. [9] reported that SFM was equivalent to SBM. In addition to, Ullery [65]; Nishino *et al*. [56] when they comparing SFM with the SBM of dairy cattle nutrition they not noticed any differences in feed intakes and weight changes between cows fed on SBM or those fed on SFM. It was found that soybean or sunflower seeds can be used as dietary fat or protein supplements to increase milk yield [66, 67, 68]. Furthermore, Haro *et al*. [69] noted that feeding lambs on ration containing sunflower mean did not affect final body weight of lambs, average daily gain and feed conversion rate. Meanwhile, De Marchi *et al*. [70] reported that feeding dairy cows on ration containing ground sunflower seeds had no effect on feed intake that expressed as dry matter, organic matter, crude protein, neutral detergent fiber or acid detergent fiber.

Table 4: Productive performance of the experimental groups

Item	Experimental rations					
	R_1	R_2	R_3	R_4	R_5	
Level of incorporated sunflower seed meal in the ration formulation	0 % SFSM	5% SFSM	10% SFSM	15% SFSM	18% SFSM	SEM
Live body weight						
Lambs number	5	5	5	5	5	-
Initial weight (kg)	21.900	22.200	21.500	22.500	21.700	0.175
Final weight (FW, kg)	41.500^{c}	42.920^{b}	43.340^{ab}	43.780^{ab}	44.100^{a}	0.269
Total body weight gain (TBWG, kg)	19.600^{d}	20.720^{c}	21.840^{ab}	21.280^{bc}	22.400^{a}	0.287
Experimental duration period	112 days					
Average daily gain (ADG, g/day)	175^{d}	185^{c}	195^{ab}	190^{bc}	200^{a}	2.565
Average body weight, kg*	31.700^{b}	32.560^{ab}	32.420^{ab}	33.140^{a}	32.900^{a}	0.176
Metabolic body weight ($kgW^{0.75}$)	13.36^{b}	13.63^{ab}	13.59^{ab}	13.81^{a}	13.74^{a}	0.055
Feed intake						
Dry matter intake (DMI) as						
g/h/day	1250^{a}	1200^{b}	1150^{c}	1125^{cd}	1100^{d}	14.78
$g/kgW^{0.75}$	93.56^{a}	88.04^{b}	84.62^{c}	81.46^{cd}	80.06^{d}	1.358
kg/ 100 kg live body weight (LBW)	3.943^{a}	3.686^{b}	3.547^{bc}	3.395^{cd}	3.343^{d}	0.061
Crude protein intake (CPI) as						
g/h/day	202^{a}	195^{b}	188^{c}	181^{d}	177^{e}	2.474
$g/kgW^{0.75}$	15.12^{a}	14.31^{b}	13.83^{b}	13.11^{c}	12.88^{c}	0.226
g/ 100 kg live body weight (LBW)	637^{a}	599^{b}	580^{b}	546^{c}	538^{c}	10.11
Digestible crude protein intake (DCPI) as						
g/h/day	154^{a}	150^{b}	145^{c}	140^{d}	138^{d}	1.647
$g/kgW^{0.75}$	11.53^{a}	11.01^{b}	10.67^{b}	10.14^{c}	10.04^{c}	0.156
kg/ 100 kg live body weight (LBW)	486^{a}	461^{b}	447^{b}	422^{c}	419^{c}	7.15
Total digestible nutrients intake (TDNI) as						
g/h/day	877^{a}	849^{b}	814^{c}	802^{cd}	788^{d}	9.028
$g/kgW^{0.75}$	65.64^{a}	62.29^{b}	59.90^{bc}	58.07^{cd}	57.35^{d}	0.858
kg/ 100 kg live body weight (LBW)	2.767^{a}	2.607^{b}	2.511^{bc}	2.420^{c}	2.395^{c}	0.039
Gross energy intake (GEI) as						
kcal/h/day	5228^{a}	5018^{b}	4809^{c}	4703^{cd}	4598d	62.07
$kcal/kgW^{0.75}$	391^{a}	368^{a}	354^{b}	341^{bc}	335c	5.61
Mcal / 100 kg live body weight (LBW)	16.492^{a}	15.412^{b}	14.833^{bc}	14.191^{cd}	13.976d	0.257
Digestible energy intake (DEI) as						
kcal/h/day	3973^{a}	3814^{b}	3655^{c}	3574^{cd}	3495^{d}	47.11
$kcal/kgW^{0.75}$	297^{a}	280^{b}	269^{bc}	259^{cd}	254^{d}	4.34
Mcal / 100 kg live body weight (LBW)	12.533^{a}	11.823^{b}	11.274^{bc}	10.785^{cd}	10.623^{d}	0.2
Feed conversion expressed as g. intake / g. gain of						
Dry matter	7.14^{d}	6.49^{c}	5.90^{b}	5.92^{b}	5.50^{a}	0.155
Crude protein	1.15^{d}	1.05^{c}	0.96^{b}	0.95^{b}	0.89^{a}	0.025
Digestible crude protein	0.88^{d}	0.81^{c}	0.74^{b}	0.74^{b}	0.69^{a}	0.018
Total digestible nutrients	5.01^{d}	4.59^{c}	4.17^{b}	4.22^{b}	3.94^{a}	0.102
Feed conversion expressed as kcal intake / g. gain of						
Gross energy	29.87^{d}	27.12^{c}	24.66^{b}	24.75^{b}	22.99^{a}	0.650
Digestible energy	22.70^{d}	20.62^{c}	18.74^{b}	18.81^{b}	17.48^{a}	0.494

a, b, c, d and e: Means in the same row having different superscripts differ significantly (P<0.05).

SEM: Standard error of mean.

*Average body weight, kg = (Initial weight + final weight) / 2.

Drinking Water by the Experimental Groups: Data presented in Table (5) showed that dietary treatments significantly (P<0.05) increase drinking water that calculated as ml/h/day, ml/ $kgw^{0.75}$, liter/ kg dry matter intake, Liter/ kg crude protein intake, Liter/ kg digestible crude protein intake, Liter/ kg total digestible nutrients intake, Liter/ M cal gross energy intake and Liter/ M cal digestible energy intake. The corresponding value of drinking water was 3900, 4100, 4250, 4500 and 4650 ml/h/day. This may be related to increase the ash content

Table 5: Drinking water by the experimental groups

Item	Experimental rations					SEM
	R_1	R_2	R_3	R_4	R_5	
Level of sunflower seem meal	0 % SFSM	5% SFSM	10% SFSM	15% SFSM	18% SFSM	
Drinking water calculated as:						
ml/h/day	3900^d	4100^{cd}	4250^{bc}	4500^{ab}	4650^a	81.18
ml/ $kgw^{0.75}$	292^c	301^c	313^{bc}	326^{ab}	338^a	5.18
Liter/ kg dry matter intake	3.120^c	3.417^b	3.696^b	4.000^a	4.227^a	0.111
Liter/ kg crude protein intake	19.31^c	21.03^b	22.61^b	24.86^a	26.27^a	0.703
Liter/ kg digestible crude protein intake	25.32^c	27.33^{bc}	29.31^b	32.14^a	33.70^a	0.859
Liter/ kg total digestible nutrients intake	4.447^d	4.829^{cd}	5.221^{bc}	5.611^{ab}	5.901^a	0.148
Liter/ M cal gross energy intake	0.746^d	0.817^c	0.884^b	0.957^a	1.011^a	0.027
Liter/ M cal digestible energy intake	0.982^c	1.075^b	1.163^b	1.259^a	1.330^a	0.035

a, b, c and d: Means in the same row having different superscripts differ significantly (P<0.05).

SEM: Standard error of mean.

R_1: 1st experimental ration (complete feed mixture) assigned as control and it contained 0% SFSM.

R_2: 2nd experimental ration (complete feed mixture) contained 5% SFSM.

R_3: 3rd experimental ration replace ration contained 10% SFSM.

R_4: 4th experimental ration (complete feed mixture) contained 15% SFSM...

R_5: 5th experimental ration (complete feed mixture) contained 18% SFSM

in tested ration (R_2, R_3, R_4 and R_5) in comparison with the control (R_1). These results in agreement with those found by [62] who observed that water consumption was increased when sesame meal (SM) replaced 50 or 100% of soy bean meal (SBM) quantity that used in basal ration of growing male Barki lambs but these values less than that recorded in the present study (2833, 3000 and 3250 ml/h/day). These may be related to differences in live body weight, the ingredient used in ration formulation and chemical analysis contents especially ash and CF in two comparison studies. DMI and water intake are positively associated [71], so ash is not the only constituent of dry matter in the feed, therefore, the ash contents could not be the sole cause of the changes in the water consumption. Also, Omer *et al*. [72] noted that Ossimi sheep received rations composed of 50% concentrate feed mixture plus 50% of peanut vein hay, beans straw, kidney beans straw, or linseed straw increased (P<0.05) drinking water compared to control group that offered ration composed of (50% concentrate feed mixture plus 50% berseem hay) Also, they recorded that the corresponding values of drinking water were 3088, 3742, 4650, 3660 and 3038 ml/h/day for control and the other four experiment groups mentioned above. On the other hand, Ahmed and Abdalla [73] showed that replacing 50% of cotton seed cake (CSC) by sesame seed cake (SSC) in yearling sheep had no effect on water intake (3.04 vs. 3.00 l/kg DM intake) for CSC and SSC, respectively. They also, think that ash content in the two sources in the same range had not caused any adverse effect on quantity water consumption.

Economic Evaluation of the Experimental Groups: Incorporation SFSM in lamb rations at different levels (5, 10, 15 and 18%) caused gradually decreasing in daily feed cost per kilogram gain and feed cost/ kg gain in comparison with the lambs that fed control ration (R_1, 0% SFSM) which recorded the highest feed cost. Moreover, values of daily profit above feeding cost and relative economical efficiency were enhanced gradually with increasing the level of SFSM incorporation in the ration (5, 10, 15 and 18%) for (R_2, R_3, R_4 and R_5), respectively comparing to the control one (R_1). These results were in harmony with those noted by [62] who replaced 50 or 100% of soybean meal by sesame meal in lamb rations. This depressed in daily feed cost and feed cost/ kg gain was related to lowering in costs of rations that containing SFSM in the present study or sesame oil cake that used by [28] with Awassi lamb rations or sesame meal that incorporated by [62] with growing male Barki lambs. On the other hand, Fitwi and Tadesse [74] noticed that using 300 g DM of sesame seed cake was potentially more feasible and economically beneficial for growing sheep. Also, Mahmoud and Bendary [75] noted that the use of sesame seed meal reduced feed cost and therefore it can be used to improve total revenue, net revenue, economic efficiency and relative economic efficiency in ration on performance of growing lambs and calves. When Rao *et al*. [76] examined replacing groundnut cake protein with sunflower cake in complete rations for sheep they noted that balanced low-cost complete diets could be formulated for sheep by replacing costly groundnut cake protein with sunflower cake. Sayda *et al*. [77] recorded that when

Table 6: Economic evaluation of the experimental groups

Item	Experimental rations R$_1$	R$_2$	R$_3$	R$_4$	R$_5$
Level of sunflower seem meal	0 % SFSM	5% SFSM	10% SFSM	15% SFSM	18% SFSM
Daily feed intake (fresh, kg)	1.365	1.310	1.255	1.227	1.200
Value of 1-kg feed (LE)	3.615	3.590	3.565	3.503	3.480
Daily feeding cost (LE)[a]	4.93	4.70	4.47	4.30	4.18
Average daily gain (kg)	0.175	0.185	0.195	0.190	0.200
Value of daily gain (LE)[b]	12.25	12.95	13.65	13.30	14.00
Daily profit above feeding cost (LE)	7.32	8.25	9.18	9.00	9.82
Relative economical efficiency [c]	100	112.7	125.4	123.0	134.2
Feed cost (LE/ kg gain)	28.17	25.41	22.92	22.63	20.90

LE = Egyptian pound equals 0.06 American dollars ($) approximately.

[a]: based on price of 2020. [b]: Value of 1-kg live body weight equals 70 LE (2020).

[C]: Assuming that the relative economic efficiency of control ration (R_1) equals 100.

R_1: 1st experimental ration assigned as control and it contained 0% SFSM.

R_2: 2nd experimental ration contained 5% SFSM.

R_3: 3rd experimental ration replace ration contained 10% SFSM.

R_4: 4th experimental ration contained 15% SFSM...

R_5: 5th experimental ration contained 18% SFSM.

groundnut meal (GNM) was substituted by sunflower seed meal (SFM) by inclusion of either 0% sunflower meal (SFM 0%), 50% (SFM 50%) or 100% (SFM 100%) of the total plant protein in the diet. The feed costs per hen were generally lower for the SFM groups. Moreover, Mahmoud and Ghoneem [78] reported that there was a decrease in the feed cost per one kg 7% fat corrected milk (FCM) in Egyptian lactating buffaloes fed ration composed of (50% roughage and 50% concentrate feed mixture that contained 50% sesame seed meal) in comparison with control ration. Meanwhile, El-Nomeary *et al*. [79] found that incorporation sesame seed meal in rabbit diets supplemented with black cumin, mustard, sesame and rocket seed meals improved relative economic efficiency that reached to 140% in comparison with the control diet that considered 100%.

CONCLUSION

The findings of this study suggest that sunflower seed meal (SFSM) can be incorporated in growing sheep rations up to 18 % of ration formulation (high level of SFSM used in this study) that realized improvements in their productive performance, in addition to it causing a decreasing in their daily feed costing with improving their relative economic efficiency, so farmers can incorporate SFSM in sheep rations to obtained an improvements in profitability or net revenue and decrease feed cost/ kg gain.

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