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Effects of Dietary Supplementing *Moringa oleifera* Seeds, Seeds-Cake, and Leaf on The Ovarian Dynamics and Hemodynamics, Blood Biochemicals, and Antioxidant Status in Yearling Fat Tail Ewes

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Abstract

THIS study aimed to explore the effects of supplementing pubertal ewes with moringa seeds, seeds cake and leaves on the ovarian and uterine dynamics and hemodynamics, ovarian hormones, oxidants-antioxidants status, and blood biochemicals. Forty yearling fat-tail ewes were equally divided into four groups. In addition to the basal requirements (control), the moringa seeds cake (MSCG) was fed 7.0 g moringa seed cake, the moringa leaves (MLG) was fed 10.0 g moringa leaves, and the moringa seeds group (MSG) was supplemented 7.0 g moringa seeds. Blood samples and reproductive Doppler ultrasonographic examinations were performed weekly for six weeks. Results displayed increased ovulation rates ($P<0.05$), dominant and subordinate follicle diameters ($P<0.001$), and high estradiol ($P<0.05$) concentration in all moringa-supplemented ewes. MLG and MSG demonstrated lower corpus luteum (CL) diameter than the controls. CL of MSCG exhibited higher ($P<0.001$) color area/ pixel and color area % than controls, MLG, and MSG. MSCG obtained higher ($P<0.001$) ovarian area/pixel and progesterone concentration while MLG had higher ovarian color area /pixel ($P<0.001$) than controls. Ewes supplemented with MSCG presented the lowest ($P<0.05$) ovarian artery peak systolic velocity (PSV), end-diastolic velocity (EDV), time average mean velocity (TAMV), mean velocity (Mean V), resistance index (RI), pulsatility index (PI), and blood flow volume (BFV) that associated lower ($P<0.001$) uterine artery PSV, EDV, TAMV, Mean V, and BFV. Total cholesterol, LDL, urea, and AST reached minimum ($P<0.001$) values whereas HDL, globulin, and creatinine reached the highest value ($P<0.001$) in ewes supplemented with MSG. All treated ewes displayed lower ($P<0.001$) MDA and higher NO and SOD levels than controls. Ewes of MSCG had the highest ($P<0.001$) catalase and GSH activities. In conclusion, *Moringa oleifera* can be supplemented to yearling ewes to improve their productive and reproductive performance.

Keywords: Moringa, dietary supplementation, ovarian-uterine hemodynamics, ovulation rate, ewes.

Introduction

The need to develop new economic nutrients for humans and animals is increasing. *Moringa oleifera* is one of the trees that can be included in human and animal nutrients [1]. Supplementing the leaves, seeds, oil, flowers, and roots of *Moringa oleifera* is beneficial for humans [2], rabbits [3,4], goats [5], West African dwarf goats [6], dairy cows [7], rams [8], and ewes' health [9], due to their nutritional and therapeutic potentials [10,11]. Humans and animals can safely consume all parts of the Moringa tree [11,12]. The high phenolic content of Moringa leaves showed potent antioxidant properties by directly trapping the free radicals or by chelating metals [13].

Feeding lactating ewes or goats with a Moringa leaf diet improved milk yield, increased milk fat, lactose, and solid-not-fat, decreased glucose, total cholesterol, and lipid peroxidation, increased catalase activity and total antioxidants, and improved their kid's average daily gain [9]. In Najdi ewes, when 25% of either *Moringa oleifera* or *Moringa peregrina* leaf diets were fed as a supplement to the alfalfa hay diet, *Moringa oleifera* increased milk yields and improved its composition, decreased lipid peroxidation, increased catalase and antioxidants capacity [14]. In lactating Nubian goats, increased Moringa leaf extract from 10 to 40 ml increased nutrient intake, dry matter, organic matter, fiber digestibility, serum albumin, and glucose while the

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total cholesterol was decreased [15]. In dairy cows, Moringa seeds added to the total mixed ration increased milk yield by 1.91% and milk fat by 0.26%, decreased milk proteins by 2.28%, and milk antioxidant activity by 20% [16]. Though the replacement of 25% of alfalfa hay and 50% of maize silage with Moringa did not influence either milk yield or blood serum biochemical in dairy cows, the replacing 50% of alfalfa and 100% of maize silage with Moringa lowered serum total cholesterol, high-density lipoprotein, and low-density lipoprotein and increased serum of urea concentrations [17].

Regarding the effects of Moringa on the reproductive performance of female livestock, several researches were conducted on female mice [18], and rabbits [19]. Another study was made on Barki ewes, which were supplemented with Moringa seed aqueous extract [20]. Meanwhile, ewes supplemented with 15% Moringa leaves of their concentrates [21], without focusing on the follicular and ovarian dynamics or the uterine or ovarian blood flows.

Ovarian and uterine dynamics and hemodynamics have been studied in ewes-supplemented polyunsaturated fatty acids [22], L-carnitine [23], insulin sanitizing drug [24], but not studied in ewes supplemented with Moringa leaves, seeds, or seed cake. Therefore, the current study aimed to study the effects of supplementing Moringa seeds, seed cake, and leaves on the ovarian and uterine dynamics and hemodynamics, ovarian hormones, blood serum biochemical, and oxidants-antioxidant status in cycling pubertal ewe-lambs during the winter season.

Material and Methods

This study was approved by the Animal Care and Use Committee of the Faculty of Veterinary Medicine Cairo University (Vet CU 18042024936).

Moringa leaves, seeds and seed cake were purchased from the National Research Center (Moringa Products public office) after extracting seed oil by using the squeezing mechanical cold press method.

Animal housing and management

The study was conducted from November 2023 to February 2024 at the research farm of the Faculty of Agriculture (EL-Azhar's University, Cairo). Yearling pubertal fat tail ewes (N=40) with average body weight (30.0 kg ± 2.5 kg) were housed in semi-open yards under natural daylight and temperature. Ewes were fed their maintenance requirements of pelleted concentrate according to NRC [25] containing 14% crude protein, 2% lipids, 15% crude Fiber, and 9.0% ash, in addition to hay and wheat straw. Fresh water and mineral licks were available *ad libitum*.

Complete clinical, cardiovascular, gynecological, and ultrasonography examinations were done for each female to ensure the absence of pregnancy and any abnormalities related to the reproductive tract before conducting the research and to include healthy and sound animals. The animals were regularly vaccinated and dewormed before the beginning of the experiment.

Experimental design

Ewes were equally divided into four groups. Control ewes were fed the basal maintenance diet. Besides the maintenance diet, the Moringa seed cake group (MSCG) was supplemented daily with 10.0 g Moringa seed cake/animal for 45 days [26]. Moringa leaves group (MLG) was supplemented daily with 10.0 g Moringa leaves/animal [20]. Moringa seeds group (MSG) was supplemented daily with 7.0 g seeds/animal [27]. Ewes were allowed to adapt dietary treatments for the first 17 days before starting the experiment [26].

Determination of ash

For determining ash percentage [28], a 3.0 g sample of dry powdered (at105 Co for 24 h.) was collected in the crucible, and the preaching of the sample was performed by placing the crucible in a muffle furnace maintained at 300□C for 3 h. The temperature of the ashing was increased to 600 Co for 9 h. The crucible was then cooled, kept in a desiccator for some time, and weighed. The percentage of ash was calculated based on the recorded weights.

Calculation:

The percentage of ash was calculated using the following formula:

Weight of ash = (Weight of crucible + ash) - weight of crucible

% Ash = Wt. of ash/ Wt. of sample X100

Determination of crude fat

Crude fat was determined in the dry matter of Moringa seed cake as A.O.A.C. method [29].

Determination of Protein

The total nitrogen percentage in dray matter seed cake using the modified micro Kjeldahl methods [30], and total protein % was calculated by multiple total N × 6.25.

Determination of Carbohydrates

The approximate analysis of carbohydrate content was determined according to [31].

Estrous synchronization:

After adaptation time, ewes in control and treated groups were subjected to estrous synchronization using an intravaginal sponge (Day 0, synchro vet 45 mg ® for 6 days and injected intra vulvo-submucosally [32, 33], with 2.5 mg of Dinoprost

tromethamine (Lutalyse, Zoetis, Belgium SA) on day of sponge removal [34].

Ultrasonography and Doppler examination:

Ovarian structures of all ewes were monitored using real-time ultrasonography, B-mode, diagnostic scanner equipped with 12.0 MHz linear array real-time B-mode trans-rectal (Sono Vet R3, Samsung Madison, South Korea) to determine the number, diameter, and position of the follicles (F) and corpora lutea (CL) on both ovaries [35]. The ovarian follicles were categorized into small (2 to ≤ 2.9 mm), medium (≥3–≤4.9 mm), and large-sized (≥ 5 mm) follicles [36, 37]. The largest diameter follicle is considered the dominant and the second largest one is considered the subordinate. Follicles with diameters < dominant and subordinate are considered small growing follicles. The numbers of CL were counted and their diameters were measured [38]. Ultrasonography color Doppler mode was used to determine the vascularization within the ovaries (Fig. 1A), corpus luteum (Fig. 1A,B), ovarian follicles (Fig. 1C,D), and the uterus (Fig. 1F). Pulsed-wave Doppler mode was used to assess the blood flow velocity of the uterine (Fig. 1E) and ovarian arteries [39].

Blood sampling collection:

After each ultrasonography examination blood samples (5.0 ml) were withdrawn from the jugular vein into plain as well as anticoagulant vacuum tubes. Sera and plasma were harvested after centrifuging blood samples at 3000 rpm for 15 min. Sera and plasma were separated and stored at -20°C till the assessment of circulating ovarian hormones and antioxidants.

Hormonal and blood biochemical analysis

Progesterone and estradiol hormones were assayed using a commercial ELISA kit (Monocent, Monocent Inc USA - California). For progesterone, the range of the assay was between 0.0 ng/mL to 40 ng/mL the sensitivity was 0.045 ng/mL, and intra- and inter-assay variability was 6.81% and 7.25%, respectively. For estradiol, the range of the assay was between 9.7 pg /mL to 200 pg /mL, the sensitivity was 9.714 pg/mL, and intra- and inter-assay variability were 6.86% and 5.59%, respectively. Glutathione reduced (GSH), catalase, superoxide dismutase (SOD), malondialdehyde (MDA), nitric oxide (NO), total antioxidants capacity (TAC), proteins, albumin, urea, creatinine, Aspartate transaminase (AST), Alanine aminotransferase (ALT), total cholesterol, low-density lipoproteins (LDL), and high-density lipoproteins (HDL) were assayed using the colorimetric diagnostic kits (Biodiagnostics, Egypt).

Image analysis

Images of the ovarian follicles and corpora lutea were subjected to image analysis using Photoshop CC. The area, and perimeter (circumference) of the ovaries, follicle, and corpus luteum were estimated using the magnetic lasso tool. The color area % of ovaries were calculated by dividing the color area by the area in pixels.

Statistical analysis

The data were presented as means ± SEM (standard error of the mean). Statistical analysis was carried out using the SPSS program, version 26 [40]. Simple One-Way ANOVA to study the effect of treatments on ovarian, uterine, and circulating parameters. Duncan's Multiple Range test was used to differentiate between significant means at $P<0.05$ [41].

Results

Moringa seed cake contains the highest ($P<0.001$) total proteins and the lowest ($P<0.001$) oil contents (Table 1). Moringa leaves contain the highest ($P<0.001$) carbohydrates, ash, and the lowest ($P<0.001$) total proteins. Moringa seeds contain the highest oil ($P<0.001$) and the lowest ($P<0.001$) ash and carbohydrates (Table 1).

The ovulation rate (Table 2) of ewes with Moringa cake (MSCG) (1.23±0.06) was significantly higher ($p< 0.05$) than the control (1.00±0.00), and seeds supplemented (MSG) group (1.08±0.04). MSCG ewes had an insignificantly higher number of dominant follicles. The significantly larger dominant follicles ($P<0.001$) were obtained in the three treated groups than control. Ewes in MSCG had a significantly larger ($P<0.001$) subordinate follicle diameter than control and MSG groups (Table 2). The diameter of small follicles (SFD) which were smaller than dominant and subordinate follicles were significantly higher ($P<0.001$) in MSCG ewes than in control and the other treated groups. The diameter ($P<0.001$) of all average follicle populations (Av F.) and circumference were significantly ($P<0.001$) larger in all supplemented groups than in the control. The significantly highest diameter and circumference were noticed in MSCG ewes (Table 2). Follicles of all supplemented groups had significantly higher area ($P<0.001$) and perimeter ($P<0.001$) than controls. Follicles of ewes supplemented with Moringa seeds showed the highest circulatory % ($P<0.05$). All supplemented ewes showed the highest ($P<0.05$) estradiol concentrations compared to the control.

Regarding the corpus luteum (Table 3), control ewes showed a significantly higher diameter/mm, circumference/mm, area/cm2, and perimeter/pixel than all treated groups ($p<0.001$). Ewe in MLG showed lower CL area/cm2 (2.31±0.11) and CL perimeter/pixel (231.3±11.4) than control. From Table 3, we noticed that control ewes and MSG showed a significant ($P<0.05$) lower CL. Color

area/pixel and CL. color area % than other treated groups. Meanwhile, the significantly lowest CL circulatory% (82.29±1.26) was observed in control ewes only (P<0.05) also the ovarian area/pixel was lower in the control group (P<0.001) than those of the supplemented groups. Neither ovarian color area/pixel nor ovarian color area % varied greatly between the control and supplemented groups (Table 3). Ewes supplemented with MSCG tended to have high progesterone concentrations compared to controls, MLG, and MSG.

The peak systolic velocity (PSV) of the ovarian artery (OVA) reached the minimum (P<0.001) value in ewes supplemented with MSC, followed by the control group (table 4). Both groups supplemented with ML or MS showed the significantly highest level of PSV (P<0.05). From Table 4, the end-diastolic velocity (EDV) cm/s and the mean velocity of the ovarian artery were the significantly highest values (P<0.05) in ewes supplemented with Moringa seeds (14.02±0.69&18.49±1.31, respectively). The time average mean velocity (TAMV) tended to significantly decrease (P<0.05) in ewes supplemented with MSC (7.07±0.37) while the highest value was reported in MSG (9.62±0.94). A non-significant decrease in the resistance index (RI) of the ovarian artery can be observed in ewes supplemented with MSC than MLG (table 4). Ewes supplemented with Moringa leaves obtained a significantly higher (P<0.001) pulsatility index (3.36+0.98) than the control and other treated groups. There were no significant differences in the ovarian artery blood flow volume (BFV) between the control and treated groups (table 4).

The uterine color area/ pixel was significantly increased (P<0.05) in all supplemented groups than the control group (Table 4). From Table 4, we noticed that the uterine artery diameter/mm (P<0.05), PSV, TAMV, Mean V., and BFV were significantly (p<0.001) increased in ewes supplemented with Moringa leaves and seeds compared to controls or Moringa seed cake groups. Only, ewes supplemented with Moringa seeds obtained the significantly highest uterine artery EDV (P<0.001) and the significantly lowest RI (P<0.001) and PI (P<0.001).

It can be observed from Table (5) that ewes supplemented with Moringa seeds had the significantly lowest cholesterol (P<0.001), and low-density lipoproteins -Cholesterol (LDL; P<0.001). Ewes supplemented with either Moringa seeds or leaves showed significantly higher high-density lipoproteins -cholesterol (HDL; P<0.001) than controls and those supplemented with Moringa cake (Table 5). Total protein level was significantly higher (P<0.001) in ewes supplemented with MSC, followed by MSG than controls and MLG. There were no significant variations detected in albumin concentrations in all experimental groups of this study. The globulin concentration was significantly higher (1.87±0.03) in ewes supplemented with MS than control and other treated groups (P<0.001). From Table 4, we noticed a significantly higher concentration of urea in the control group followed by MSCG than MLG and MSG. Meanwhile, the significantly lowest (P<0.05) creatinine concentration was detected in MLG than in all other groups. Also, table 4 showed that a significantly lower AST (P<0.05) was detected in MLG and MSG than in control and MSCG while the significantly lowest ALT was detected in the control group.

All supplemented groups resulted in significantly lower malondialdehyde (MDA; P<0.001) than the control group (Table 6). Supplemented ewes with Moringa seeds, leaves, and seed cake obtained significantly higher nitric oxide (NO; P<0.001) and superoxide dismutase (SOD; P<0.001) than control. Glutathione reduced (GSH) significantly decreased (P<0.001) in ewes supplemented with MS while it was significantly higher in MLG and MSCG than control and MSG (P<0.001). Ewes supplemented with MSC got the significantly highest (P<0.001) catalase concentrations. The total antioxidant capacity (TAC) tended to reach higher values in ewes supplemented with Moringa leaves (Table 6).

Discussion

Moringa leaves, seeds, oils, and seeds cake have been used in livestock nutrition to improve the health status, feed conversion efficiency, growth performance, and product quality [42]. The nearly similar proteins [43], oil [44], and the lower carbohydrates [45], and carotenoids [43], in Moringa leaves or the decrease of proteins [46], and similar values of oils [47], and carbohydrates [48], in the seeds compared to the lower values reported in the leaves [43,44,49] or in the seeds [44,48] than the seeds or leaves used in the current experiment can be referred to the difference in the growth environment, stage of harvest, soil type and method of processing [42]. The composition of Moringa seeds and cakes used to supplement ewes in this study is nearly similar to those reported by [50]. However, the higher oil content in our Moringa seed cake could be attributed to separating oil by the squeeze machine, not by oil extraction chemicals [50].

In agreement with the improvement in the ovulation rate and increased follicle growth and the diameters of the ovulating follicles in ewes of the current study there was a study [51] reported that supplementation of Moringa, seeds, cakes, and leaves, Moringa leaf extract improved folliculogenesis. In agreement with the increased ovulation rate in all supplemented groups of this study, the ovulation rate and the number of embryos increased in Avishaan ewes supplemented with dried Moringa leaf for two months during the heat stress months [21]. As well as, moringa leaf meal increased the number of growing ovarian follicles in dairy

cows twenty-one days postpartum [52]. This improvement in folliculogenesis, ovarian and luteal dynamics and hemodynamics could be referred to the increase in the energy value in the group supplemented with seed cake [53], the improvement in body condition score, and the decrease in the subcutaneous fat after supplementing Moringa foliage [54], the improvement in daily gain after supplementing Moringa seed [27], and the improvement in body weight and milk yield in lactating ewes [9, 14]. Similarly, Moringa increased the ovulation rate, twinning, and birth rates in goats [55].

In agreement with the increase in estradiol all ewes supplemented with Moringa seeds, seed cake, and leaves, Moringa powder increased estradiol concentrations [56]. This increase in the estradiol in Moringa-supplemented groups of this study was referred to as the enlargement in the granulosa cells and granulosa layer thickness which is responsible for the synthesis of estradiol [56].

In agreement with the decrease of malondialdehyde (MDA) in the blood serum of all supplemented groups, ewes supplemented with the moringa diet showed lower MDA that was attributed to the high total phenolic content and the antioxidant capacity [9,14]. Though progesterone increased in ewes supplemented with Moringa seed cake and tended to increase in those supplemented with Moringa seeds and leaves, Barki ewes aged 15- 18 months supplemented with moringa leaves for 45 days and their control group obtained lower progesterone than 1.0 ng/ml with no differences between the two groups throughout their study age [20].

The decrease in the total cholesterol in ewes supplemented with Moringa seeds in this study was also reported in Najdi ewes supplemented with the moringa diet for 6 weeks [9, 14]. The similar total cholesterol observed in ewes supplemented with leaves for six weeks in the current study was also reported in Avishaan ewes supplemented with dried Moringa leaf for two months [21]. In agreement with the decrease in total cholesterol and LDL with increasing HDL in our ewes supplemented with Moringa seeds, rats supplemented with Moringa leaves for 30 days indicated decreased cholesterol and LDL and higher HDL [57]. In agreement with the increase of total proteins in ewes supplemented with Moringa leaf, seeds, and cake, the supplementation of Moringa increased total proteins in Barki ewes from one month after Moringa supplementation [20]. In agreement with the nonsignificant difference in the total proteins and albumin levels between control ewes and those supplemented with Moringa leaves in this study, Avishaan ewes supplemented with dried Moringa leaf for two months during the heat stress months showed nearly similar total proteins and albumin compared to their control [21]. Similarly, albumin did not vary between the control and supplemented groups [20]. In agreement with the increase of globulin in ewes supplemented with Moringa seeds, globulin started to increase in Barki ewes supplemented with Moringa leaves one month after supplementing Moringa [20]. The significant decrease in blood urea nitrogen in ewes supplemented with Moringa seeds and leaves in the current study contrasts the tendency to increase in Avishaan ewes supplemented with dried Moringa leaf for two months [21].

The increase in blood urea in ewes supplemented with Moringa seed cake compared to those supplemented with Moringa seeds and cake in this study could be attributed to its higher content of total proteins. Similar to the absence of any effect of supplementing Moringa leaves on total proteins, albumin, globulin, AST, and total cholesterol, the supplementation of Mutton Merino sheep with the methanolic extracts of Moringa oleifera for 75 days did not alter the concentrations of ALT, AST, total cholesterol, urea, total proteins, albumin, and globulin [58]. The decreased AST in ewes supplemented with Moringa leaves and seeds of this study agrees with the ability of Moringa to prevent liver damage and improve its functions [59].

The increase in nitric oxide (NO) and the uterine blood flow in ewes supplemented with Moringa seeds, cake, and leaves could be referred to as the presence of arginine amino acid which is the precursor of nitric oxide synthetase enzyme [60]. 51% of tocopherols in Moringa seed oil are alpha and 47.24% of the total sterol content is β-Sitosterol and are resistant to oxidation [12]. The increase in the superoxide dismutase activity in the Moringa-supplemented ewes in the current study was also reported in Najdi ewes [14], and was attributed to the increase in the antioxidant capacity with the increase in the concentration of Moringa leaf [60,61]. Moringa leaves showed concentration-dependent protection of oxidative DNA damage induced by HO and inhibited the toxicity administration by decreasing lipid peroxides (LPO) and increasing glutathione (GSH) levels, restoring superoxide dismutase (SOD) and catalase (CAT) levels to almost normal levels [13]. The increased catalase activity in our ewes supplemented with Moringa seed cake was also reported in Najdi ewes fed on a diet supplemented with Moringa for 6 weeks [9, 14]. The increased serum SOD in all supplemented groups of this study agrees with its increase in the red blood cells of Avishaan ewes supplemented with dried Moringa leaf for two months [21]. Contrary to the slight but significant increase in the catalase activity in the red blood cells of Avishaan ewes supplemented with dried Moringa leaf for two months [21], the present study indicated a significant increase in the serum of ewes supplemented with

Moringa cake. The antioxidant properties of Moringa leaves were attributed to the presence of phenolic acids such as gallic, chlorogenic, ellagic, and ferulic acid and flavonoids such as kaempferol, quercetin, and rutin that mediated through direct trapping of the free radicals and the metal chelation [13]. Total antioxidant capacity did not vary in ewes of this study supplemented with Moringa leaves, seeds, and cake and in Barki ewes supplemented with Moringa for 45 days [20] or Najdi ewes supplemented with Moringa for 6 weeks [9, 14]. In agreement with the increase of total antioxidants in ewes-supplemented Moringa leaves of this study, Avishaan ewes supplemented with dried Moringa leaf for two months showed higher plasma total antioxidants capacity [21].

Conclusion

Moringa seeds, leaves, and seed cake improved the ovarian dynamics, the luteal, ovarian dynamics and hemodynamics, the health status, and the antioxidant capacity of the supplemented animals. Moringa seed cake increases the ovulation rate and is recommended to be supplemented as a cheap by-product of Moringa oil production because of its low price and ability to add to the ration of sheep.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study was approved by the Animal Care and Use Committee of the Faculty of Veterinary Medicine Cairo University (Vet CU 18042024936).

TABLE 1. Concentrations of oil, total proteins, carbohydrates, and Ash contents in different parts of *Moringa oleifera* (Means ± SDM)

Composition %	Cake (MSC)	Leaves (ML)	Seed (MS)	P-Value
Sample number	3	3	3	
Oil	13.85±0.78^{a}	17.49±1.23^{b}	34.09±.18^{c}	0.0001
Toral proteins	39.43±1.33^{c}	25.28±0.84^{a}	31.84±1.3^{b}	0.0001
Ash	5.39±0.24^{b}	9.25±0.90^{c}	3.19±0.19^{a}	0.0001
Carbohydrates	41.32±2.36^{b}	47.97±1.90^{c}	30.87±1.09^{a}	0.0001
Total Carotenoids	-	8.24±0.05	-	

Superscript letters within the row (a, b, c) indicate significance at P<0.05.

TABLE 2. Ovarian follicle dynamics and hemodynamics in control and treated ewes groups. (Means ± SEM)

Parameters	Control	MSCG	MLG	MSG	P-Value
Ovulation rate	1.00±0.00^{a}	1.23±0.06^{c}	1.16±.06^{bc}	1.08±0.04^{ab}	0.005
N. Dom .F	1.23±0.08	1.34±.09	1.32±0.11	1.23±0.08	0.746
Dom. FD /mm	3.86±0.09^{a}	4.50±0.10^{b}	4.45±0.09^{b}	4.66±0.10^{b}	0.0001
Sub. FD /mm	2.96±0.05^{a}	3.41±0.07^{c}	3.24±0.09^{bc}	3.11±0.06^{ab}	0.0001
S. FD/mm	2.15±0.04^{a}	2.92±0.24^{b}	2.30±0.06^{a}	2.39±0.07^{a}	0.0001
Av. FD/mm	2.81±0.05^{a}	3.49±0.06^{c}	3.25±0.07^{b}	3.16±0.07^{b}	0.0001
F. circum./mm	8.82±0.16^{a}	10.95±0.19^{c}	10.22±0.23^{b}	9.93±0.22^{b}	0.0001
F. area / pixel	1083±56.58^{a}	1454±59.47^{b}	1376±70.93^{b}	1417±60.49^{b}	0.0001
F. perimeter/ pixel	119.78±2.57^{a}	139.68±2.69^{b}	134.69±2.99^{b}	137.01±2.84^{b}	0.0001
Circulatory%	82.65±0.28^{a}	82.89±0.27^{a}	82.75±.30^{a}	83.78±0.25^{b}	0.017
Estradiol pg/ml	31.80±1.29^{a}	50.96±1.81^{b}	53.11±2.72^{b}	51.61±2.18^{b}	0.014

MSCG (Moringa seed cake group), MLG (Moringa leaves group), MSG (Moringa seed group), N. Dom. F (number of dominant follicles), Dom. FD (Dominant follicle diameter), S. FD (small Follicle diameter), Av. FD (average Follicle diameter), F. Circum. (F. circumference). Superscript letters (a, b, c) within the rows indicate significant differences at least at P<0.05

TABLE 3. Ovarian and corpus luteum (CL) dynamics and hemodynamics in the control group and ewes supplemented with Moringa seeds cake, Moringa leaves, and Moringa seeds. (Means ± SEM)

Parameters	Control	MSCG	MLG	MSG	P-Value
CL diameter/mm	9.43±0.19^{b}	9.19±0.21^{ab}	8.81±0.21^{a}	8.77±0.18^{a}	0.062
CL circumference/mm	29.61±0.61^{b}	28.88±0.66^{ab}	27.66±0.66^{a}	27.54±0.56^{a}	0.062
CL area/cm^2	2.75±0.13^{b}	2.61±0.13^{ab}	2.31±0.11^{a}	2.40±0.11^{ab}	0.063
CL area /pixel	7517±529.6	7918±311.6	787±38.3	7037±39.4	0.306
CL perimeter /pixel	271.6±12.98^{b}	262.7±12.66^{ab}	231.3±11.4^{a}	240.1±10.92^{ab}	0.228
CL color area/ pixel	1775.9±151.65^{a}	2396.7±165.3^{b}	2120.1±145.8^{ab}	1680.5±158.1^{a}	0.004
CL color area %	25.26±2.28^{a}	30.84±1.59^{b}	26.69±1.44^{ab}	23.49±1.49^{a}	0.015
CL circulatory%	82.29±1.26^{a}	84.16±0.47^{b}	84.64±0.28^{b}	84.89±0.31^{b}	0.031
Ovarian area /pixel	12359±518^{a}	14896±643^{b}	13659±467^{ab}	13518±407^{ab}	0.008
Ovarian color area	1402±87^{a}	1554±71^{ab}	1732±140^{b}	1651±104^{ab}	0.139
Ovarian color area %	11.57±0.62	10.97±0.48	10.53±0.49	11.53±0.59	0.522
P4 ng/ml	3.32±0.21^{a}	4.22±0.28^{b}	3.55±0.27^{ab}	3.83±0.23^{ab}	0.068

MSCG (Moringa seed cake group), MLG (Moringa leaves group), MSG (Moringa seed group), corpus luteum (CL), and Progesterone (P4). Superscript letters (a, b) within the rows indicate significant differences at least at P<0.05.

TABLE 4. Ovarian and uterine arteries blood flow velocities and blood flow volumes in control and ewes supplemented with Moringa seeds cake, Moringa leaves, and Moringa seeds. (Means ± SEM)

Parameters	Control	MSCG	MLG	MSG	P-Value
OV. A. PSV cm/s	25.53±0.95^{b}	21.38±0.85^{a}	37.14±2.54^{c}	35.52±1.34^{c}	0.001
OV. A. EDV cm/s	10.30±0.93^{a}	9.76±0.76^{a}	10.92±0.94^{ab}	14.02±0.69^{b}	0.032
OV. A. TAMV cm/s	8.51±0.65^{ab}	7.07±0.37^{a}	8.69±0.79^{ab}	9.62±0.94^{b}	0.086
OV. A. Mean V.	14.95±0.95^{a}	13.64±0.79^{a}	14.18±1.88^{a}	18.49±1.31^{b}	0.041
OV. A. RI	0.60±0.03^{ab}	0.54±0.03^{a}	0.67±0.04^{b}	0.60±0.03^{ab}	0.163
OV. A. PI	1.34±0.16^{a}	0.99±0.09^{a}	3.36±0.98^{b}	1.35±0.12^{a}	0.0001
OV. A. BFV ml/min	14.95±.95	13.63±0.79	14.18±1.88	18.49±1.31	0.083
Uterine color area	2493±127^{a}	3274±228^{b}	3441±328^{b}	3192±186^{b}	0.046
Ut. A. diameter /mm	4.81±0.01^{a}	5.01±0.07^{ab}	5.13±0.01^{b}	5.19±0.01^{b}	0.002
Ut. A. PSV /cm/s	29.78±0.56^{a}	29.83±0.48^{a}	35.34±0.61^{b}	35.14±.98^{b}	0.0001
Ut. A. EDV cm/s	5.78±0.17^{a}	5.74±0.15^{a}	5.28±0.13^{a}	7.36±0.23^{b}	0.0001
Ut. A. TAMV cm/s	5.24±0.16^{ab}	4.99±0.13^{a}	5.59±0.15^{b}	6.38±0.17^{c}	0.0001
Ut. A. Mean V.	9.49±0.25^{ab}	8.76±0.22^{a}	9.99±0.27^{b}	11.48±0.32^{c}	0.0001
Ut. A. RI	0.79±0.01^{b}	0.80±0.00^{b}	0.85±0.00^{c}	0.78±0.00^{a}	0.0001
Ut. A PI	3.35±0.20^{b}	3.32±0.11^{b}	3.69±0.13^{b}	2.78±0.10^{a}	0.0001
Ut. A. BFV	58.33±1.97^{a}	59.39±2.25^{a}	67.9±2.39^{b}	81.08±2.69^{c}	0.0001

MSCG (Moringa seed cake group), MLG (Moringa leaves group), MSG (Moringa seed group), Ovarian Artery (OV. A.), Uterine Artery (Ut. A.), peak systolic velocity (PSV), end-diastolic velocity (EDV), time average mean velocity (TAMV), mean Velocity (Mean V.), resistance Index (RI), pulsatility index (RI), blood flow volume (BFV). Superscript letters (a, b, c) within rows indicate significant differences at least at P<0.05.

TABLE 5. Serum biochemical in control and ewes supplemented with Moringa seeds cake, Moringa leaves, and Moringa seeds. (Means ± SEM)

Parameters	Control	MSCG	MLG	MSG	P-Value
Cholesterol mg/dl	135.44±0.35^{b}	137.41±0.44^{b}	136.03±0.58^{b}	130.29±1.08^{a}	0.0001
LDL mg/dl	68.91±0.53^{b}	67.82±0.52^{ab}	67.39±0.80^{ab}	65.99±0.92^{a}	0.0001
HDL mg/dl	63.74±0.80^{a}	71.16±0.78^{a}	83.73±4.29^{b}	100.09±5.77^{c}	0.0001
Total proteins g/dl	5.57±0.02^{a}	5.68±0.02^{b}	5.61±0.02^{a}	5.62±0.03^{ab}	0.008
Albumin g/dl	3.88±0.02^{ab}	3.92±0.02^{b}	3.85±0.02^{a}	3.85±0.02^{a}	0.023
Globulin g/dl	1.76±0.02^{a}	1.75±0.02^{a}	1.76±0.03^{a}	1.87±0.03^{b}	0.002
Urea mg/dl	42.04±0.12^{c}	40.43±0.15^{b}	37.39±0.35^{a}	37.49±0.35^{a}	0.0001
Creatinine mg/dl	1.03±0.02^{b}	0.95±0.01^{b}	0.19±0.08^{a}	1.15±0.29^{b}	0.0001
AST (GOT)U/L	57.49±0.59^{b}	60.66±0.75^{b}	46.55±1.73^{a}	48.99±2.13^{a}	0.0001
ALT(GPT) U/L	45.39±0.59^{a}	51.56±.57^{b}	53.07±1.47^{b}	51.28±1.99^{b}	0.005

MSCG (Moringa seed cake group), MLG (Moringa leaves group), MSG (Moringa seed group), Low-density lipoproteins cholesterol (LDL), high-density lipoproteins cholesterol (HDL), Aspartate transaminase (AST); Alanine transaminase (ALT). Superscript letters (a, b, c) within rows indicate significant differences at least at P<0.05

TABLE 6. Serum oxidants and antioxidants in control and ewes supplemented with Moringa seeds cake, Moringa leaves, and Moringa seeds. (Means ± SEM)

Parameters	Control	MSCG	MLG	MSG	P-Value
MDA nmol/ml	8.71±0.02^{b}	8.65±0.01^{a}	8.65±0.02^{a}	8.62±0.02^{a}	0.001
NO µmol/L	58.07±0.15^{a}	59.56±0.16^{b}	61.10±0.24^{d}	60.46±0.24^{c}	0.0001
GSH mg/dl	68.03±0.57^{b}	70.45±0.48^{c}	69.88±0.67^{c}	60.83±0.55^{a}	0.0001
Catalase U/L	255.71±1.53^{a}	269.04±1.06^{b}	254.46±1.79^{a}	258.31±1.63^{a}	0.0001
SOD U/ml	279.25±1.94^{a}	296.64±2.59^{b}	312.99±2.14^{c}	310.17±3.00^{c}	0.0001
TAC mM/L	0.94±0.01^{a}	0.94±0.01^{a}	0.98±0.01^{b}	0.95±0.01^{ab}	0.064

MSCG (Moringa seed cake group), MLG (Moringa leaves group), MSG (Moringa seed group), Malondialdehyde (MDA), nitric oxide (NO), Glutathione reduced (GSH), Superoxide dismutase (SOD), total antioxidants capacity (TAC). Superscript letters (a, b, c) within the rows indicate significant differences at least at P<0.05.

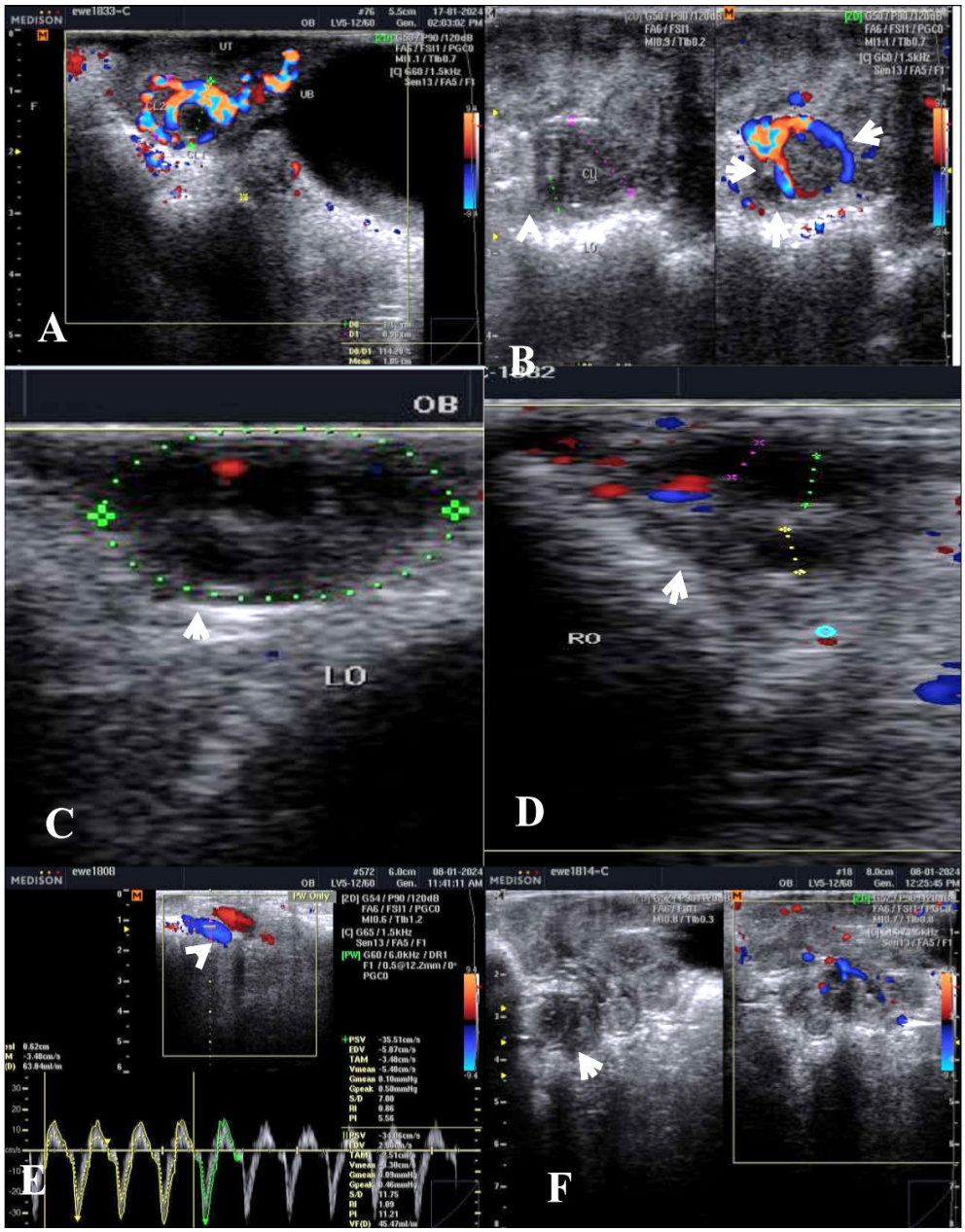

Fig. 1. Color Doppler mode of two corpora lutae (A), one corpus luteum in greyscale mode (left split) and color mode (right split white arrows (B), left ovary with multiple follicles in color Doppler mode (arrow, C), right ovary with multiple follicles with color Doppler (arrow, D), The spectral Doppler mode of the uterine arteries (arrow, E), the uterus in greyscale mode left split (arrow) and vascularization with color Doppler mode (right split, F)

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تأثير البذور و الاوراق و كسبة بذور المورينجا اوليفيرا كمكمل غذائي على ديناميكة و تدفق الدم للمبيض و كيمياء الدم و حالة مضادات الاكسدة في النعاج الحولية ذات الإلية

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الملخص

هدفت هذه لدراسة لاستكشاف تاثير تغذية النعاج البالغة ببذور و كسبة البذور و اوراق المورينجا على تدفق الدم الرحمي و المبيضي و هرمونات المبيض و المؤكسدات و مضادات الاكسدة و كيمياء الدم. تم تقسيم اربعون من النعاج بالتساوي لاربع مجموعاتز بالاضافة للاحتياجات الغذائية الاساسية (المجموعة الحاكمه) تم اطعام 7جم من كسبة المورنجا لمجموعة كسبة المورنجا (MSCG) و 7 جم من البذور لمجموعة بذور المورنجا(MSG) و 10 جم من الاوراق المطحونة لمجموعة اوراق المورينجا (MLG) لمدة 6 اسابيع . تم تجميع عينات الدم و عمل فحص بجهاز الدوبلر لمدة 6 اسابيع . اظهرت النتائج زيادة معنوية بمعدل التبويض ($P<0.05$) مع اقطار الجريبيات السائدة و الاصغر منها ($P<0.001$) و تركيزات الاستروجين ($P<0.05$) و في كل المجموعات المغذاه على المورنجا. و انخفض قطر الجسم الاصفر معنويا في النعاج المغذاه على بذور و اولراق المورنجا كما ذادت مساحة المنطقة الملونة ونسبتها في النعاج بمجموعة كسبة المورنجا بالمقارنة بالمجموعة الحاكمة و الاوراق و الكسبة. كما ذادت ذادت مساحة المبيض و تركيزات البروجيستيرون في النعاج بمجموعة الكسبة بينما ذادت مساحة المبيض الملونة بمجموعة الاوراق بالمقارنة بالمجموعة الحاكمة و اظهرت النعاج بمجموعة الكسبة انخفاض ($P<0.05$) معنوي في تدفق الدم الانقباضي و الارتخائي و متوسط سرعة تدفق الدم الوقتي و متوسط سرعة الدم و معامل المقاومة و معامل النبضي و حجم تدفق الدم لشريان المبيض و التي تزامنت مع انخفاض ($P<0.001$) في سرعة تدفق الدم الانقباضي و الارتخائي و الوقتي و متوسط سرعته و حجمه لشريان الرحم. بينما انخفضت مستويات الكوليستيرول الكلي و الكوليستيرول منخفض الكثافة و اليوريا و انزيم الكبد ذادت مستويات الكوليستيرول عالي الكثافة و الجلوبيولين و الكرياتينين في مجموعة النعاج المغذاة على بذور المورنجا. و اظهرت كل النعاج بمجموعات المورينجا انخفاض في مستويات المالون ثنائي الهيدروجين ($P<0.001$) مع زيادة ($P<0.001$) في اكسيد النيتروجين و انزيم الديسميوتاز فوق الاكسجيني عن المجموعة الحاكمة. و ذاد ($P<0.001$) نشاط انزيم الكتاليز و الجلوتاثيون المختزل في مجموعة المعاج المغذاة على الكسبة. و تستنتج هذه الدراسة امكانية استخدام بذور و كسبة و اوراق المورنجا كمكمل غذائي لتحسين التناسل في النعاج الحولية.

الكلمات الدالة: المورينجا ، مكمل غذائي، اتدفق الدم للمبيض و الرحم، معدل التبويض، النعاج.