Effect of add maca powder to the base diet on weaning lambs and rams semen characteristics

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ABSTRACT

This study was conducted on lambs and rams. Hence, 15 weaning lambs at 60 days of age were randomly distributed to G1, G2 and G3 groups (n=5 in each) at live body weight (LBW) 9.8 kg. The G1, G2 and G3 were received maca powder at 0, 200, 400 mg / kg LBW plus daily basal requirements diet (DBRD), respectively. The LBW, daily weight gain (DWG), scrotal development, testosterone level and blood parameters were assayed. Otherwise, 9 maturity rams at 19 months with 53.98 kg formed G1, G2 and G3 (n=3 in each) were used to evaluate semen characteristics. The G1, G2 and G3 were given 0, 50, 100 mg of maca powder / kg LBW plus DBRD, respectively. The findings indicated that, G2 and G3 lambs had more positive changing in LBW, DWG, scrotal development, testosterone level and blood parameters than G1 lambs. Also, G2 and G3 rams had more significantly improved semen characteristics than G1 rams. Economic efficiency (EE) of lambs was greater in G2 (2.62) than G3 (2.50) and G1 (2.43). The EE of rams was 3.24, 4.42 and 4.32 in G1, G2 and G3, respectively. Thusly, lambs and rams had respectively the best results at 200 or 50 mg of maca add to DBRD diet.

Key words: ***maca, lambs, productive, rams, reproductive.***

INTRODUCTION

Feeding is the main component cost in animal production; at nutritional crises the rations are not availability of nutrients for animals. Therefore, numerous nutritional solutions have been adopted as supplementation of products. Accordingly, **Khalifa *et al.* (2014)** noticed that feeding additives to basal diet led to great profitability under conditions of decrease diet in the farm without negative effects on production, reproduction and growing quality. In this respect, **Khalifa *et al.* (2022)** pointed that many feed additives used to improve productive and reproductive performance. Additive plants had bioactive as alkaloids, flavenoids, glycosides, mucilages, saponins, tannins, and phenol, phenolic acids, coumarin, terpenes, essential oils, lectins and polypeptides **(Liu *et al.*, 2015)**. These chemical compounds had antiviral and antibacterial effects and cause strengthen the immune system. Then, there is generally demand for using natural sources of herbal as feeding additives; it is among of this herbal was maca powder. Finding of, **Inoue *et al.* (2016)** who stated that maca could influence the physiological effects due to the additional bioactive compounds. In this context, *Lepidium meyenii* (maca) is a food crop and treat sterility in humans and domestic animals **(Beharry and Heinrich, 2018)**. Maca is rich in protein, crude oil, essential acids, and a pharmacological compound **(Ohta *et al.*, 2016)**. A dry maca contains 10.2% proteins, 59% carbohydrates, 2.2% lipids, 8.5% fibre, 40.1% free fatty acids (linoleic, palmitic, and oleic acids) and 52.7% saturated fatty acids and unsaturated fatty acids according to **(Gonzales, 2012)**. Furthermore, **Zhou *et al.* (2017)** reported thatN-benzyl-palmitamide, benzylisothiocyanate, glucosinolates and phenolics in maca effects on lipid, mineral and antioxidant metabolisms. In addition, maca contains important fatty acids, macacids, macaridin, alkaloids and glucosinolates **(Tafuri *et al.*, 2019)**. Using maca by **Clément *et al.* (2012)** in cow, **El-Sheikh *et al.* (2019)** in rabbits, **Lavana *et al.* (2013)** in sheep, **Korkmaz *et al.* (2016)** in hens, **(Wan *et al.*, 2018)** in rat and **Gül *et al.* (2022)** in quails. In the results obtained from various studies by **(Li *et al.*, 2017 [a and b])**, it was declared that the moisture (4.63-10.40%), protein (9.56-21.90%), crude oil (0.59-2.20%), total carbohydrate (46.1-74.8%) and ash (3.41- 4.90%,) in maca root (as dry matter). Beside, **Mona *et al.* (2023)** concluded that oral administration of maca extract could be had positive alteration in rabbits.

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Purpose of the research was to add maca powder at different levels to preservative daily nutritional requirements to study growing in weaning lambs and semen characteristics in rams.

MATERIALS AND METHODS

The study was carried out in EL-Serw Research Station, Animal Production Research Institute (*APRI*), Agricultural Research Center, Ministry of Agriculture, Egypt. The date of study was from September 2022 to April 2023.

General feeding of weaning lambs

The lambs grazed with their dams until weaning. The lambs were weaned at 60 days of age and then housed separately in a shed and raised under the same management and nutritional conditions. All lambs were fed preservative daily nutritional requirements included concentrate feed mixture (CFM) and berseem hay (BH) and rice straw (RS) according to the recommendation of the National Research Council **(NRC, 2007)**. The chemical analysis of CFM and BH and RS according to **AOAC (2007)** and determination of ingredients feeding values are given in Table (1).

Table 1: Chemical analysis and ingredients feeding values of basal experimental diet (on DM basis).

Chemical composition (%)	Basal experimental diets		
	*CFM	BH	RS
Organic matter (OM)	87.60	84.03	84.95
Crude protein (CP)	14.42	14.90	3.81
Ether extract (EE)	2.44	1.03	1.62
Crude fiber (CF)	7.33	30.83	39.91
Nitrogen free extract (NFE)	63.41	37.27	39.61
Ash	12.40	15.97	15.05
**** Ingredients feeding values**			
Total digestible nutrients (TDN)	62.76	65.25	54.49
Digestible crude protein (DCP)	10.29	10.75	0.11
Digestible energy (DE) M cal/kg DM	2.77	2.88	2.40
Metabolizable energy (ME) M cal/kg DM	2.35	2.46	1.97
Net energy (NE) M cal/kg DM	1.42	1.47	1.23

***The CFM consisted of 26 % undecortecated cotton meal, 40 % yellow corn, 27 % wheat bran, 3.5 % molasses, 2 % limestone, 1 % common salt and 0.5 % minerals mixture.**

**** Ingredients feeding values as total digestible nutrients (TDN) = 129.39 - 0.9419 (CF+ NFE), digestible crude protein (DCP) = 0.9596 (CP) - 3.55, digestible energy (DE) M cal/kg DM = 0.04409 (TDN %), metabolizable energy (ME) =1.01(DE) - 0.45 and net energy (NE) = 0.0245 (TDN %) - 0.12** was calculated according to **NRC (2007).**

The experiment assaying as follows:

Assaying productive performance of weaning lambs

Fifteen lambs (after weaning at 2-month old) single born were randomly obtained simultaneously were used. The lambs were formed randomly three groups as G1 (control), G2 (trial) and G3 (trial) each group contained 5 lambs / group rearing up to 120 days of age (post-weaning). Immediately after choosing the individual weights / lamb were recorded. Then, the average initial live body weight (LBW) of G1, G2 and G3 were 9.8 ± 0.37, 9.8± 0.74, and 9.8±1.66 kg, respectively. The G1, G2 and G3 were given the same veterinary care and housed under the identical environmental conditions. In addition, the G1, G2 and G3 were received daily maintenance nutritional requirements from CFM, BH and RS according to **(NRC, 2007)**. At supplying maca powder, sacks of rice paper contain either 0 or 200 or 400 mg / kg of body weight /day / lamb were given as bolus to G1, G2 and G3, respectively. The analysis of dry maca powder as amino acids and minerals **(Gonzales, 2012)** represented in Table (2). While, it is shown in Table (3) the chemical composition of maca powder.

Table2: Analysis of amino acids and minerals presented in dry maca powder.

Items	Levels of amino acid in dry maca powder (mg/g protein)
Leucine	91.0
Arginine	99.4
Phenylalanine	55.3
Lysine	54.3
Glycine	68.3
Alanine	63.1
Valine	79.3
Isoleucine	47.4
Glutamic acid	156.5
Serine	50.4
Aspartic acid	91.7
Levels of minerals in dry maca powder (mg/ 100 g dry matter of maca powder)	
Iron	16.6
Calcium	150.0
Copper	5.9
Zinc	3.8
Potassium	2050.0

Table3: Chemical compositions of maca powder.

Item	Chemical composition						
	Water (%)	Protein (%)	Oil (%)	Ash (%)	Maca amide (mg/g maca)	Glucosinolate (mg/g maca)	Alkaloid (mg/g maca)
Maca powder	7.01	13.42	1.42	3.41	0.14	1.24	0.20

Data in this table are all expressed by wet basis content according to **Li *et al.* (2017[a])**.

Determination of productive performance for weaning lambs

It was included following parameters measured in G1, G2 and G3:

Live body weight (LBW)

Live body weight was recorded regular at 20-day intervals between 60 and 180 days of age before offered the morning feedstuffs.

Daily weight gain (DWG)

It was calculated as following equation:

$$\text{DWG, kg} = \frac{\text{Final LBW (kg)} - \text{initialLBW(kg)}}{\text{Duration of experimental period}}$$

Total feed intake

Feed intake from either G1 or G2 or G3 lambs was estimated by collected the residual amount of basic feed daily duration 120 days.

Feed conversion ratio

The feed conversion ratio was calculated as following equation:

$$\text{FCR} = \frac{\text{Feed intake}}{\text{The average body weight gain}}$$

Performance index (PI)

PI was calculated as follow equation;

$$\text{PI} = \frac{\text{Final live body weight (kg)} \times 100}{\text{Feed conversion ratio}}$$

Production efficiency factor (PEF):

It was calculated according as following equations:

$$\text{PEF} = \frac{\text{Livability} \times \text{Mass (Kg)} \times 100}{\text{FCR} \times \text{Age study (days)}}$$

Livability = 100 – Mortality rate (%) the mortality % in this study reached to zero then the livability in this study = 100 - 0.

Mass (Kg) = Final live body weight.

FCR = Feed conversion ratio.

Age in this study = 180 days.

Determination of scrotal development and testosterone level in lambs

At weaning of lambs (at 60 days) length, diameter, circumference of the testes and body weights were measured at 20-days as interval period up to 180 days of age. Each testis was moved into the distal part of the scrotum and its circumference was measured with a flexible cloth tape at the largest diameter of scrotum. The testicular length was measured by a caliper both on the left and right testicles as the distance between the top of the tail and the head of the epididymis. The testicular diameter was recorded with a caliper on the left and right testicles as the widest anteroposterior diameter after forcing it against the scrotum. Then, volume of the testes was calculated as reported by **Godfrey *et al.* (1998)**:

Testes volume (cm^3) = 0.0396 x (average testis length) x (scrotal circumference)^2.

Also, the testosterone level (ng/ml) was determined at 60, 120 and 180 days for lambs by kit produced by Germany IBL Company; with catalogs No RE52151 and the ELISA Plate Reader (Biotek ELX808, USA made).

Determination of blood serum constituents for lambs

Blood samples of G1, G2 and G3 groups (3 lambs /treatment) done from the jugular vein between 8:00 and 9:00 am before feeding into clean and sterilized tubes at 180 days of age. The serum was isolated by centrifugation at 4000 *rpm* for 15 min, then serum separated immediately into clean tubes and frozen in a deep freezer at -20°C until analysis. The glucose, total protein, globulin, creatinine, triglyceride and total cholesterol were determined using commercial assay kit obtained from Nanjing Jiancheng Bioengineering Institute (Nanjing, China).

Economic efficiency for lambs

The economic efficiency was calculated according to the local market price of diet ingredients and sell of lamb live weight up to 180 days as following:

Money output (price of sole lamb) ÷ input (total price of feed consumed) ×100.

The relative economic efficiency % relative to G1 or G2 or G3 was calculated as following:

The economic efficiency amount of (G2 or G3– economic efficiency amount of G1÷economic efficiency amount of G1) ×100+100 (considering economic efficiency of G1 is attained 100%).

Assaying reproductive performance for ram

At 19 months of age, other 9 ram at average LBW up to 53.98±5.56 kg were divided into three groups as G1, G2 and G3 (*n*=3 in each trial) were used to evaluate semen characteristics. The G1, G2 and G3 were received respectively rice paper packaging sacks contained either 0 or 50 or 100 mg / kg /day / ram plus daily basal nutritional requirements from CFM, BH and RS according to **(NRC, 2007)** before 60 days of semen collection.

Determination semen characteristics

The semen samples were collected at 21 months (post two months of feeding) of ram age using an artificial vagina as one ejaculate / week up to 4 weeks (*n*= 12 samples /group up to one month). The semen ejaculates were immediately transported to the laboratory and immersed in a water bath at 37°C to assay semen parameters included volume, progressive motility and sperm concentration x10^9 according to **Khalifa *et al.* (2023)**.

Economic efficiency for semen collection

The economic efficiency was calculated according to the local market price of diet ingredients and sell of frozen straw form which obtained from ram as following:

Money output (price of selling frozen straw) ÷ input (total price of feed consumed) ×100. In addition, the relative economic efficiency % relative to G1 or G2 or G3 was calculated as previous.

Statistical Analysis

Productive and reproductive performance was performed by ANOVA followed by the Duncan *post hoc* test to determine significant differences in all the parameters among all maca trial using the SPSS/PC computer program (**SPSS Statistics version 2020**). Also, correlation a coefficient of growing lambs was affected by consumption different levels of maca powder was carried out with Pearson SPSS/PC computer program. The test in a completely randomized design as the following model:-

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

Y_{ik} = an observation.

μ = the overall mean.

T_i = the effect of treatments (either lambs or rams).

e_{ik}= residual error.

RESULTS

Assaying productive performance of lambs

Live body weight (LBW)

The average values of LBW in G1, G2 and G3 lambs rearing from 60 to 180 days of age are given in Figure (1). The best (P>0.05) LBW observed in G2 and G3 compared with G1 from 60 to 100 days of age. However, the results of the growth curve from 120 to 180 days of age for G2 and G3 lambs were represented more (P<0.05) in LBW than G1 lambs. Then, the average LBW values were 11.96, 15.64 and 16.12 kg at 120 days of age, 13.24, 17.58 and18.44kg at 140 days of age, 16.62, 20.54 and 21.85 kg at 160 day of age and 18.10, 22.64 and 24.64 kg at 180 days of age in G1, G2 and G3 lambs, respectively.

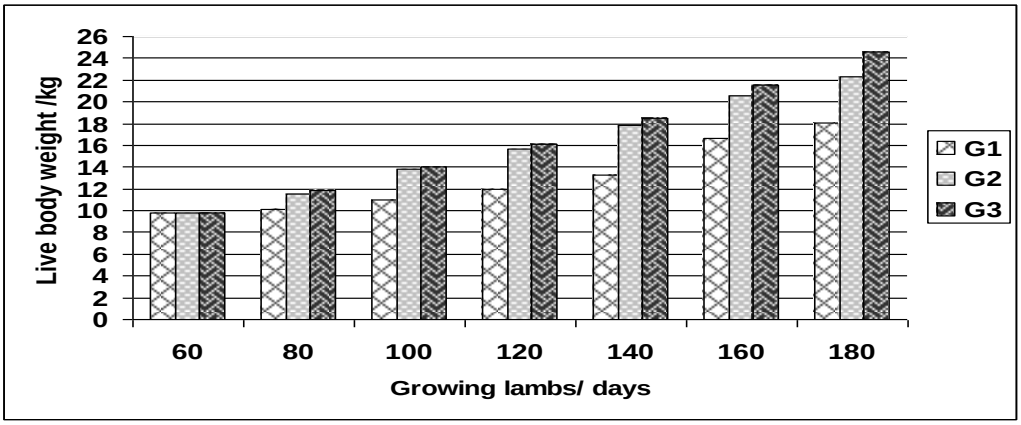

Figure 1: The change of LBW of lambs from 60 to 180 days of age for G1, G2 and G3.

Determination of final body weight (FBW), daily weight gain (DWG), daily feed intake (DFI), feed conversion ratio (FCR), performance index (PI), production efficiency factor (PEF) and metabolic weight (MW)

Table (4) demonstrated that FBW, DWG, DFI, FCR, PI and PEF parameters which obtained in G1, G2 and G3 lambs with effects of maca powder. The maca did not affect statistically in DFI and MW (P > 0.05). However, it effects higher on FBW (P < 0.05) and DWG (P < 0.05) of G2 and G3 than G1 lambs. The highest FCR (P < 0.05) and PI (P < 0.05) were obtained with the addition maca powder to G2 and G3, but a decrease in these parameters was observed in G1. As of the final of growing period (60-180 days), FBW and FCR occurred the highest PEF (P < 0.05) for the G2 and G3 lambs fed with diet added of maca powder compared with G1 lambs.

Table4: Determination of FBW, DWG, DFI, FCR, PI, PEF and MW in G1, G2 and G3 lambs.

Parameters	Experimental lamb groups		
	G1	G2	G3
FBW,kg	18.10±0.51[b]	22.64±0.78[a]	24.64±2.17[a]
DFI amount, g	725.00±6.55	725.00±11.25	725.00±8.85
DWG, g	69.17±0.04[b]	115.16±1.13[a]	123.50±0.82[a]
FCR	10.48±2.42[a]	6.30±0.22[b]	5.87±0.35[b]
PI	1.73±0.03[b]	3.59±0.03[a]	4.20±0.01[a]
PEF	95.95±8.95[b]	199.65±11.25[a]	233.20±14.35[a]
***MW**	9.04±0.19	10.03±0.48	10.14±0.93

Means in the same column within each classification bearing different letters are significantly different (P<0.05).
*** Metabolic weight (MW) was calculated as: (Initial body weight (kg) + Final body weight (kg) ÷ 2)$^{0.75}$ according to Willems *et al.* (2013).**

Determination of testicular dimensions development in lambs:

Determination of scrotal circumference (SC)

As shown by Figures 2, 3, 4 and 5 the development of testicular dimensions such as SC, TD, TL and TV, respectively. There were no differences between right and left testes (P> 0.05) among all trial lambs. Testicular dimensions had more (P>0.05) values from 60 to 120 days of age in G2 and G3 than G1. Thereafter, testicular dimensions remained relatively constant between G2 and G3 lambs from 140 until 180 days of age, meanwhile, the testicular dimensions were observed the lowest (P<0.05) values in G1 lambs during the same duration.

Determination of testosterone level in lambs

The effects of maca on serum testosterone level in G1, G2 and G3 groups observed in Table (5). The maca has (P > 0.05) effect on testosterone of G2 and G3 lambs. Hence, increasing of maca powder levels could cause slight (P>0.05) changing in serum testosterone level among G2 and G3 thus, changing optioned in G3 lambs. Whereas, G1 lambs occurred descending (P<0.05) changing in the serum testosterone level compared with G2 and G3 lambs through determination days.

Determination of blood serum constituents for lambs

Table (6) was shown the effects maca at different levels on selected serum biochemical parameters in G1, G2 and G3 lambs. The G2 and G3 have (P > 0.05) in serum glucose, total protein, globulin, creatinine, triglyceride and cholesterol. The G1 treatments affect lower (P<0.05) statistically serum glucose, total protein, globulin than those G2 and G3 treatment. Also, the most creatinine levels was observed in G1 lambs compared with G2 and G3 (P<0.05). It can be seem that serum triglyceride levels of G1 lambs noticed increasing (P<0.05) compared with G2 and G3 lambs. The serum cholesterol level of growing lambs was diminished (P<0.05) with the supplementation of maca powder to G2 and G3 lambs compared with G1 lambs.

Coefficients of correlation between feeding and body weight (BW), body weight gain (BWG), testosterone concentrations (TEST), scrotal conformance (SC), testis diameter (TD), testis length (TL) and testis volume (TV) in lambs.

The different between feeding and body weight, body weight gain, testosterone concentrations and testicular measurements of growing lambs were represented in Table (7). Significant positive correlations among feeding and body weight gain, body weight gain, testosterone concentration and all testicular measurements. Also, the current results had the best correlated between body weight and all testicular measurements. In addition, the relationship among testosterone production and all testicular measurements observed more significant (P<0.05) with SC, but higher (P<0.01) with TD and TV than with TL.

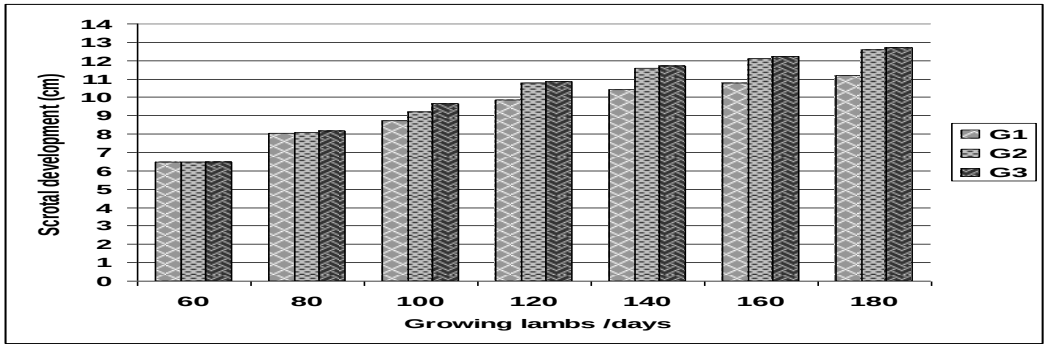

Figure 2: The change of scrotal circumference of lambs from 60 to 180 days of age for G1, G2 and G3.

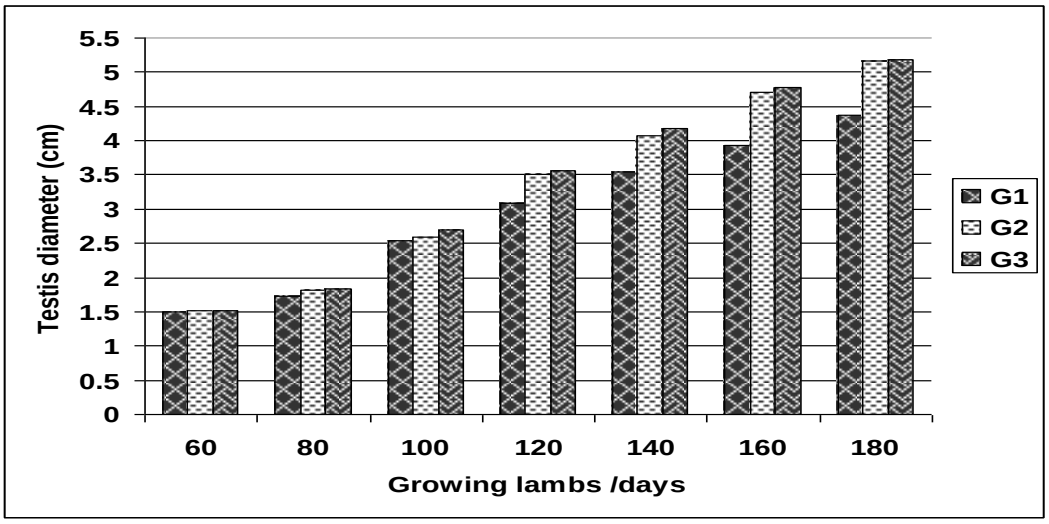

Figure 3: The change of testis diameter of lambs from 60 to 180 days of age for G1, G2 and G3

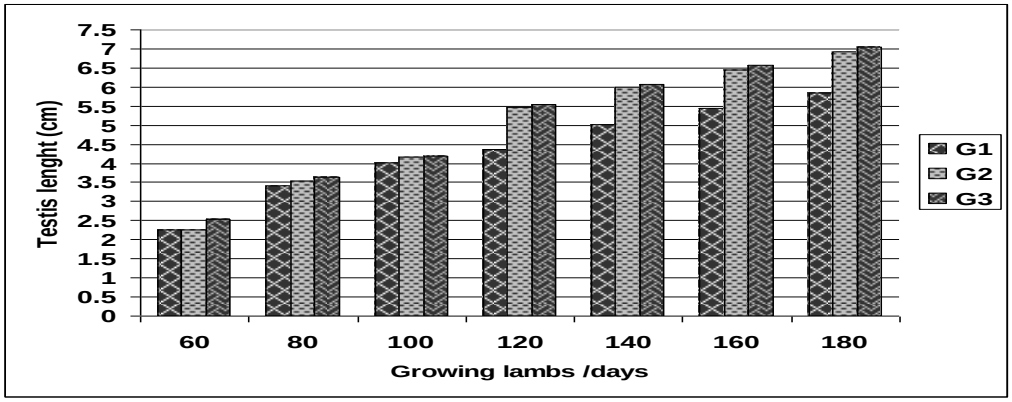

Figure 4: The change of testis length of lambs from 60 to 180 days of age for G1, G2 and G3.

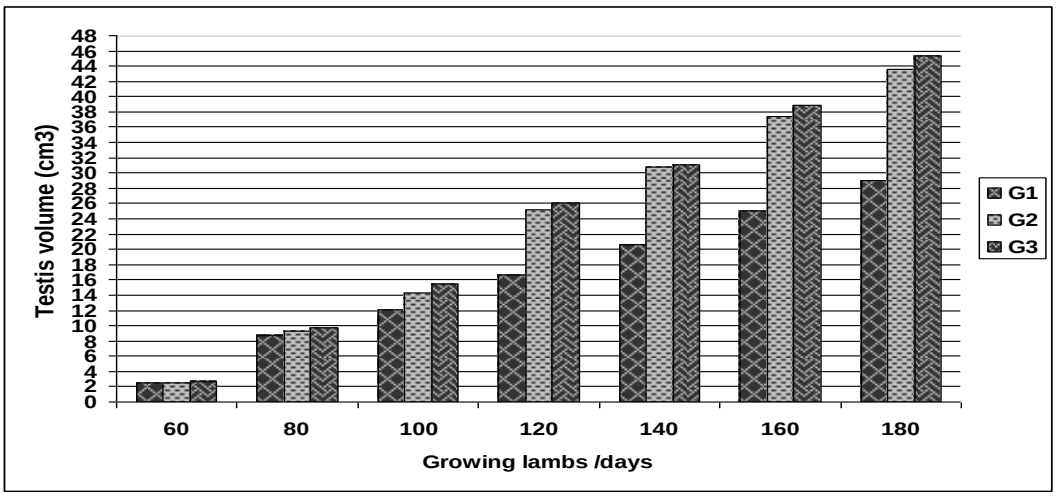

Figure 5: the change of testis volume of lambs from 60 to 180 days of age for G1, G2 and G3

Table5: Determination of testosterone level in G1, G2 and G3 lambs.

Determination days	Testosterone level in lamb groups (ng/ml)		
	G1	G2	G3
60	1.26±0.68^{b}	1.53±0.06^{a}	156±0.03^{a}
120	1.75±0.08^{b}	2.22±0.04^{a}	2.46±0.06^{a}
180	2.46±0.08^{b}	3.11±0.10^{a}	3.21±0.07^{a}

Means in the same row within each classification bearing different letters are significantly different (P<0.05).

Table6: Determination of blood serum constituents for G1, G2 and G3 lambs.

Parameters	Blood serum constituents in lamb groups		
	G1	G2	G3
Glucose, mg/dL	278.33±5.49^{b}	310.67±6.44^{a}	315.33±2.96^{a}
Total protein, g/dL	4.28±0.06^{b}	4.89±0.05^{a}	4.99±0.01^{a}
Globulin, g/dL	2.36±0.02^{b}	2.99±0.06^{a}	3.06±0.08^{a}
Creatinine, mg/dL	0.368±0.01^{a}	0.305±0.01^{b}	0.301±0.01^{b}
Triglyceride, mg/dL	255.00±5.78^{a}	189.67±4.81^{b}	183.19±5.93^{b}
Cholesterol, mg/dL	244.67±9.82^{a}	196.33±3.84^{b}	193.68±3.53^{b}

Means in the same row within each classification bearing different letters are significantly different (P<0.05).

Table 7: Correlation among feeding, BW, BWG, TSET, SC, TD, TL and TV.

Items	Feed	FBW	BWG	TEST	SC	TD	TL	TV
Feed	1	0.976	0.988	0.914	0.929	0.914	0.998	0.911
FBW		1	0.987	0.981	0.987	0.981	0.961	0.979
BWG			1	0.999*	1.000**	0.999*	0.904	0.999*
TEST				1	0.999*	1.000**	0.888	1.000**
SC					1	0.999*	0.904	0.999*
TD						1	0.888	1.000**
TL							1	0.884
TV								1

BW =body weight, BWG= body weight gain, TESTOS= testosterone, SC= scrotal conformance, TD =testis diameter, TL= testis length and TV= testis volume..

***Correlation is significant at the (P<0.05).**

****Correlation is significant at the (P<0.01).**

Determination of economic efficiency for lambs

The effects of the swallowing maca powder on economic efficiency of G1, G2 and G3 lambs (Table 8). Maca can increased economic efficiency (EE) up to 2.43, 2.62 and 2.50 in G1, G2 and G3, respectively. Furthermore, more differences values of feed efficiency (FE) and feeding cost of producing meat lamb (FCPML) were found in G2 and G3 lambs due to maca powder supplementation than G1 lambs. The results revealed that lambs in G1 group achieved the lowest EE % and economic efficiency relative (EER), but the highest observed in G2 and G3 group. Ultimately, more EE amount and EE% obtained in G2 lambs (received 200 mg) than G3 (received 400mg) lambs.

Table8: Economical efficiency of growing lambs in G1, G2 and G3.

Items	Experimental lamb groups		
	G1	G2	G3
Average of CFM consumption, kg / lamb / 120 days	39.00	39.00	39.00
Average of BH consumption, kg / lamb / 120 days	30.00	30.00	30.00
Average of RS consumption, kg / lamb / 120 days	18.00	18.00	18.00
Average of maca powder consumption, kg / lamb / 120 days	-	0.003	0.006
Total of feed consumption, kg / lamb / 120 days	87.00	87.003	87.006
Cost of CFM, kg / lamb / 120 days, LE	780.00	780.00	780.00
Cost of BH /kg/lamb / 120days, LE	300.00	300.00	300.00
Cost of RS /kg /lamb / 120days, LE	36.00	36.00	36.00
Cost of maca powder /kg/lamb / 120days, LE	-	180.00	360.00
***Total price of feed consumed, LE^{A}**	1116.00	1296.00	1476.00
Final body weight, kg ^{B}	18.10	22.64	24.64
****price of growing lamb (final weight × price sole of lamb kg), LE^{C}**	2715.00	3396.00	3696.00
Economic efficiency			
Feed efficiency (FE) $^{B/A}$	0.016	0.017	0.017
Feeding cost of producing meat lamb (FCPML) $^{A/B}$	60.66	57.24	59.90
Economic efficiency (EE) amount , $^{C/A}$	2.43	2.62	2.50
Economic efficiency (EE), % $^{C/A\times100}$	243.00	262.00	250.00
*****EE (%) relative (EER) to control**	100.00	107.82	102.88

* **Total price of feed consumed= cost of CFM+ BH+RS its prices were 20000, 10000, 2000 LE/ ton but maca powder up to 500 LE/ kg at 2021, respectively.**

** **Price of sole kg of growing lamb is 150 (LE).**

*****EE (%) relative (EER) to control with G2 or G3= EE (G2 or G3) – EE of G1÷ EE of G1×100 +100 (conceder EE of G1 is 100%).**

Assaying reproductive performance for ram including:

Determination semen characteristics

The statistically significant differences in semen parameters of G1, G2 and G3 were found in Table (9). We found that semen quality in both G2 and G3 rams shows rising (P<0.05) trends compared with G1 rams. Hence, the percentage of semen parameters were increased by 72.50 and 78.75% in semen volume, 6.41and 7.69% in progressive motility and 36.41 and 39.67% in sperm concentration in G2 and G3, respectively. Generally, the parameters for semen quality of G3 rams consumed the 100 mg/ kg LBW of maca are shown slight (P>0.05) improvement compared with Grp2 rams.

Table 9: Determination of semen characteristics in G1, G2 and G3 rams.

Semen characteristics	Ram groups		
	G1	G2	G3
Volume, ml	0.80±0.04^{b}	1.38±0.10^{a}	1.43±0.05^{a}
Progressive motility, %	78.54±1.25^{b}	83.33±1.12^{a}	83.75±1.25^{a}
Sperm concentration,n×10^{9}	1.84±0.09^{b}	2.51±0.08^{a}	2.57±0.05^{a}

Means in the same row within each classification bearing different letters are significantly different (P<0.05).

Table10: Economical efficiency of ram in G1, G2 and G3.

Items	Experimental ram groups		
	G1	G2	G3
Feeding items			
Average of CFM consumption, kg / ram / 90 days	81.00	81.00	81.00
Average of BH consumption, kg / ram / 90 days	27.00	27.00	27.00
Average of RS consumption, kg / ram / 90 days	31.50	31.50	31.50
Average of maca powder consumption, kg / ram / 90 days	-	0.243	0.486
Total of feed consumption, kg / ram / 90 days	139.50	139.74	139.99
Cost of CFM, kg / ram / 90 days, LE	1620.00	1620.00	1620.00
Cost of BH /kg/ram / 90 days, LE	270.00	270.00	270.00
Cost of RS /kg /ram / 90 days, LE	63.00	63.00	63.00
Cost of maca powder /kg/ram / 90days, LE	-	121.50	243.00
* Price of total feed consumed, LE	1953.00	2074.50	2196.00
Semen items			
Mean of semen volume, ml	0.8	1.38	1.43
Mean of sperm motility,%	78.54	83.33	83.75
**Extension rate as semen :extension	1:39	1:41	1:41
Extender volume, ml	31.00	56.58	58.63
Total extension semen= volume semen +extender volume, ml	40.00	57.96	60.10
No. of frozen straws (0.5ml)	80.00	116.00	120.00
Total cost of frozen straw, LE	25.00	25.00	25.00
Total price of feeding consumption and cost of frozen straw, LE ^{A}	1978.00	2099.50	2221.00
price of sole frozen straws (No. of frozen straw×80 pounds), LE^{B}	6400.00	9280.00	9600.00
Economic efficiency			
Economic efficiency (EE) amount , $^{B/A}$	3.24	4.42	4.32
Economic efficiency (EE), % $^{B/A\times100}$	324.00	442.00	432.00
****EE (%) relative (EER) to control	100.00	136.42	133.33

* **Total price of feed consumed= cost of CFM+ BH+RS its prices were 20000, 10000, 2000 LE/ ton but maca powder up to 500 LE/ kg at 2021, respectively.**

** **Extension rate=½ × motility.**

**** **EE (%) relative (EER) to control with Grp2 or Grp3= EE (Grp2 or Grp3) – EE of G1÷ EE of Grp1×100 +100 (conceder EE of G1 is 100%).**

Determination of economic efficiency for semen collection

The effects of maca on economic efficiency of G1, G2 and G3 are explained in Table (10). The addition of maca has more semen volume in G2 and G3 let to more semen extension quantity which resulting in amelioration in economic efficiency (EE) amount than G1. As would be expected, greater EE amount and EE% in G2 when using of 50 mg/kg LBW of maca powder than G3 ram.

DISCUSSION

Maca (*Lepidium meyenii* Walp.) is a plant belonging to the *Brassicaceae* family that is native to the Andes of Peru **(Turgud and Narinç, 2022)**. Maca shows high nutritional value **(Korkmaz, 2018)**.

Assaying productive performance of lambs

Live body weight (LBW)

The LBW increased with maca from 60 to180 days of age. In the current result, it was reported that LBW was not affected among G1, G2 and G3 lambs received maca powder at 60- 120 days of age which agree with **(Korkmaz *et al.*,2016)** and **(Turgud and Narinç, 2022)** . According to the LBW at 180 days of age, higher values were found in G2 and G3 lambs (22.64 and 24.64 kg, respectively) than G1 lambs (18.10 kg). Maca let to amelioration of LBW. Finding of, **Vastolo *et al.* (2023)** who seem that the addition of 300 mg of maca to ruminants' standard diet could modulate the rumen fermentation in terms of gas, volatile fatty acid production, antimicrobial activity on specific microbial populations and antioxidant activity which may be caused LBW improving. Additionally, the best LBW in maca lambs reflected several nutritional contains **(Nabil *et al.,* 2023)** that have been widely used as a nutritional supplement, it riches in proteins reflect growing LBW positively.

Determination of DWG, DFI, FCR, PI, PEF and MW

Our studying has been reported that DWG and FCR values of maca lambs are higher than control lambs. Although G1, G2 and G3 lambs were consumed similar amounts of feed, it was determined that G2 and G3 lambs with a higher DWG also had better FCR (Table 4). Improving of LBW and DWG values of the lambs used maca in the study of **Wan *et al.* (2018)**. In accordance with many researches **(Korkmaz *et al.,* 2016, Çetin *et al.,* 2021 and Gül *et al.,* 2022)** that DFI not affected by maca supplementation. It is thought that, the best changing in PI, PEF and MW in maca lambs wing to improving DWG, DFI and FCR. Maca has activity antioxidants function which protect harmful and neutralizing free radicals. In the study performed by **Turgud and Narinç (2022**) it was determined that the addition of maca with it's an antioxidant effects to the rations causes more significant differences in productive performance than control. Generally, **Beharry and Henrich (2018)** declared that maca improved productive parameters and susceptibility of the selected trial model systems.

Determination of testicular dimensions development

Maca has its antioxidant power and ability to improve male reproductive functions **(Tafuri *et al.,* 2019[a])**. The mice of the maca group showed the greatest alterations with a seminiferous tubules with complete spermatogenesis and normal interstitial connective tissue **(Del Prete *et al.,* 2018)**. Also, ultrasound examination with the imaging technique could explore *in vivo* morphology the testis, showed improvement testicular cell membranes in animal fed maca **(Tafuri *et al.,* 2019[b])**. In experimental the transverse sections of the testis **(Greco *et al.*, 2021)** showed the best testicular parenchyma with scattered seminiferous tubules in mice maca groups. The mean of body weight, testicular volume (TV), scrotal circumference (SC) and scrotal length were close association with each other this result is similar to study of **Nazari-Zenouz *et al.* (2016)**. In the current study, increase in both SC and TV was observed from all lamb groups from 2 to 6 months of age with an accompanied increase in body weight of the growing lambs. According to, **Al-Kawmani *et al.* (2017)** who found that increasing in testis diameter, testis length, scrotum circumference and scrotum length between 2 and 6 months of age in lambs. Anyway, there were relationships between all testicular parameters, body weight, testis size and spermatogenesis development in testicular **(Al-Akawmani, 2019)**.

Determination of testosterone level in lambs:

Maca has effect on testosterone concentrations, one of representative hormones regulating male reproductive organs. Thus, **Ohta *et al.* (2016)** have reported that feeding maca from 6 to 8 weeks to male rats, increases serum testosterone and enhances the steroidogenic ability of cultured Leydig cells when compared with

controls. Then in rats, **Yoshida *et al.* (2018)** found that the testosterone production (pg/10^4 cell / 2hours) at 27 weeks of age was 239 and 359, but it was 107 and 172 at 30 weeks of age in control and maca groups, respectively. **Olgun *et al.* (2022)** reported that testosterone levels were 217, 253, 266, 319, 321 and 388, ng/dL when growing quail diets contained maca powder at 0.0, 0.5, 1.0, 1.5, 2.0 and 2.5 g/kg, respectively. According to pervious knowledge for maca analysis had active substances which are clear to affect testosterone production positively **(Smith *et al.,* 2021)**.

Determination of blood serum constituents for lambs

In the current study, among the serum biochemical parameters, creatine, triglyceride and cholesterol were decreased by maca treatments. However, glucose, total protein and globulin concentrations were more affected by the treatments of maca than control. Finding of, **Wan *et al.* (2018)** who found that 300, 600, or 1200 mg/kg maca given high levels of glucose, decreased cholesterol at all levels, while triglyceride concentration increased at all levels except for 300 mg/kg. In another study by, **Olgun *et al.* (2022)** it was reported that blood glucose was 318, 388 and 388 mg/dL, protein at 2.95, 310 and 295 g/dL, globulin up to 1.95, 2.05 and 2.43 g/dL at supplementation different levels maca powder to growing quail diets up to 0, 1.0 and 1.5 g/kg, respectively. Likewise, **Gül et al. (2022)** using maca powder at 0, 1 and 2 g /kg diet could be observed that blood glucose concentration was 293, 294 and 308 mg/dL, protein up to 2.28, 4.95 and 4.25 g/dL and 0.333, 0.333 and 0.346 mg/dL in laying quails, respectively. Regarding the cholesterol and triglycerides levels in growing lambs, the current study could be noticed that decreased ($P<0.05$) in them when 200 and 400 mg /kg LBW of maca powder were used. Concordant to the our present results, **Olgun *et al.* (2022)** who reported that 0, 0.5, 1.0, 1.5, 2.0 and 2.5 g/kg diet could appear blood cholesterol level at 255, 215, 202, 196, 198 and 165 mg/dL while, blood triglyceride up to 244, 259, 304, 183, 158 and 177 mg/dL, respectively. **Gül et al. (2022)** noticed that cholesterol level was 161.80, 173.6 and 137.3 mg/dL and triglyceride reached to 800, 689 and 770 mg/dL in laying quails received maca powder at 0, 1 and 2 g /kg diet, respectively. Moreover in rabbits, **Mona *et al.* (2023)** suggested that lower concentrations of creatinine, cholesterol and triglycerides in the maca rabbits than control.

Coefficients of correlation between feeding and body weight (BW), body weight gain (BWG), testosterone concentrations (TEST), scrotal conformance (SC), testis diameter (TD), testis length (TL) and testis volume (TV) from 60 to 180 days of age in lambs

The current study was conducted to examine the relationship between feeding and BW and testicular measurement traits using Pearson's correlation. Our results firstly showed a highly remarkable relationship between feeding, BW and all the testicular measurement traits. A similar report has been reported by **Esma *et al.* (2021)**. This pilot study appears to extend the knowledge of maca's properties and supports several findings of previous studies. Secondly; the current results suggested the most correlation among BW and all the testicular measurement. Similarly, **Salim *et al.* (2014)** reported that the strong correlation between body weight and testicular measurements which can be used to select rams for breeding programs. Also, **Faith *et al*. (2016)** recorded that rams with larger testicular measurement traits might have larger BW therefore; both BW and testicular measurement traits indicate spermatozoa production. According to**, Faith *et al*. (2018)** in African Dwarf rams indicated that BW had a statistical significant correlation with the TD and SC but not significant with TL. Hence, our findings suggest that BW might be improved by improving TL, TD and SC of rams. A similar report has been reported by **(Tyasi *et al.,* 2023)**.

Assaying reproductive performance for ram
Determination of semen characteristics

Increasing of ejaculate volume is in agreement with **Melnikovova *et al.* (2015)** who highlighted this effect in humans. Also, **Tafuri *et al.* (2019 [a])** recorded that total ejaculates volume was 38.38 and 60.88 ml, sperm concentration reached to124.38 and 178.88 $\times10^6$ and total sperm count was 3.68 and 8.20 $\times10^9$ in control and maca trial stallions, respectively. In addition, **Levano *et al.* (2023)** found that maca sperm motility at 10 mg/mL and 20 mg/mL were greater ($p < 0.05$) than the control group. This reproductive effect of maca can be associated with its antioxidant capacity. Similar results were observed in horses where the dietary supplementation with maca increased sperm production and stabilized semen quality **(Ghaleno *et al.,* 2021)**. Then, the presence of glucosinolates and macamides allows maca to protect sperm cells from oxidative stress damage **(Inoue *et***

***al.,* 2016)** also antioxidant activity of maca could show that maca scavenges free radicals and provides cell protection during oxidative stress. In accord with the present study **Melnikovova *et al.* (2015)** noticed that semen volume (ml), progressive sperm motility (%), sperm concentration×10^6 were 3.66, 47.72 and 77.27 when testosterone concentration was 19.92nmolL^{-1} for control men however, 3.99, 56.20 and 87.80 when testosterone concentration was 20.10 nmolL^{-1} for men has given 350mg maca, respectively. According to **Leiva-Revilla *et al.* (2022)** reported that controlled concentrations of ROS in testes by maca are necessary for proper sperm function, there is also the possibility that ROS clearance may be beneficial to sperm function. Finally, these results may also present interesting economic advantages, as an increased volume of the ejaculate allows preparation of a greater number of frozen straws to be used for artificial insemination (AI) and a greater concentration allows a higher probability of fertilization.

CONCLUSION

This study revealed that maca composition may be responsible for improvement measurement activity in lambs. Moreover, our data showed that maca supplying has positively effected on some reproductive parameters as semen characteristics in rams. This study appears that economic efficiency amount has better ameliorated at using little quantity of maca than high amount of maca.

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الملخص العربى

تأثير إضافة مسحوق الماكا علي الأداء الإنتاجي للحملان المفطومة والأداء التناسلي للكباش

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دراسة تأثير ابتلاع مسحوق الماكا على الحملان والكباش لتقييم الأداء الإنتاجي للحملان والأداء التناسلي للكباش. ولمعايرة الأداء الإنتاجي الحملان تم توزيع ١٥ حمل بعد الفطام بعمر ٦٠ يوم بشكل عشوائي على مجموعات G1 و G2 و G3 (ن = ٥ في كل مجموعة) عند وزن حي (LBW) ٩.٨ كجم. تم إعطاء مستويات ماكا لحملان G1 و G2 و G3 عند ٠، ٢٠٠، ٤٠٠ مجم / كجم من وزن الجسم والمتطلبات الأساسية اليومية حتى عمر ١٨٠ يومًا، على التوالي. كان الفحص LBW، وزيادة الوزن اليومية (DWG)، وتطور كيس الصفن، ومستوى هرمون التستوستيرون ومعايير الدم. لقياس الأداء التناسلي، تم تقسيم ٩ كباش بعمر ١٩ شهرًا عشوائيا إلى G1 و G2 و G3 (n = 3 في كل منهما) كان متوسط وزن الكباش ٥٣.٩٨ كجم. تم فحص خصائص السائل المنوي للمجموعات G1 و G2 و G3 بعد إعطاء ٠، ٥٠، ١٠٠ ملجم / كجم من وزن الجسم بماكا والمتطلبات الأساسية اليومية على التوالي. وفقًا لدراسة إنتاج الحملان حدث تغير إيجابي أكثر في G2 و G3، في LBW و DWB وتطور كيس الصفن ومستوى هرمون التستوستيرون ومعايير الدم من G1 وأظهرت الكباش تحسن بشكل ملحوظ فى خصائص السائل المنوي من الكباش G1 عن G2 و G3. وجد عند قياس الإنتاج والتكاثر الكفاءة الاقتصادية تحسنت مع تقليل مستوى الماكا. خلصت الدراسة الي إن أفضل إنتاجية وقياسات تكاثر حدثت مع الماكا كنظام إمداد غذائي.