MITIGATING CLIMATE CONDITION EFFECTS WITH OMEGA-3 OR OMEGA-6 SOURCES IN HOLSTEIN DAIRY COW'S RATIONS

Shahira, M.M. El-Ganainy[1]; A.A. Tantawi[1]; A. Zanouny[1]; Fatma, I. Hadhoud[2]; A.S. Shams[3]; A.M. Shaarawy[3], and E.M. brahim[1]*

[1]Animal Production Department, Faculty of Agriculture, Minia University, Egypt

[2]Dairy Sciences Department, National Research Centre, Dokki, Giza, Egypt.

[3] Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

**Corresponding author E-mail: shahira.elganainy@mu.edu.eg*

(Received 1/7 /2024, accepted 27/ 7/2024)

SUMMARY

Production of healthy milk under climate heat conditions has an enormous challenge in the global dairy industry. The objective of the presented study was to evaluate milk production and nutrients digestibility of Holstein dairy cows during rising temperatures period (spring and summer conditions) in response to feeding omega-3 or omega-6 sources. Fifteen multiparous cows (30 d in milk) were divided into 3 equal groups (5 cows in each) in a complete randomized design according to their milk production, body weights and parity. The first group fed on basal diet and served as control. The second group fed on basal diet supplemented with 10 % Omega-3 sources (Flax seed meal and Flax seed in a ratio of 65: 35 %, respectively on DM basis), meanwhile the third group fed on basal diet supplemented with 8 % Omega-6 sources (equal portions of safflower and sunflower seeds). Data indicated that dry matter intake (DMI) increased ($P<0.05$) in cows fed Omega-3 or omega-6 by 5.60 and 8.22 %, respectively *vs.* control. Milk yield increased ($P<0.05$) with feeding omega-3 and omega-6 sources by 23.61% (3.60 kg) and 11.48 % (1.75 kg), respectively than those fed control one. The cows in both omega-3 and omega-6 groups produced more ($P<0.05$) fat corrected milk (FCM), energy corrected milk (ECM), fat %, lactose %, fat yield and lactose yield than the control one. Feeding omega-3 had a positive effect on DM, OM, EE digestibilities, enhancing the nutritive values (TDN and DCP %). However, feeding Omega-6 had no effect on DM, OM and CP digestibilities compared to feeding the control ration. Omega-3 increased ($P<0.05$) rumen NH_3-N concentrations, however TVF's values decreased. This study, therefore, may be suggested that both omega-3 and omega-6 can be effectively used as acceptable healthy fat sources in dairy cow's ration during the spring and summer conditions concomitant with positive effect on milk production.

***Keywords**: Climate conditions, Dietary omega-3 and omega-6, Milk production, Digestibility.*

INTRODUCTION

Egypt is an arid country subjected to high ambient temperatures and humidity especially during summer season. Livestock critically contributes to global warming and is affected by climate change. Therefore, most researchers believe that livestock sector under Egyptian climate conditions will become more of a concern in the future. Despite dairy animals have thermoregulatory capability to maintain their body core temperature within a set narrow limit for controlling biological reactions and physiological activities but also subjected to heat stress (when the environmental temperature rises), hence, reducing their productive and reproductive performance (Mohammed *et al.*, 2024). Additional studies have revealed that thermal heat adversely affects energy balance, feed intake, rumination, nutrient absorption and milk yield and composition in ruminant animal (Kumar *et al.*, 2019 and Penev *et al.*, 2021). Interestingly, developing feed strategies of dairy cows with omega-3 and omega-6 fatty acids, which can't be synthesized in rumen, may alleviate immune responses associated with thermal stress (El-Garhi, 2018) and produce modified milk (Al-Saiady *et al.*, 2024). Moreover, healthy food products are gaining popularity all around the world, thus feed is no longer intended to satisfy hunger or provide the necessary nutrients, but also to prevent metabolic disorders or lower the risk of chronic illnesses and infection diseases (Chooi *et al.*, 2019). Several studies have demonstrated that milk and dairy products regardless of their fat content, may have beneficial effects on metabolic and cardiometabolic health (Srour *et al.*, 2019; Timon *et al.*, 2020; hirahatake *et al.*, 2020), diabetes (Schwingshackl *et al*, 2017), and obesity (Brondel *et al*, 2022). So, it has been suggested that reducing saturated fatty acids (SFAs) and trans fatty acids in dairy cow's rations may lower the incidence of human diseases (Kim *et al.*, 2016). Feeding lactating ruminant diets rich in 18-carbon FAs such as oilseeds or vegetable oils might increase milk content of monounsaturated FAs (MUFA) by 50 to 80 % (Go´mez-Corte´s *et al.*, 2018; Pi *et al.*, 2019; Salles *et al.*, 2019; and Oliveira *et al.*, 2021). In this regard, omega-3 and omega-6 polyunsaturated fatty acids (PUFAs) have been shown to be beneficial for general human and dairy animal health (Kabeya *et al.*, 2018; Saini and Keum, 2018). Flaxseed and its products are known to be the richest sources of PUFAs (El-ganainy, *et al.,* 2023). They considered a source of Omega -3 FAs, containing a high level of α-linolenic acid (ALA), 18 % of the total seed (DM basis) and constituting about 52-58 % of the seed or oil's total fatty acids (Petit, 2003; Perumal, 2019 and El-ganainy *et al.,* 2023). Previous studies also, have shown that flaxseed supplementation can increase the concentration of omega-3 PUFAs, particularly ALA in milk (Meignan *et al.*, 2017; Brzozowska *et al.*, 2018; Marino *et al.*, 2019). Sunflower seeds and oil are also the main sources of PUFAs, containing omega-6 FAs, over 60% of their composition is linoleic acid (C18:2), (Esmaeili *et al.*, 2014 and Shaarawy *et al.*, 2018). Thus, feeding dairy cattle with omega-3 and omega-6 could modulate the ruminal biohydrogenation process, increasing PUFAs and decreasing saturated fatty acids (SFA) concentrations in milk (Rego *et al.*, 2009; Rodríguez *et al.*, 2020).

Therefore, the objective of the presented study was to investigate the possibility of omega-3 and omega-6 fatty acids to enhance dairy cow health via increasing feed intake, nutrient digestibility and milk production under subtropical conditions.

MATERIAL AND METHODS

Study period and location:

This study was conducted from 22 of April to 22 of July in the experiment trail at El-Karada Animal Experimental Station, Kafr El-Sheikh governorate, Animal Production Research Institute, Ministry of Agriculture, Egypt. During the experimental period range of ambient temperature (°C) was 30.0°C–35.0°C and relative humidity (%) was 50 – 60% and The THI was 78.20 -86.76 that calculated using the formula reported by (Garcia-Ispierto *et al.*, 2006).

$$\text{Mean THI} = 0.8 * \text{ Mean T} + \frac{\text{Mean RH(\%)}}{100} * (\text{ Mean T} - 14.4) + 46.4$$

The estimated values of the THI were classified as follows: below 72 is no heat stress, from 72.1 to 83 is moderate heat, from 83.1 to 86 is severe heat stress, above 86 very severe heat stresses.

Animals and experimental design:

Fifteen multiparous of Holstein dairy cows (30 d in milk) were assigned to a completely randomized design for a 12-wk trial with the first 2 weeks for adaptation to the diets followed by 10-weeks for collecting the data. The experimental cows were housed in a free-stall under open loose system, earthen floor, 30% shaded area. At the beginning of the experiment, the cows were divided into three groups according to their averages of milk yield (15±0.97kg/d), body weight (500±30 kg) and parity, (2.3± 1.5), respectively. The first group was fed on basal diet and served as control. The second group fed on basal diet with 10 % Omega-3 sources (Flax seed meal and Flax seed in a ratio of 65: 35 %, respectively on DM basis), meanwhile the third group was fed on basal diet supplemented with 8 % Omega-6 sources (equal portions of safflower and sunflower seeds). The two sources (omega-3 or omega-6) were designed to provide similar CP and EE concentrations and were formulated to meet cow's nutritional requirements. Cows were fed on concentrate feed mixture (CFM) contained 39% uncorticated cotton seed meal, 32 % yellow corn, 23% wheat bran, 3% molasses, 2 % limestone and 1 % sodium chloride. The ration was prepared to cover the cows nutrients requirements according to national research council (NRC, 2001).

In this study, all cows were mechanically milked twice daily at 5 am and 5 pm, while feed was offered twice daily at 8 am and 4 pm. Drinking water, Berseem hay (BH) and Rice straw (RS) were also available along the experiment. Cows were routinely vaccinated and inspected by a veterinarian.

Dietary sampling and laboratory analysis:

Dietary samples were collected biweekly along the experimental period and a composite sample was performed. A portion of the composite sample was dried at 105 °C in a forced air oven until constant weight for DM determination. The rest of the composite sample was dried at 70 °C for a constant weight, grounded and kept in closely tied jars for later laboratory analysis. Samples of diets, Omega-3 and omega-

6 sources were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to AOAC (2003). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Goring and Van Soest (1970).

Fatty acids methyl esters of the CFM, Omega-3 and Omega-6 sources were detected using gas chromatography model, Shimadzua-8A, equipped with FID detector and glass column 2.5 X 3 mm I'd, under the following conditions: Column 5 % DEGS on 80/100 Chromo Q, Column temperature (Temp.) 150-180 ^{o}C at rate 2 ^{o}C/min. Detector tem. 270 ^{o}C, N2 flow rate: 20 ml/min, H2 flow rate: 75 ml/min, Air flow rate: 0.5 ml/min, Sensitivity: 16 X 102, Shart speed: 2.5 mm/min. (Radwan, 1978). Grasp fecal samples were collected before feeding at 7 am and 3 pm from each cow biweekly, dried at 70 °C till constant weight and analyzed for DM, OM, CP, CF, , EE and ash by using acid insoluble ash (AIA) as an internal marker according to Van Keulen and Young (1977).

Rumen fluid samples and laboratory analysis:

Rumen fluid were collected on the last day of experimental period from each cow using stomach tube attached to an automatic suction machine at the aforementioned times of providing the diets. Rumen fluid pH was measured immediately using digital pH meter, and then samples were filtered through four layers of sheath cloth. Two drops of diluted formalin solution (10 %) were added to stop microbial activity, acidified and kept frozen at – 20 ºC for the determination of ammonia (NH3-N) according to Conway (1957) and total volatile fatty acids (TVFA's) as previously described by Warner (1964).

Milk sampling and analysis:

The milk samples were obtained from each cow weekly for 2 consecutive milking at morning and afternoon throughout the 10-wk experimental period. Fresh milk samples were analyzed for protein, fat, lactose and solid not fat (SNF) using infrared spectrophotometry MilkoScan (model 130 series_ type 10900 FOSS electric- Denmark). Fat and protein yields were calculated by multiplying the milk yield by the respective fat and protein percentages. Fat-corrected milk (FCM) was calculated by the equation: 3.5% FCM = (0.432×kg of milk) + (16.216×kg of milk fat) according to Tyrrell and Reid, (1965). Energy corrected milk (ECM) was individually calculated by the following equation:

ECM = 0.327×milk (kg) + 12.95 ×fat (kg) + 7.20×protein (kg) (Tyrrell and Reid, 1965).

Statistical analysis:

Data of feed intake, milk yield and composition, nutrients digestibility and ruminal fermentation were analyzed by least square means analysis of variance using General Linear Model (GLM) procedure of the statistical analysis system (SAS, 2000). The model used to analyze the different traits studied for cows was as follows:

$$Yij = \mu + Ti + eij.$$

Where: Yij= ijth observation, μ = yij, Population mean; Ti = Effect of ith treatments and eij= Random error. Duncan's Multiple Range test was used to detect differences between means of the experimental groups (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition of omega-3, omega-6 sources and CFM:

As shown in Table 1, both omega-3 and omega-6 sources were enriched in unsaturated fatty acid, the total n-3 content in omega3 sources was 57 times more than omega 6 sources. By contrast, the total n-6 content in omega3 sources was lower about 2.59 times than in omega 6 sources. These finding are consistent with earlier observations reported by Perumal (2019) and El-ganainy *et al.* (2023) they reported that flaxseed oil contains an elevated level of linolenic acid constituting about 55 % of total fatty acids. As well as sunflower seed and oil contain omega-6 FAs, over 60 % linoleic acid (Esmaeili *et al.*, 2014 and Shaarawy *et al.*, 2018). The chemical composition of the different CFM diets fed to lactating Holstein cow's is presented in Table 2. The CFM that containing omega-3 or omega-6 acid sources were higher in EE content than control one; however, other nutrients were almost similar among the treatments.

Table (1): Proximate analysis and fatty acids profile of omega-3 and omega-6 sources fed to Holstein dairy cows (on DM basis, %).

Parameters	Omega-3	Omega-6
DM	92	93
OM	95	97
CP	29	19
CF	9	30
EE	25	30
NFE	32	18
Fatty acids profile (g/100 g FA)		
Palmitic acid (C16:0)	4.56	17.00
Stearic acid (C18:0)	2.70	7.23
Oleic acid (C18:1 ω9)	16.46	24.40
Linoleic acid (C18:2 ω6)	15.63	40.55
Linolenic aid (C18:3 ω3)	57.00	1.00
Unkown	3.65	9.82
Saturated fatty acids (SFA)	7.26	24.23
Unsaturated fatty acids (UFA)	89.09	65.95
Mono-unsaturated fatty acids (MUFA)	16.46	24.40
Poly-unsaturated fatty acids (PUFA)	72.63	41.55
Total n-6	15.63	40.55
Total n-3	57.00	1.00
n-6/ n-3	3.65	40.55
PUFA / SFA	10.00	1.71

SFA= C16 + C18; UFA = C18:1 + C18:2 + C18:3; MUFA = monounsaturated fatty acid (C18:1); PUFA = polyunsaturated fatty acid (C18:2 + C18:3); Total n−6 = C18:2; Total n−3 = C18:3. Abbreviations: CF, crude fibre; CP, crude protein; DM, dry matter; NFE, nitrogen-free extract; OM, organic matter, NDF, neutral detergent fibre; TDN, total digestible nutrient .

Feed intake:

Data presented in Table 3 showed that inclusion of omega-3 or omega-6 sources in Holstein dairy cow's ration had no perceptible (P>0.05) effect on DMI during hot season. While, the average DMI was higher in cows fed omega-6 and omega-3 diets than that in control cows. This finding could be attributed to feeding cows, in control group, un-protected fat sources especially cotton seed meal during hot season that result a reduction in fiber digestion and lead to prolonged ruminal fill (El-Garhi *et al.*, 2018). Similar result was noticed by Huang *et al.*, (2022) and Al-Saiady *et al.* (2024) who found that supplemented ration with flaxseed had no effect on DMI. Also, these results are in agreement with the previous studies, which reported that there no changes in DM intake in dairy cows (De Souza *et al.*, 2019; Lopes *et al.*, 2020) or lactating buffaloes (Patel *et al.*, 2023) supplemented with sunflower oil. In the same way, Ghasemi *et al.*, (2021) showed that no significant differences in DMI were detected for Holstein dairy cow's fed control or diets enriched in n-3 or n-6 fatty acids. This result could be explained as omega-3 or omega-6 is readily accepted by dairy cows and had no negative effect on DMI (Ghasemi *et al.*, 2021). Moreover, omega-3 FA intake/ day was higher (P<0.05) in omega-3 group than those in omega-6 and control groups, whereas omega-6 FA intake/day was lower (P<0.05) in omega-3 group.

Milk yield and composition:

Data presented in Table 4 indicated that inclusion of omega-3 in dairy cow's diet under hot season conditions improved (P<0.05) milk yields by 23.61 and 10.88 % vs. those fed control or omega-6 diet, respectively, while, fat corrected milk (FCM) was significantly (P<0.05) higher by 28 to 27.29 % and energy corrected milk (ECM) by 21.51 to 25.93 for cows fed omega-3 and omega-6 sources, respectively comparing to those fed control one. These results could be attributed to the higher EE content in omega-3 and omega-6 diets compared with the control diet (Table, 2). This meaning more energy density and intake, as noticed in the present study (Table 3), causing greater fat mobilization leading to increase a milk yield (Petit *et al.* 2004). The improvement may be due to higher by pass protein supplied from omega-3 sources in diet and control heat stress due to the anti-inflammatory effect of omega-3. Furthermore, the improvement noticed in milk yield could be correlated with the higher DM, OM, EE, CF digestibility and nutritive values as TDN observed in the current study (Table, 5) with feeding omega-3 or omega-6 sources which ensure sufficient supply of different nutrients for optimize milk production. This finding is consistent with Patel *et al.*, (2023), who reported that dietary inclusion of sunflower oil in Buffaloes ration improved milk, FCM and ECM yields comparing to those fed control ration. Similar results were reported by Beauregard *et al.*, (2023) and Al-Saiady *et al.* (2024). Sammad *et al.* (2020) reported that supplemented linoleic acid may act as a direct antioxidant potential thus enhance cow productivity (Diesel *et al.*, 2007).

Table (2): Ingredient, chemical composition and major fatty acids profile of concentrate feed mixture (CFM) fed to Holstein dairy cows (on DM basis, %).

Ingredients	**CFM**	**Omega-3**	**Omega-6**
Uncorticated cotton seed meal	39.00	27.00	36.00
Yellow corn	32.00	34.00	27.00
Wheat bran	23.00	23.00	23.00
Omega-3 sources	0.00	10.00	0.00
Omega-6 sources	0.00	0.00	8.00
Molasess	3.00	3.00	3.00
Limstone	2.00	2.00	2.00
Salts	1.00	1.00	1.00
Chemical composition of CFM			
DM	88.69	89.88	90.13
Ash	4.79	4.49	4.84
CP	15.09	15.38	15.51
CF	15.25	12.48	16.56
EE	2.11	4.22	4.22
NFE	62.76	63.43	58.88
ADF	18.96	16.77	19.11
NDF	35.93	33.11	36.06
TDN	69.85	72	71.09
Major fatty acids profile (% of total fatty acids) of experimental CFM:			
Palmitic acid (C16:0)	12.58	8.39	9.11
Palmitoleic acid (C16:1ω9)	0.23	0.16	0.15
Stearic acid (C18:0)	1.64	2.18	2.17
Oleic acid (C18:1 ω9)	20.13	18.30	20.87
Linoleic acid (C18:2 ω6)	40.63	27.85	45.79
Linoliniec aid (C18:3 ω3)	0.69	30.00	0.84
Saturated fatty acids (SFA)	14.22	10.57	11.28
Unsaturated fatty acids (UFA)	61.68	76.31	67.65
Mono-unsaturated fatty acids (MUFA)	20.36	18.46	21.02
Poly-unsaturated fatty acids (PUFA)	41.32	57.85	46.63
Total n-6	40.63	27.85	45.79
Total n-3	0.69	30.00	0.84
n-6/ n-3	58.88	0.93	54.51
PUFA / SFA	2.91	5.47	4.13

Note: Analysis performed on one composite sample for the study. SFA = C16 + C18; UFA = C18:1 + C18:2 + C18:3; MUFA = monounsaturated fatty acid (C18:1); PUFA = polyunsaturated fatty acid (C18:2 + C18:3); Total n−6 = C18:2; Total n−3 = C18:3. Abbreviations: CF, crude fibre; CP, crude protein; DM, dry matter; NFE, nitrogen-free extract; OM, organic matter.

Milk fat % was not significantly changed by feeding omega-3 sources, while it raised up ($P<0.05$) by feeding omega-6 sources comparing with control diet (table, 4). The values of milk fat were 3.00, 3.20 and 3.80 % for cows fed control, omega-3 and omega-6 sources, respectively. In addition, milk fat yield was higher ($P<0.05$) by 30.43 and 39.13 % for cow's fed omega-3 and omega-6 sources compared with those fed control, respectively. In agreement with these findings, several studies revealed no effect of flaxseed supplementation on milk fat content in dairy cows (Brossillon *et al.*, 2018; Schossow, 2019; Beauregard *et al.*, 2023; Al-Saiady *et al.*, 2024). In the current study, milk protein concentration and yield were decreased ($P< 0.05$) for cows fed omega-3 or control diet vs. those fed omega-6 diet (Table, 4). Meanwhile, there were no significant differences in milk protein yield among groups (0.50 vs. 0.49g /kg, respectively). It has been evidenced that, flaxseed supplementation, as omega-3 sources, significantly reduced milk protein content in lactating cows (Moallem *et al.*, 2020; Vlaicu *et al.*, 2020), and sheep (Mughetti *et al.*, 2012) as well as in goats (Ali *et al.*, 2019). Other studies recorded similar milk protein (%) with or without flaxseed supplementation in the diets (Vargas-Bello-Pérez *et al.*, 2020; Sun *et al.*, 2022; Nanas *et al.*, 2023).

Table (3): Feed intake of Holstein dairy cow's fed on rations containing omega-3 or omega-6 fatty acids sources (on DM basis).

Parameters	Control	Omega 3 ration	Omega 6 ration	SE
CFM intake (kg/day)	4.70	5.20	5.11	0.29
Berseem hay intake (BHI, kg/d)	7.17	7.44	7.90	0.50
Rice straw intake (RS, kg/d)	2.00	2.00	2.00	
DMI (kg/d)	13.87	14.64	15.01	0.78
DMI % of weight	2.87	2.93	2.86	0.10
Omega3 from (CFM) intake (g /day)	0.68^{b}	34.93^{a}	0.91^{b}	0.26
Omega6 from (CFM) intake (g /day)	40.27^{a}	33.09^{b}	49.43^{a}	3.61

a and b, means within the same row having different superscripts significantly different (P<0.05).*

Table (4): Milk production and its composition of Holstein dairy cow's fed on rations containing omega-3 or omega-6 fatty acids sources.

Parameters	Control	Omega-3	Omega-6
TDMI	13.87±0.78	14.64±0.78	15.01±0.78
Milk (Kg/day)	$15.25^{c} \pm 0.74$	$18.85^{a} \pm 0.42$	$17.00^{b} \pm 0.53$
3.5% FCM (kg/day)	$14.00^{b} \pm 0.76$	$17.92^{a} \pm 0.43$	$17.82^{a} \pm 0.54$
ECM	$14.46^{b} \pm 1.04$	$17.57^{a} \pm 0.59$	$18.21^{a} \pm 0.74$
FCM/TDMI	1.01	1.22	1.19
Milk composition %			
Fat	$3.00^{b} \pm 0.10$	$3.20^{b} \pm 0.05$	$3.80^{a} \pm 0.07$
Protein	$3.23^{b} \pm 0.03$	$2.65^{c} \pm 0.02$	$3.46^{a} \pm 0.02$
Lactose	4.70 ± 0.13	4.95 ± 0.07	4.80 ±0.09
Solid not fat	$8.60^{b} \pm 0.12$	$8.23^{c} \pm 0.07$	$8.90^{a} \pm 0.09$
Milk composition kg/day			
Fat	$0.46^{b} \pm 0.03$	$0.60^{a} \pm 0.01$	$0.65^{a} \pm 0.02$
Protein	$0.490^{b} \pm 0.02$	$0.50^{b} \pm 0.01$	$0.59^{a} \pm 0.03$
Lactose	$0.72^{c} \pm 0.06$	$0.93^{a} \pm 0.08$	$0.82^{b} \pm 0.05$

Fat-corrected milk was calculated by = (0.432×kg of milk) + (16.216×kg of milk fat); 3.5% ECM, Energy-corrected milk was calculated by the equation for; ECM = 0.327×milk (kg) + 12.95 ×fat (kg) + 7.20× protein (kg); a,b Means within the same row having different superscripts significantly different (P<0.05).*

The inconsistency among the effects of the various flaxseed products on milk protein might be attributed to differences among the various studies' diets in terms of type of delivery, amount, or composition. Accordingly, Beauregard *et al.*, (2023) found that milk protein concentration was lower in herds fed extruded flaxseed vs. to those fed without supplementation, but milk protein yield remained unchanged among treatments. In this respect, Wu and Hubert (1994) suggested that the decrease in milk protein content with fat supplementation could be due to a shortage in availability of amino acids to the mammary gland for protein synthesis. In some cases, high fat inclusion can decrease milk yield and milk protein concentrations. This is possibly due to the negative effect of fat supplementation on microbial fermentation and microbial protein yield, consequently decreasing the availability of amino acid supply for absorption (Behan *et al.*, 2019). Moreover, Plata-Pérez *et al.*, (2022) reviewed that substitution of energy ingredients in starch-deficient ruminant diets, such as lipids, affects microbial protein synthesis (Palmquist and Jenkins, 2017), resulting in a decreased supply and absorption of amino acids in the duodenum, which are required for the formation of milk protein (Petit, 2003). However, it is possible that milk protein is reduced by the relative decrease in ruminal microorganisms (Mahdavi *et al.*, 2009; Leduc *et al.*, 2017), caused by the presence of UFA in the rumen (Ye *et al.*, 2009), which are the main components of the FA structure of the evaluated oilseeds, also, may that the omega-3 group had a lower amount of meal intake than other groups.

As shown in Table 4, there was no noticeable change in milk lactose content (%) in cows fed omega-3 or omega-6 sources vs. control. However, milk lactose yields increased (P<0.05) by 29.17 and 13.89 % with feeding omega-3 and omega-6 sources, respectively. Research has shown inconsistent effects of different forms of flaxseed on milk lactose concentrations, varying from no impact to a slight, but significant increase under different experimental conditions (Leduc *et al.*, 2017) such as, production systems. In agreement with these findings, some studies recorded a similar milk lactose (%), whereas lactose yield was greater or not changed with different forms of flaxseed and sunflower seeds supplementation in the diets

(Ali *et al.*, 2019; Lopes *et al.*, 2020; Musco *et al.*, 2022; Sun *et al.*, 2022 ; Beauregard *et al.*, 2023; Patel *et al.*, 2023; Bhavsar *et al.*, 2023).

The percentage of solids not fat (SNF) as shown in Table 4, were decreased (P< 0.05) for cows fed omega-3 or control diets comparing with those fed omega-6 diet (8.23 and 8.60 vs. 8.90, respectively). Such a decrease in SNF for cows fed omega-3 or control diets likely reflects – the decrease in protein content, which directly affect its percentage. In accordance to the present results, Al-Saiady *et al.*, (2024) observed that lactating dairy cows fed extruded flaxseed had lower (P < 0.05) SNF values than those fed control diet. However, non-significant effect of flaxseed on milk SNF has been reported in other studies (Schossow, 2019; Vargas-Bello-Pérez *et al.*, 2020; Huang *et al.*, 2022; Bhavsar *et al.*, 2023)

Nutrient digestibility and feeding value:

The obtained results indicated that most nutrient digestibility (DM, OM, EE, and NFE) were significantly (P<0.05) higher for cow's fed omega-3 ration than those fed omega-6 or control rations (Table 5). Meanwhile, there were no significant differences in DM, OM, CP, EE and NFE digestibility between omega-6 vs. control. However, CF digestibility was significantly increased (P<0.05) for cow's fed omega-6 ration compared to those fed omega-3 or control rations. Moreover, there were no significant differences in CP digestibility among the experimental rations. Nutritive values as TDN and DCP were significantly improved (P<0.05) for cow's fed omega-3 rations compared to those fed omega-6 or control rations (Table 5).

Table (5): Nutrient digestibility coefficients, nutritive values and rumen parameters of Holstein dairy cows fed on rations containing omega-3 or omega-6 fatty acids.

Parameters	Control	Omega-3	Omega-6	SE
Nutrients digestibility (%)				
DM	65.00[b]	68.00[a]	66.10[b]	0.50
OM	67.12[b]	70.00[a]	68.36[b]	0.39
CP	67.66	68.00	67.55	0.86
CF	66.10[b]	67.16[b]	70.00[a]	0.44
EE	70.00[b]	78.00[a]	70.30[b]	2.09
NFE	71.10[ab]	72.95[a]	68.56[b]	1.10
Nutritive value (%)				
TDN	63.00[b]	66.10[a]	64.00[b]	0.68
DCP	8.80[ab]	9.33[a]	8.63[b]	0.20
Ruminal parameters				
Ruminal pH	6.40	6.70	6.76	0.21
NH_3-N, mg/ 100ml	15.36	16.53	15.00	0.72
TVFA's meq/100 ml	11.27[b]	9.00[c]	15.00[a]	0.96

a and b, means within the same row having different superscripts significantly different (P<0.05).*

The improvement in nutrient digestibility for cow's fed omeg-3 diet may be due to the oil released slowly when oil seeds exposed to rumen digestion, which effects on DMI, fiber digestibility and passage rate. Also, may due to flaxseeds are characterized by their small, flat and oval-shaped (2×5 mm), thus, it has a higher possibility of escaping from mastication as well as increased its passage rate from the rumen. Moreover, the flaxseed fat content is protected by the seed coats which make a kind of protection for its content of oils and bypass to intestinal degraded by lipase enzymes without any adverse effect on rumen microorganisms (Brask *et al.*, 2013, Zagorakis *et al.*, 2015), leading to negligible effect on the digestion of fibers while promoting feed intake and increase the energy content of the diet (Kim *et al.*, 2004). Furthermore, flaxseeds are rich in unsaturated fatty acids content which, usually, have higher digestibility compared to saturated fatty acids (Palmquist and Mattos, 2006). The results of this work are in agreement with Shaarawy *et al.*, (2018) who reported that adding safflower or sunflower seeds (omega-6 sources) to Friesian dairy cow's diet tended to increase (P<0.05) digestibility of all nutrients compared to those fed control ration except for NFE digestibility.

Ruminal parameters:

The effects of omega-3 or omega-6 supplementation in dairy cow's diets on ruminal pH, ammonia-N, and total VFA concentrations under summer season condition are shown in Table5. The pH and NH3-N concentration were not significantly different among treatments, the pH values ranged from 5.75 to 7.30 and NH3-N concentration ranged from 5.00 to17.65 mM indicated that these values were within the normal conditions to support rumen microbial growth and fermentation (Satter and Slyter, 1974; McDonald *et al.*, 2011). In this respect many authors documented that ruminal fermentation as measured by Ruminal pH and NH3-N were unchanged (P>0.05) by temperature Kang et al (2019) or flaxseed supplementation (Pi *et al.*, 2019; Huang *et al.*, 2021; Al-Saiady *et al.*, 2024; Ghedini *et al.*, 2024). The present results confirm that the inclusion of omega-3 sources in the basal diet has no effect on rumen function (Al-Saiady *et al.*, 2024). On the other hand, the ruminal TVA's concentration was significantly (P<0.05) higher for cow's fed omega-6 compared to those fed control or omega-3 diet (Table 5). The presence results are confirmed by Shaarawy *et al.* (2018) and Morsy *et al.* (2015) who stated that TVFA´s concentration was higher when dairy cows fed on whole sunflower seeds. The depression of ruminal VFAs under hot conditions with omega-3 diet resulted from greater EE digestibility, VFA metabolism and utilization from arterial blood (Martz *et al.*, 1971).

CONCLUSION

Cows fed sources of omega-6 and omega-3 fatty acids had a greater DMI compared with those fed control diet, which resulted in enhanced milk production. Moreover, milk yield (kg) or (FCM and ECM) was higher for cows fed omega-3 and omega-6 than control group. In addition, most nutrient digestibility and nutritive values were enhanced with cows fed on omega-3. Cows fed treatment diets had no harmful effect on liver enzymes, which may contribute to enhancing the health status of dairy cows. Present results could be suggest that ruminal bio-hydrogenation degree of fat in diet differed according to fat source so, most of them need to protect before feeding.

RECOMMENDATIONS

Fat sources should be protected before use in rations to prevent their components from saturation or being changed in the rumen. Also, Future studies should be directed to identify fatty acids in fat milk and the direct effects of fat sources supplementation on the ruminal microbiome diversity.

REFERENCES

Ali, M. A.; M. Sh. Thabet and E. M. Ibrahim (2019): Effects of flaxseed oil supplementation to lactating goats diet on milk production, composition and fatty acids profiles. Al-Azhar Journal of Agricultural Research V. (44) No. (2) December (2019) 66-78.

Al-Saiady M; T. Al-Shaheen; A. El-Waziry and A. Mohammed (2024): Effects of extruded flaxseed and Salmate® inclusion in the diet on milk yield and composition, ruminal fermentation and degradation, and kinetic flow of digesta and fluid in lactating dairy cows in the subtropics, Veterinary World, 17(3): 540–549.

AOAC (2003): International. Official Methods of Analysis, 17th ed.; AOAC International: Gaithersburg, MD, USA.

Beauregard, A.; M.-P. Dallaire; R. Gervais and P.Y. Chouinard (2023): Lactational performance of cows fed extruded flaxseed in commercial dairy herds. animal - open space 2 100043

Behan, A.A., Loh, T.C., Fakurazi, S., Kaka, U., Kaka, A., Samsudin, A.A. (2019) Effects of supplementation of rumen protected fats on rumen ecology and digestibility of nutrients in sheep. Animals, 9 (7): 400.

Bhavsar, M. Y.; P. R. Pandya; Y. G. Patel; S. V. Shah and P. P. Bhavsar (2023): Effects of Feeding Flaxseeds and Rapeseeds on Milk Fatty Acid Composition in Crossbred Dairy Cattle. Ind J Vet Sci and Biotech. 19(1), 51-56.

Brask, M.; P. Lund; M. R. Weisbjerg; A. L. F. Hellwing; M. Poulsen; M. K. Larsen and T. Hvelplund (2013): Methane production and digestion of different physicalforms of rapeseed as fat supplements in dairy cows J. Dairy Sci., 96 :2356–2365.

Brondel, L.; D. Quilliot; T. Mouillot; N. A. Khan; P. Bastable; V. Boggio; C. Leloup and L. Pénicaud (2022): Taste of Fat and Obesity: Different Hypotheses and Our Point of View. Nutrients, 14, 555. [CrossRef] [PubMed]

Brossillon, V.; S. F. Reis; D. C. Moura; J. G. B Galvão; A. S. Oliveira; C. Côrtes and A. F. Brito (2018): Production, milk and plasma fatty acid profile, and nutrient utilization in Jersey cows fed flaxseed oil and corn grain with different particle size. J. Dairy Sci., 101, 2127–2143. [CrossRef]

Brzozowska, A. M.; P. Micek; B. Kuczynska; M. Lukaszewicz; J. M. Oprzadek (2018): Corrigendum to: The use of energy-protein supplement increases performance of high-yielding dairy cow's and improves health-promoting properties of milk. Anim. Prod. Sci. **2018**, 58, 1766. [CrossRef]

Chooi, Y.C.; C. Ding and F. Magkos (**2019):** The epidemiology of obesity. Metabolism, 92, 6–10. [CrossRef] Conway, E.H. (1957): Micro diffusion analysis and volumetric error.5th Ed. Crosby Lockwood and Sons Ltd., London.

De Souza, S.M.; F. C. F. Lopes; S. D. C. Valadares Filho; M. A. S. Da Gama; L. N. Renno and J. P. P. Rodrigues (2019). Milk fatty acid composition of Holstein x Gyr dairy cow's fed sugarcane-based diets containing citrus pulp supplemented with sunflower oil. Semina. Ciencias Agrarias. 40(4): 1663-1680.

Diesel, B., Kulhanek-Heinze, S., Höltje, M., Brandt, B., Höltje, H. D., Vollmar,m A. M., *et al.* (2007). a-lipoic acid as a directly binding activator of the insulin receptor: protection from hepatocyte apoptosis. Biochemistry 46, 2146–2155. doi: 10.1021/bi602547m

Duncan, D.B. (1955). Multiple Ranges and Multple F-Test. Biometics, 11: 1-42.

El-Ganainy, M. M. Shahira; Shams, A. Sh.; Kandial, M. H. H.; Badr, M. M. Azza; (2023). Milk production and milk fatty acid profile as a response to feeding dairy cows with flax products during the persistence period J Anim Physiol Anim Nutr. 2023; 107:1187–1197.

EL-Garhi M.S. ; Fadel, M.S.; Manal B. Mahmoud and Mansour, A.M.(2018) Effect of long chain fatty acids on the production and reproductive immunity of Holstein dairy cows Assiut Vet. Med. J. Vol. 64 No. 156 January, 18-25.

Esmaeili V.; A. H. Shahverdi; A. R. Alizadeh; H. Alipour and M. Chehrazi (2014): Saturated, omega-6 and omega-3 dietary fatty acid effects on the characteristics of fresh, frozen-thawed semen and blood parameters in rams. *Andrologia* 46:42–49.

Garcia-Ispierto, I., F. Lopez-Gatius, P. Santolaria, J. L. Yaniz, C. Nogareda, M. Lopez-Bejar, and F. De Rensis. (2006). Relationship between heat stress during the peri-implantation period and early fetal loss in dairy cattle. Theriogenology 65:799–807.

Ghasemi, E.; D. Golabadi and A. Piadeh (2021): Effect of supplementing palmitic acid and altering the dietary ratio of n-6 : n-3 fatty acids in low-fibre diets on production responses of dairy cows. British Journal of Nutrition, 126, 355–365

Ghedini C. P.; L. H. P. Silva; D. C. Moura and A. F. Brito (2024): Supplementing flaxseed meal with sucrose, flaxseed oil, or both: Effects on milk enterolactone, ruminal microbiota profile, production performance, and nutrient utilization in dairy cows. J. Dairy Sci., 107:6834–6851 https://doi.org/10.3168/jds.2024-24649

Go´mez-Corte´s P.; A. Cı´vico; M. A. de la Fuente; N. Nu´ ñez Sa´nchez; M. Jua´rez; F. Peña Blanco; *et al.*(2018): Quick changes of milk fatty acids after inclusion or suppression of linseed oil in the diet of goats. J. Sci., Food Agric., 98: 5269–5277. https://doi.org/10.1002/jsfa.9065 PMID: 29652436

Goring, H.K. and P. J. Van Soest (1970). Forage fiber analysis USDA. Agricultural hand book No. 379.

Hirahatake, K.M.; A. Astrup; J. O. Hill; J. L. Slavin; D. B. Allison; K. C. Maki (2020): Potential Cardiometabolic Health Benefits of Full-Fat Dairy: The Evidence Base. Adv. Nutr., 11, 533–547. [CrossRef]

Huang G.; L. Guo; X. Chang; K. Liu; W. Tang; N. Zheng; S. Zhao; Y. Zhang and J. Wang (2021): Effect of Whole or Ground Flaxseed Supplementation on Fatty Acid Profile, Fermentation, and Bacterial Composition in Rumen of Dairy Cow's. Front. Microbiol. 12:760528. doi: 10.3389/fmicb.2021.760528

Huang, G.; J. Wang; K. Liu; F. Wang; N. Zheng; S. Zhao; X. Qu; J. Yu; Y. Zhang and J. Wang (2022): Effect of Flaxseed Supplementation on Milk and Plasma Fatty Acid Composition and Plasma Parameters of Holstein Dairy Cows. Animals, 12, 1898. https://doi.org/10.3390/ani12151898

Kabeya, N.; M. M. Fonseca; D. E. K. Ferrier; J. C. Navarro; L. K. Bay; D. S. Francis; D. R. Tocher; L. F. C. Castro and Ó. Monroig (2018): Genes for de novo biosynthesis of omega-3 polyunsaturated fatty acids are widespread in animals. Sci., Adv., 4, r6849. [CrossRef] [PubMed]

Kang, H.J.; Piao, M.Y.; Park, S.J.; Na, S.W.; Kim, H.J.; Baik, M. Effects of heat stress and rumen-protected fat supplementation on growth performance, rumen characteristics, and blood parameters in growing Korean cattle steers. Asian Aust. J. Anim. Sci. 2019, 32, 826–833.

Kim C.M.; J. H. Kim; T. Y. Chung and K. K. Park (2004): Effects of Flaxseed Diets on Fattening Response of Hanwoo Cattle: 2. Fatty Acid Composition of Serum and Adipose Tissues. J. Anim. Sci., 17(9), 1246-1254.

Kim, J. H.; Y. Kim; Y. J. Kim and Y. Park (2016): Conjugated linoleic acid: Potential health benefits as a functional food ingredient. Annu. Rev.Food Sci., Technol., 7, 221–244. [CrossRef]

Kumar, D., De, K., Shekhawat, I., Bahadur, S., Balaganur, K. and Naqvi, S.M.K. (2019) Combined effect of heat and nutritional stress on superovulation of Malpura ewes in a semi-arid region. J. Therm. Biol., 80: 158–163.

Leduc, M.; M. P. Létourneau-Montminy; R. Gervais and P. Y. Chouinard (2017): Effect of dietary flax seed and oil on milk yield, gross composition, and fatty acid profile in dairy cows: A meta-analysis and meta-regression. Journal Dairy Science 100, 8906–8927.

Lopes, F.C.F., de Souza, S.M., Valadares Filho, S.D.C., da Gama, M.A.S. and Renno, L.N. (2020). Ruminal parameters and fatty acid composition of omasal digesta and milk in cows fed sugarcane-based diets supplemented with sunflower oil. Semina: Ciencias Agrarias. 41**:** 2317-2334.

Mahdavi, A.; B. Darabighane; A. Mead and M. R. Lee (2009): Effects of soybean oil supplement to diets of lactating dairy cows, on productive performance, and milk fat acids profile: A meta-analysis. Ital. J. Anim. Sci., 18, 809–819. [CrossRef]

Marino, R.; A. della Malva; M. Caroprese; P. de Palo; A. Santillo; A. Sevi and M. Albenzio (2019): Effects of whole linseed supplementation and treatment duration on fatty acid profile and endogenous bioactive compounds of beef muscle. Animal, 13, 444–452. [CrossRef]

Martz FA, Mishra M, Campbell JR, Daniels LB, Hilderbrand E. (1971). Relation of ambient temperature and time postfeeding on ruminal, arterial and venous volatile fatty acids, and lactic acid in Holstein steers. J Dairy Sci;54:520-5.

McDonald, P.; R. A. Edward; J. F. D. Greenhalgh; C. A. Morgan; L. A. Sinclair and R. G. Wilkinson (2011): Animal Nutrition 7th Ed. Pierson Education Ltd, Harlow.http://gohardanehco.com/wpcontent/uploads/2014/02/Animal-Nutrition.pdf

Meignan, T.; C. Lechartier; G. Chesneau and N. Bareille (2017): Effects of feeding extruded linseed on production performance and milk fatty acid profile in dairy cow's: A meta-analysis. J. Dairy Sci., 100, 4394–4408. [CrossRef]

Moallem, U.; H. Lehrer; L. Livshits, and M. Zachut (2020): The effects of omega-3 α-linolenic acid from flaxseed oil supplemented to high-yielding dairy cows on production, health, and fertility. Livestock Science, 242, 104302.

Mohammed A.A; Al-Shaheen, T.; Al-Saiady, M.; and El-Waziry, A.; (2024) Effect of Dietary Source of Omega-3 Fatty Acids on Milk Production, Fatty Acid Profiles and IGF-1of Lactating Dairy Cows in Arid Subtropics. Pakistan J. Zool., vol. 56(5), pp 2319-2326.

Morsy, T.A.; S.M. Kholif; A.E. Kholif; O.H. Matloup; A.Z.M. Salem and A. Abu Elella (2015). Influence of sunflower whole seeds or oil on ruminal fermentation, milk production, composition, and fatty acids profile in lactating goats. Asian Australas. J. Anim. Sci., 28(8): 1116 -1122.

Mughetti, L.; F. Sinesio; G. Acuti; C. Antonini; E. Moneta; M. Peparaio and M. Trabalza-Marinucci (2012): Integration of extruded linseed into dairy sheep diets: Effects on milk composition and quality and sensorial properties of Pecorino cheese. Anim. Feed Sci., Technol., 178, 27–39. [CrossRef]

Musco, N.; R. Tudisco; G. Esposito; P. Iommelli; P. Totakul; B. D'Aniello; P. Lombardi; R. Amato; M. Wanapat and F. Infascelli (2022): Effects of Linseed Supplementation on Milk Production, Composition, Odd- and Branched-Chain Fatty Acids, and on Serum Biochemistry in Cilentana Grazing Goats. Animals, 12, 783. https://doi.org/10.3390/ani12060783

Nanas, I.; S. Dokou; L. V. Athanasiou; E. Dovolou; T. M. Chouzouris; S. Vasilopoulos; K. Grigoriadou; I. Giannenas and G. S. Amiridis (2023): Feeding Flaxseed and Lupins during the Transition Period in Dairy Cows: Effects on Production Performance, Fertility and Biochemical Blood Indices. Animals, 13, 1972. https://doi.org/ 10.3390/ani13121972

NRC,(2001): National Research Council, Nutrient Requirements of Dairy Cattle. 7th ed. Natl. Acad. Sci., Washington, DC.

Oliveira, M. X. S.; A. S. V. Palma; B. R. Reis; C. S. R. Franco; A. P. S. Marconi; F. A. Shiozaki; L. G. Reis; M. S. V. Salles and A. S. Netto (2021): Inclusion of soybean and linseed oils in the diet of lactating dairy cow's makes the milk fatty acid profile nutritionally healthier for the human diet. PLoS ONE, 16, e0246357. [CrossRef]

Palmquist D.L. and W. R. S. Mattos (2006): Metabolismo de lipídeos. In: BERCHIELLI, T. T. Nutrição de ruminantes. Jaboticabal: FUNEP, pp. 287-310.

Palmquist, D.L. and T. C. Jenkins (2017): A 100-Year Review: Fat feeding of dairy cows. J. Dairy Sci., 100, 10061–10077. [CrossRef] [PubMed]

Patel, J. R.; S. S. Patil; M. M. Pawar; Y. M. Gami; J. P. Gupta; H. D. Chauhan; S. H. Raval and C. P. Modi (2023): Effect of Sunflower Oil Supplementation on Milk Production, Composition, Fatty Acid Profile and Blood Metabolites of Mehsana Buffaloes. Asian Journal of Dairy and Food Research. DOI:10.18805/ajdfr.DR-2039.

Penev, p.; Naydenova, N.; Dimov, D.; and Marinov, I.(2021): Influence of Heat Stress and Physiological Indicators Related to It on Health Lipid Indices in Milk of Holstein-Friesian Cows J. Oleo Sci. 70, (6) 745-755

Perumal, P.; S. Chang; K. Khate; K. Vupru and S. Bag (2019): Flaxseed oil modulates semen production and its quality profiles, freezability, testicular biometrics and endocrinology profiles in mithun. Theriogenology, 136, 47–59. [CrossRef]

Petit, H. V. (2003): Digestion, milk production, milk composition, and blood composition of dairy cow's fed formaldehyde treated flaxseed or sunflower seed. J. Dairy Sci. **2003**, 86, 2637–2646. [CrossRef]

Petit, H. V.; C. Germiquet and D. Lebel (2004): Effect of feeding whole, unprocessed sunflower seeds and flaxseed on milk production, milk composition, and prostaglandin secretion in dairy cow's. J. Dairy Sci., 87:3889–3898

Pi, Y.; L. Ma; H. R. Wang; J. Q. Wang; J. C. Xuand D. P. Bu (2019): Rubber seed oil and flaxseed oil supplementation on serum fatty acid profile, oxidation stability of serum and milk, and immune function of dairy cow's. Asian Australas. J. Anim., 32, 1363–1372. [CrossRef]

Plata-Pérez, G.; J. C. Angeles-Hernandez; E. Morales-Almaráz; O. E. Del Razo-Rodríguez; F. López-González; A. Peláez-Acero; R. G. Campos-Montiel; E. Vargas-Bello-Pérez and R. Vieyra-Alberto (2022): Oilseed Supplementation Improves Milk Composition and Fatty Acid Profile of Cow Milk: A Meta-Analysis and Meta-Regression. Animals, 12, 1642. [CrossRef] [PubMed]

Radwan, S.S. (1978) Coupling of Two Dimensional Thin Layer Chromatography with Gas Chromatography for the Quantitative Analysis of Lipid Classes and Their Constituent Fatty Acids. Journal of Chromatographic Science, 16, 538-542. https://doi.org/10.1093/chromsci/16.11.538

Rego, O.A.; S. P. Alves; L. M. S. Antunes; H. J. D. Rosa; C. F. M. Alfaia; J. A. M. Prates; A. R. J. Cabrita; A. J. M. Fonseca; R. J. B. Bessa (2009): Rumen biohydrogenation-derived fatty acids in milk fat from grazing dairy cow's supplemented with rapeseed, sunflower, or linseed oils. J. Dairy Sci., 92, 4530–4540. [CrossRef]

Rodríguez, R.; D. Alomar; and R. Morales (2020): Milk and meat fatty acids from sheep fed a plantain–chicory mixture or a grass-based permanent sward. Animal., 14 (5): 1102-1109. https://doi.org/10.1017/S1751731119002611

Saini, R. K. and Y. Keum (2018): Omega-3 and omega-6 polyunsaturated fatty acids: Dietary sources, metabolism, and significance-A review. Life Sci., 203, 255–267. [CrossRef] [PubMed]

Salles, M. S.V.; L. F. D'Abreu; L. C. R. Júnior; M. C. César; J. G. L. Guimarães; J. G. Segura; C. Rodrigues; M. A. Zanetti; K. Pfrimer and A.S. Netto (2019): Inclusion of Sunflower Oil in the Bovine Diet Improves Milk Nutritional Profile. Nutrients, 11, 481. [CrossRef]

Sammad, A., Wang, Y. J., Umer, S., Lirong, H., Khan, I., Khan, A., *et al.* (2020). Nutritional physiology and biochemistry of dairy cattle under the influence of heat stress: consequences and opportunities. Animals 10:793. doi: 10.3390/ani10050793

SAS, (2000). SAS/STAT Guide for personal computers, SAS Inst., Cary. N.C., USA.

Satter, L. D., and L. L. Slyter. 1974. Effect of ammonia concentration on rumen microbial protein production in vitro. Br. J. Nutr., 32:199–208.

Schossow, C. (2019): Evaluation of flax oil supplementation on performance of growing dairy heifer calves and lactating cows. Electronic Theses and Dissertations, South Dakota State University, USA

Schwingshackl, L.; G. Hoffmann; A. M. Lampousi; S. Knüppel; K. Iqbal; C. Schwedhelm; A. Bechthold; S. Schlesinger and H. Boeing (2017): Food Groups and Risk of Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis of Prospective Studies. Eur. J. Epidemiol., 32, 363–375. [CrossRef] [PubMed]

Shaarawy A. M.; A. M. Abd El-Hafeez; A. Sh. Shamas; Shahira El-Ganainy and A.M. Bakr: (2018): Ruminal fermentation, milk production, milk composition and reproductive performance of Friesian dairy cows supplemented with safflower or sunflower seeds. Egyptian J. Nutrition and Feeds, 21(2): 319-335

Srour, B.; L. K. Fezeu; E. Kesse-Guyot; B. Allès; C. Méjean; R. M. Andrianasolo; E. Chazelas; M. Deschasaux; S. Hercberg; P.Galan; *et al.* (2019): Ultra-Processed Food Intake and Risk of Cardiovascular Disease: Prospective Cohort Study (NutriNet-Santé). BMJ, 365, l1451. [CrossRef] [PubMed]

Sun, X.; C. Guo; Y. Zhang; Q. Wang; Z. Yang; Z. Wang; W. Wang; Z. Cao; M. Niu and S. Li (2022): Effect of diets enriched in n-6 or n-3 fatty acids on dry matter intake, energy balance, oxidative stress, and milk fat profile of transition cows. J. Dairy Sci. 106:5416–5432 https://doi.org/10.3168/jds.2022-22540

Timon, C.M.; A. O'Connor; N. Bhargava; E. R. Gibney and E. L. Feeney (2020): Dairy Consumption and Metabolic Health. Nutrients, 12, 3040. [CrossRef] [PubMed]

Tyrrell, H.F., and J.T. Reid. 1965. Prediction of the energy value of cow's milk. J. Dairy Sci., 48:1215-1223. http://www.doi.org/10.3168/jds.S0022-0302(65)88430-2

Van Keulen, J. and B.A. Young (1977). Evaluation of acid insoluble ash as a natural marker in ruminant digestibility studies. J. Anim. Sci., 44: 282-287.

Vargas-Bello-Pérez, E.; C. Montes de Oca; N. Salas; J. Flores; J. Bernal; L. Robles-Jimenez and M. Gonzalez-Ronquillo (2020): Productive Performance, Milk Composition and Milk Fatty Acids of Goats Supplemented with Sunflower and Linseed Whole Seeds in Grass Silage-Based Diets. Animals, 10, 1143; doi:10.3390/ani10071143

Vlaicu, P.A.; R. P. Turcu; T. D. Panaite and M. Olteanu (2020): Effect of feeding flax meal on milk fatty acids profiles and performance of Holstein dairy cows. Indian Journal of Animal Sciences 90 (5): 744–748. https://doi.org/10.56093/ijans.v90i5.104618

Warner, A.C.I. (1964). Production of volatile fatty acids in the rumen: methods of measurement. Nutr. Abstr. Rev., 34: 339–352.

Wu, Z. and Hubert, J.T. (1994) Relationship between dietary-fat supplementation and milk protein-concentration in lactating cows - a review. Livest. Prod. Sci., 39: 141–155.

Ye, J.A.; Wang, C.;Wang, H.F.; Ye, H.W.;Wang, B.X.; Liu, H.Y.;Wang, Y.M.; Yang, Z.Q.; Liu, J.X. Milk production and fatty acid profile of dairy cows supplemented with flaxseed oil, soybean oil, or extruded soybeans. Acta Agric. Scand A Anim. Sci. 2009, 59, 121–129.

Zagorakis, K.; Liamadis, D.; Milis, C.; Dotas, V.; Dotas, D. (2015): Nutrient digestibility and in situ degradability of alternatives to soybean meal protein sources for sheep. Small Rumin. Res. 2015, 124, 38–44. [CrossRef]

تخفيف آثار الظروف المناخية بإستخدام مصادر أوميجا 3 أو أوميجا 6 في علائق الأبقار الهولشتين الحلابة

شهيرة محمد محمود الجنايني[1] – أبو القاسم طنطاوي[1] – عبد الر حمن إبراهيم زنوني[1] – فاطمة ابراهيم هدهود[2] – احمد شعبان شمس[3] – المعتز بالله محفوظ شعراوي[3] - عماد الدين محمد ابراهيم[1]

[1]*قسم الإنتاج الحيواني، كلية الزراعة، جامعة المنيا، مصر.*

[2]*قسم علوم الألبان، المركز القومي للبحوث، الدقي، الجيزة، مصر.*

[3]*معهد بحوث الإنتاج الحيواني، مركز البحوث الزراعية، وزارة الزراعة، مصر.*

يمثل إنتاج الحليب الصحي في ظل ظروف حرارة المناخ تحديًا هائلاً في صناعة الألبان العالمية. تهدف هذة الدراسة إلى تقييم إنتاج اللبن ومعاملات الهضم لأبقار الهولشتين الحلابة خلال فترة ارتفاع درجات الحرارة نتيجة لتغذيتها على مصادر للأوميجا 3 أو الأوميجا 6. تم تقسيم خمسة عشر بقرة متعددة الولادات (30 يومًا في الحليب) إلى ثلاثة مجموعات متساوية (5 أبقارفي كل منها) تبعا لإنتاجها من اللبن وأوزان الجسم وموسم الولادة باستخدام تصميم تام العشوائية. غذيت المجموعه الأولى على العليقة الأساسية (الكنترول) وتم امداد المجموعة الثانية بــ 10 ٪ من مصادر الأوميغا 3 (كسب بذور الكتان وبذور الكتان بنسبة 65 : 35 ٪ على الترتيب) بينما غذيت المجموعة الثالثة على 8 ٪ من مصادر الأوميغا 6 (نسب متساوية من بذور القرطم وبذورعباد الشمس). ادت التغذية علي الأوميغا 3 والأوميجا 6 إلى زياده المأكول من المادة الجافة بنسبة 5.6، 8.22 ٪ على التوالي مقارنة بالكنترول. كما حدثت زيادة معنوياً في إنتاج اللبن (P<0.05) للأبقار التى غذيت على الأوميغا 3 والأوميجا 6 بنسبة 23.61 ٪ (3.60 كجم)،.11.48 ٪ (1.75كجم) على التوالي مقارنة بتلك المغذاه على عليقة الكنترول. حدثت أيضا زيادة معنوية (P<0.05) في كلا من انتاج اللبن المعدل لنسبة الدهن، اللبن المعدل للطاقة، نسبة دهن اللبن، نسبة لاكتوز اللبن وكذلك محصول الدهن واللاكتوز في اللبن لأبقار كلا المجموعتين المغذاه على الأوميغا 3 والأوميجا 6 مقارنة بتلك المغذاه على عليقة الكنترول. كان للتغذية على الأوميجا 3 تأثير إيجابي على معاملات هضم المادة الجافة، المادة العضوية والمستخلص الإيثيري كما أدت إلى تحسين القيمة الغذائية للمركبات الكلية المهضومة والبروتين المهضوم. بينما لم يكن للتغذية على الأوميجا 6 أي تأثير على معاملات هضم المادة الجافة، الماده العضوية، البروتين الخام مقارنة بالتغذية على عليقة الكنترول. أظهرت التغذية على الأوميجا 3 ارتفاعاً (P<0.05) في تركيز الامونيا بسائل الكرش بينما انخفضت تركيزات الاحماض الدهنية الطيارة. وبناء على ذلك تقترح هذه الدراسة إمكانية استخدام كلا من الأوميجا 3 والأوميجا 6 كمصادر صحية للدهون في علائق الأبقار الحلابة خلال الظروف المناخية للربيع والصيف مصحوبا بتأثير إيجابي على إنتاج اللبن.