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Productive Performance of Growing Barki Lambs Fed on Jojoba Meal under Desert Conditions

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ABSTRACT

The study was carried out in Animal Production Research Unit in the Sustainable Development Center for Matrouh Resources (SDCMR), Matrouh Governorate, belonging to Desert Research Center, El-Matarya, Cairo, Egypt. The main problem of utilizing Jojoba meal as a feed source is the presence of simmondsin as a major toxic compound with other anti –nutritional factors. The main objective of the present study was to assess the influence of replacing (70%) of undecorticated cotton seed meal (CSM) of concentrate feed mixture (CFM) with Jojoba meal (JM) (*Simmondsia chinensis)*, either as untreated JM (UJM) (R2) or treated biologically with lactic acid bacteria (JMB) (R3) or treated chemically with 70% isopropanol (JMI) (R4) on the concentration of anti –nutritional factors ANF's (mainly simmondsin), dry matter intake (DMI), daily gain, digestion coefficients, rumen fermentation, some of blood biochemical parameters and consequently animal performance. Control group (R1) fed on traditional CFM. Twenty four Barki lambs weighed 24 kg 6 months old were used in this experiment. Obtained Results indicated that both treatments (biologically or chemically) showed a positive effect in reducing ANF's while chemical composition of all the experimental rations had comparable values. Detoxified JM with bacteria or with isopropanol showed the highest feed intake as dry matter, crude protein (CP), total digestible nutrients (TDN) and digested crude protein (DCP) with significant differences . Consequently, the average daily gain (ADG) g/h was descendingly arranged as follow : lambs fed on (R4), followed by those fed on (R3), control lambs (R1) then those fed on (R2).The values of DM,TDN and DCP intake /kg gain indicated that lambs fed JMI were the highest , followed by R1 fed lambs then JMB fed lambs, while the least values for lambs fed on UJM. Rumen parameters as pH, ammonia –Nitrogen (NH_3-N) and volatile fatty acids (VFA's) concentrations were affected with treatments. No significant differences were detected in serum metabolites, except that for liver enzymes (AST and ALT). Since both treatments showed elevated activities in all JM fed animals, compared with control one. Generally, the endocrine function tests (T_3 and T_4) showed a significant elevations in lambs fed JM rations either treated or untreated. It could be concluded that, chemical or biological treatments of Jojoba meal with isopropanol or with lactic acid bacteria could offer a good solution for the reduction or elimination of toxic and bitter simmondsin and some of phenolics from Jojoba meal and could be used in animal nutrition without negative effects on animal performance.

Keywords: Jojoba meal, biological treatment ,productive performance, chemical treatment, lambs, anti-nutritional factor.

INTRODUCTION

Owing to the high cost of protein ingredients used for animal feed, nutritionists have to find alternative protein sources to be included for continued efficient animal production. Numerous studies have investigated the potential use of alternative protein sources instead of traditional plant protein meal.

Jojoba, the perennial shrub, is a promising new crop that grows naturally in the Sonora desert (Mexico) and in the South-West of USA *(Mabrouk, et al 2011)*. Jojoba (*Simmondsia chinensis*) is a desert shrub that grow on arid or semi-arid regions is being cultivated to provide a renewable source of a unique high- quality oil (Sabien *et al*., 1997) that is used in the cosmetic and skin care industry (Swezey *et al*., 2000).

Many advantages are favoring Jojoba seed to be grown in Egypt such as a limited water requirement, high seed yield in new reclaimed soils and relatively high oil content (50%) *(El-Kady et al., 2008*).

The remaining meal that left after seed's oil extraction contains from 26% to 33% crude protein (A.O.A.C., 1995) as well as carbohydrate and fiber *(Abou-Raya, 1967)*. Jojoba meal (JM) is underutilized because it contains high levels of some anti-nutritional compounds such as simmondsins, that have adverse effects on animals (NRC, 1985 and Van Boven *et al*., 2000). Simmondsins has been identified as the most responsible food intake inhibition and appetite suppression to rodents, rats, dogs, chickens (Lievens *et al*., 2003) and sheep (Weber and Reid 1975).

Jojoba meal, as a by-product of Jojoba seeds squeeze, is a promising feedstuff after being detoxified (Motawe, 2006). Accordingly, in order to use Jojoba meal as an ingredient for livestock feed, it is necessary to try debittered and detoxify anti-nutritional compounds of JM. In that respect, several studies that tend to give benefit to the by-product; Jojoba press-cake had reported information about chemical and microbiological detoxification methods for elimination of anti-nutritional compounds (simmondsin) found in residual cakes and Jojoba seeds (Elliger *et al*., (1974) and Motawe, 2006) . Other compounds than simmondsin including poly phenolics, phytic acid and trypsin inhibitors, may be contributing to impaired feed intake and body weight gain of animal fed rations containing JM (Abbott *et al*., 2004) . Different methods were reported to reduce these toxic and bitter compounds in JM such as chemical treatments using aqueous isopropanol (Medina and Gonzalez 1990).

There is a considerable attention to evaluate JM as a protein source in animal nutrition . A few published data on the response of ruminants to diet containing JM. Consequently the current experiment was initiated to investigate the effect of a chemical treatment (aqueous isopropanol) and a biological treatment (bacteria strains *Lactobacillus Acidophilus*) on reduction of toxic and bitter components of Jojoba meal and the acceptability of these treated diets to lambs. Also to determine and compare diets containing 70% of treated or untreated Jojoba meal (JM) and 30% undecorticated cotton seed with control one supplied with CFM containing undecorticated cotton seed and their effect on performance, digestibility, blood biochemistry and endocrine functions of growing Barki lambs.

MATERIALS AND METHODS

This study was carried out in Animal Production Research Unit in the Sustainable Development Center for Matrouh Resources (SDCMR), Matrouh Governorate, belonging to Desert Research Center, El-Matarya, Cairo, Egypt. In the experimental rations, Jojoba meal (JM) either untreated or treated (chemically or biologically) was replaced 70% of the undecortecated cotton seed meal of rations R2, R3 and R4 , respectively . Jojoba meal (JM) samples without testa were supplied by the Egyptian Natural Oil Company (Private Sector)

Animals and feeding management

Twenty eight growing Barki lambs, weighing 24.56 ±2.19 kg 6 months old, were equally divided into four groups (7 animals /group) according to live body weight and allocated to one of four dietary treatments. The growth (fattening) trial lasted for 120 days . The composition of experimental feed mixtures (CFM) and ingredients are shown in Table (1) and (2). All ingredients of each ration were mixed well. The CFM and roughage were offered according to Kearl (1982) recommendations in separate fodder to each group. Animals were fed in groups. Animals received the experimental diets for 105 days followed by a 15- day for running digestibility trials. Fresh water and mineral blocks were freely available at all times. The experimental animals fed on rations composed of CFM and berseem hay only (R1), while about 70% of cotton seed meal replaced by untreated Jojoba (UJM) (R2) or replaced by treated Jojoba with bacteria (JMB) (R3) or by treated Jojoba with isopropanol (JMI) (R4). The experimental lambs were individually weighed bi-weekly and offered feeds were weekly adjusted according to changes of body weight.

Table 1. Feed ingredients (%) used for formulation of the experimental concentrate feed mixtures (% on dry matter basis)

Ingredients:	CFM	CFMU	CFMB	CFMI
Yellow corn	53	53	53	53
Wheat bran	10	10	10	10
Soybean	10	10	10	10
Cotton seed meal	20	6	6	6
UJM	-	14	-	-
JMB	-	-	14	-
JMI	-	-	-	14
Molasses	4	4	4	4
Limeston	1.5	1.5	1.5	1.5
Salt	1	1	1	1
Mineral premix	0.5	0.5	0.5	0.5

CFM: Concentrate feed mixture of control group
CFMU: CFM containing untreated Jojoba meal (70% of CFM)
CFMB: CFM containing treated Jojoba meal with lactic acid bacteria (70% of CFM)
CFMI: CFM containing treated Jojoba meal with Isopropanol (70% of CFM)

Table 2. Proximate chemical analysis and fiber fractions of feed ingredients (on DM basis %)

Item	on DM basis											
	DM	Ash	OM	CP	CF	EE	NFE	NDF	ADF	ADL	Hemicellulose	Cellulose
Yellow corn	88.0	1.40	98.6	7.70	2.30	3.80	84.8	32.63	22.45	2.13	10.18	20.32
Wheat bran	88.0	6.0	94.0	15.0	11.0	4.0	64.0	44.21	32.16	4.05	12.05	28.11
Soybean meal	89.0	4.5	95.5	44.0	6.0	2.92	42.58	34.18	26.2	6.84	7.98	19.36
Cotton seed meal	92.0	6.7	93.3	24.0	23.0	6.0	40.3	36.0	27.1	14.0	8.9	13.1
Molasses	75.0	9.8	90.2	4.4	0.0	0.1	85.7	-	-	-	-	-
UJM	93.86	4.76	95.24	28.07	9.41	16.5	41.26	32.21	26.72	15.49	5.49	11.23
JMB	93.29	4.4	95.6	29.15	8.67	16.18	41.6	33.24	28.78	16.15	4.46	12.63
JMI	90.76	5.96	94.04	25.71	6.05	15.16	47.12	23.14	18.35	8.77	4.79	9.58

DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract
NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin Hemicellulose= (NDF-ADF)
Cellulose= (ADF-ADL) JM U: untreated Jojoba meal JMB :treated Jojoba meal with bacteria
JMI: treated Jojoba meal with Isopropanol

Digestibility Trials:

At the end of the experiment the digestibility trials were carried out using the same experimental lambs (4 animals in each group were used). Animals were kept in individual metabolic cages. The first ten days of the digestibility trial were devoted as an adjustment period. The weighed tested CFM 's were offered daily at 8.00 am and berseem hay at 12.00 pm. Measured amounts of drinking fresh water were left free choice for all animals. Drinking water was determined for each animal daily. Total digestible nutrients (TDN) and digestible crude protein (DCP) of the different experimental rations were calculated and offered according to Kearl (1982) recommendations.

Detoxification methods:

Biological treatments (Lactic acid bacteria treatment):

Jojoba meal was treated with brand inoculants provided by Microbiology research unit , Desert Research Center. They mixed with diluted molasses in a barrel to mix all components well . Thereafter the mixture was forced in a big clean plastic bags and pressing on them to repel air . The bags sealed and kept incubated for 30 days at room temperature for anaerobic fermentation. At the end of incubation period , it dried in air. The treated JM with bacteria (JMB) mixed with rations in place of 70% undecortecated cotton seed meal for ration (R3) then fed to animals .

Chemical treatments (Isopropanol treatment):

Jojoba meal was sprayed by (70%) aqueous solution of isopropanol to inactivate simmondsin and other anti-nutritional factors . They mixed with diluted molasses in a barrel to mix all components well. After that the treated JM was forced in a big clean plastic bags and pressing on them to repel air . The bags sealed and kept incubated for 30 days at room temperature for anaerobic fermentation. At the end of incubation period, it dried in air at room temperature as described by Medina and Gorzalez (1990). The treated JM with isopropanol (JMI) mixed with rations in place of

70% undecortecated cotton seed meal for ration (R4) then fed to animals .

Analytical methods:

Proximate chemical analysis for all feed ingredients, refusals, fecal samples and urine were determine according to the standard (A.O.A.C.,1997), methods. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by Goering and Van Soest (1970). Cellulose and hemicellulose were calculated by difference.

Anti-nutritional factors (ANF) analysis:

Qualitative and quantitative estimation of condensed tannins (CT), saponins (Sap) and simmondsin as the main ANF's in all feed ingredients was carried out by Porter *et al.* (1986), Okwu and Ukanwa (2007) and Elliger *et al.* (1973), respectively.

Ruminal liquor and blood parameters:

Rumen liquor was withdrawn by stomach tube just after the end of the collection period before feeding, and at 3 and 6 hrs post feeding. The pH of rumen liquor was immediately recorded using Gallen Kamp pH Stick pH K-120 – B. Rumen liquor samples were analyzed to determine total volatile fatty acids (TVFA 's) according to Warner, (1964) and ammonia – nitrogen (NH3) according to (A. O. A. C. 1997) methods.

Biochemical and Hormonal Assay:

Blood samples were collected at 2 hours before morning feeding. All serum samples were analyzed for triglycerides (Trinder, 1969), cholesterol (Roeschlau *et al.*, 1974), total lipids (Schmit, 1964), high density lipoprotein-cholesterol (HDL-C) (Trinder, 1969) , low density lipoprotein- cholesterol (LDL-C) (Friedwald *et al.*, 1972) total protein (Reinhold, 1953), albumin (Rodkey, 1965), globulin was obtained by subtracting the total proteins values from the albumin values. Urea –N (Berthelot, 1959), creatinine (Seelig and Wust, 1969), ammonia (Konitzer and Voigt , 1963), alanine amino transferase (ALT) and aspartate amino transferase (AST) (Wilkison *et al.*, 1972). All kits used from Human Co. (Germany) using Jenway spectrophotometers (UK).

Sera were also analyzed for triiodothyronine (T3) and Thyroxin (T4) using Enzyme Immunoassay test kit (Monobind, INC, Costa Mesa, CA 92627, USA)nd Elisa Reader Stat Fax-2100, according to Braveman (1996) .

Statistical analysis:

Analysis of variance (ANOVA) was used to test the obtained data using the general linear modeling procedure (SAS, 2000). The used design was one way analysis. Duncan 's multiple tests (1955) were applied for comparison of means .

RESULTS AND DISCUSSION

Chemical composition:

The proximate analysis of feed ingredients is shown in Table (3). Treatment of JM with bacteria (JMB) resulted in an increase in crude protein (CP) content by 3.84% , while it decreased by about 9.41% in JM treated with isopropanol (JMI) . Khalel *et al*. (2008) reported the same pattern of CP of JM. It was noticed that CP content of all JM 's UJM, JMB and JMI, (28.07%, 29.15% and 25.7%, respectively) was associated with a lower crude fiber (CF) contents (9.41, 8.67 and 6.05% , respectively). These low levels of CF of all JM 's would increase it's nutritive value for ruminants . The present results are in general agreement with those reported by Sobhy *et al*. (2003) and El-Kady *et al* (2008) and Swingle *et al*. (1985). Also, it was noticed that JM had the superiority for CP content when compared with other tested materials such as cotton seed meal, yellow corn, wheat bran, while soy bean meal was higher than JM. The moisture content of UJM was less than 6% indicating the possibility of storing such material for long time. Ash contents were comparable among all JM 's . Ether extract (EE) of UJM (16.5%) showed wide variations with other published values . These variations in EE could be attributed to the differences in steps of oil removal from JM. However, variations in chemical composition of JM with the reported values could be attributed to the different varieties of jojoba used, the oil extraction procedures and even the size of seed (El-Sherbiny *et al*., 1994). Fiber fractions: neutral detergent fiber (NDF), acid detergent fiber (ADF) , acid detergent lignin (ADL), cellulose and hemicellulose showed the least values in JMI. This fact was corresponding to that of the least CF of it as well.

The chemical analysis of the concentrate feed mixtures and berseem hay are shown in Table (3). It wsa clear that the replacement of 70% cotton seed meal by JM slightly influenced the chemical composition of the rations. The most important change is slight increase in CP and decrease in CF. These differences among the experimental rations could be attributed to the replacement of cotton seed meal with JM. Similar findings were reported by Khalel *et al*. (2008) and El-Kady *et al*. (2008).

Table 3. Chemical analysis of the concentrate feed mixtures and Berseem hay (on DM basis,%)

Item	Experimental group lambs				Berseem hay
	CFM	CFMU	CFMB	CFMI	
DM	93.72	93.84	93.24	94.85	92.13
Ash	7.04	5.86	6.18	6.12	15.21
OM	92.96	94.14	93.82	93.88	84.79
CP	16.82	17.35	17.6	17.06	16.98
CF	5.66	4.7	4.23	3.6	28.10
EE	3.88	4.81	5.63	5.26	2.12
NFE	66.6	67.28	66.26	67.96	37.59
NDF	34.46	43.34	32.6	32.34	41.53
ADF	19	18.41	18.64	18.13	38.72
ADL	3.02	2.31	3.23	3.0	13.45
Hemicellulose	15.46	24.93	13.96	14.21	2.81
Cellulose	15.98	16.1	15.41	15.13	25.27

DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin CFM: Control concentrate feed mixture
CFMU: CFM containing untreated Jojoba meal CFMB:CFM containing treated Jojoba meal with bacteria
CFMI: CFM containing treated Jojoba meal with isopropanol

Anti-nutritional factors:

Data in Table (4) indicated that all treatments had positive effect in decreasing concentration of anti-nutritive compounds. Most detoxification studies on Jojoba have focused on the extraction or transformation of simmondsin as the principal toxic constituent. Other components may contribute to the toxicity and unpalatability of Jojoba seed and meal (Medina and Gonzalez, 1990). Treatment with bacteria reduced the concentration of simmondsin as the major compound by about 96.2% , condensed tannins (CT) by 27.6% and saponins by 61.3 % . Swingle *et al*. (1985) noticed that, the microbiological treatment effectively reduced the concentrations of major toxicants in JM. They also confirmed that fermentation of JM with *lactobacillus acidophilus* clearly improved its palatability and acceptability to ruminants . These findings are in agreement with the earlier observations of Nelson *et al*. (1979) with lambs. This effect was not due entirely to the reduction in simmondsin and related compounds because several other methods also effectively reduce their concentrations in JM but don't improve palatability of meal (Verbiscar *et al*., 1980). Swingle *et al*. (1985) expected that the microbiological method used to treat JM in their study act to reduce the concentration of cyano- containing compounds and may also modify the content or activity of some other as yet unidentified, intake depressing fractions. Detoxification of JM with aqueous isopropanol removed most of simmondsin by 98.2% and reduce CT and saponins by 54.3% and 79% ,respectively. These results are in harmony with that reported by Khalel *et al*. (2008). Moreover, the same author reported that incubation of JM with lactic acid bacteria decreased simmondsin and polyphenolics by about 97% and 73% , respectively. Swezey *et al*. (2000) confirmed that fermentation of JM with lactic acid bacteria effectively reduced concentration of simmondsin. Medina and Gonzalez (1990) hypothesized that the elimination of simmondsin and phenolic compounds with isopropanol improved the acceptability of the products as well as detoxifying them . Many phenolic compounds have bitter and astringent tastes (VanSumere *et al*., 1975). So, Medina and Gonzalez (1990) noted a lack of bitterness in the detoxified Jojoba products. They also explained that reduction of simmondsin content of the more polar solvents, exemplified by the differences in extractability with pure and 70% isopropanol.

Table 4. Concentration of anti – nutritional factors of treated and untreated Jojoba meal compared to Berseem hay (on DM basis %)

Item	Jojoba meals			Berseem hay
	UJM	JMB	JMI	
Simmondsine mg %	5.0	0.19	0.09	n.e.
Saponins g%	8.58	3.32	1.8	n.e.
CT mg%	7.18	5.20	3.28	1.58

UJM: untreated jojoba meal ; JMB: jojoba meal treated with bacteria ; JMI: jojoba meal treated with isopropanol
CT: condensed tannin; n.e: not evaluated

Feed and water intakes during digestibility trials:

Nutrients intake values expressed in terms of DM, CP, OM, CF, EE, NFE, NDF, ADF and ADL (g/kg BW) presented in Table (5) are significantly different among experimental groups, except that of NDF intake since the differences were not significant. Lower values were recorded for animals fed on R2, while animals fed on R3, R4 and R1 showed comparable values. Only the non significant differences are observed between animals fed R2 and those fed on R4 in CF intake and between R2 group, R3 and R4 ones in CP intake. The rejection of UJM supplemented rations was related to the presence of traces of simmondsin and other secondary metabolites that negatively affecting ration palatability. Previous studies with calves, sheep and rats reported that animals avoided consuming Jojoba particles (Verbiscar *et al*., 1981). These data confirmed by previous findings reported by Medina and Gonzalez (1990) who hypothesized that the elimination of phenolic compounds and simmondsins with isopropanol improved acceptability of the products as well as detoxifying them and also they lacked the bitterness.

Trei *et al*. (1979) and El-Kady *et al*. (2008) agree with these data with lambs and sheep and extend them to cattle i.e. UJM has a depressing effect on feed intake by ruminants as it does in non- ruminants. Lambs appear to be more sensitive to or at least more responsive to appetite depressing factors in JM. Also, Cokelaere *et al*. (1995) concluded that simmondsin induced feed intake reduction by stimulating satiation.

The current results indicated that feed intake of all nutrients expressed as g/kg BW were improved with biological and chemical treatments as recorded in lambs fed R3 and R4 while reduced in lambs fed R2. The reduction of nutrient intakes in R2 could be attributed to the presence of the highest concentration of CT and saponins as mentioned before in Table (4).

Lambs fed JMB (R3) and those fed JMI (R4) consumed the highest amount of water, compared with R1 without significant differences when water intake expressed as ml / kg BW. However, significant differences were recorded when water intake expressed as ml /g DMI and there was an inverse relationship between DMI and the amount of water Table (5) .

These findings may be due to animals tend to consume more water to get ride of anti-nutritional factors in JM as simmondsin, tannins and saponins. Drinking water pattern matched with feed intake pattern. Similar findings were recorded by El-Kady *et al*. (2008).

Table 5. Dry matter , nutrients and water intakes by the experimental group lambs as affected by tested rations during digestibility trials

Item	Experimental group lambs				± SE
	R1	R2	R3	R4	
*Average body weight, kg	34.43	35	35.33	38.63	2.17
Feed intake, g/head/day as DM	1131.7[ab]	882.3[c]	1081.3[b]	1208.1[a]	29.22
Feed intake, g/kg BW as:					
DM	32.82[a]	25.21[b]	30.60[a]	31.27[a]	1.44
CP	5.53[ab]	4.34[b]	6.02[a]	6.77[a]	0.39
OM	29.82[a]	22.97[b]	29.33[a]	28.59[a]	1.02
CF	3.76[a]	3.09[c]	3.47[ab]	3.21[bc]	0.11
EE	1.13[b]	1.0[b]	1.51[a]	1.38[a]	0.05
NFE	19.41[a]	14.56[b]	18.78[a]	18.68[a]	0.67
NDF	11.96	10.84	11.29	10.90	0.42
ADF	7.93[a]	6.31[b]	7.76[a]	7.42[a]	0.25
ADL	1.88[a]	1.49[b]	1.94[a]	1.83[a]	0.06
Water intake, as:					
Drink water ml/head/day	3172	3060	3508	3732	205.05
ml /kg BW	91.99	87.43	99.29	96.79	4.30
ml / g DMI	280.3[b]	346.8[a]	324.4[ab]	308.9[b]	13.39

a, b, c and d : values with different letters in the same row means statistically significant at P<0.05
DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin
R1: control group (Berseem hay + CFM)
R2: group fed on CFM containing untreated Jojoba meal UJM + Berseem hay
R3: group fed on CFM containing treated Jojoba meal with bacteria JMB +Berseem hay
R4: group fed on CFM containing treated Jojoba meal with isopropanol JMI + Berseem hay

Nutrients digestibilities and nutritive values of the experimental rations:

All nutrients digestibilities showed significant differences among the tested animals groups (Table 6).

Lambs fed R2 recorded the lowest digestibilities, while data of control animals are comparable with those recorded by animals fed R3 and R4 . As a result , nutritive value of R3 and R4 is better than that of R2. These improvements are confirmed by higher TDN and DCP as g/kg BW/day or as % and higher metabolizable energy (ME) in lambs fed R3 and R4, while animals fed on R2 showed the least nutritive value. The obtained results are in harmony with those reported by Khalel *et al.* (2008) who found that the improvement in nutrients digestibility followed the biological and chemical treatments could be a result of better feed intake and nutritive value. Other studies concluded that, as DM intake increased, apparent digestibility decreased in sheep which could be due to higher rumen turnover rates observed in both sheep and cattle (Mulligan *et al*., 2001). Nelson *et al*. (1979) reported that fermentation of JM clearly improved its palatability, acceptability and digestibility coefficients to ruminants. Moreover, Swingle *et al*. (1985) showed that treated JM with *lactobacillus acidophilus* minimized palatability problem but the ration with treated JM was less digestible and did not support the same level of animal performance as ration containing cotton seed meal (CSM).

Table 6. Nutrient digestibility and nutritive values of the experimental rations

Item	Experimental group lambs				± SE
	R1	R2	R3	R4	
Nutrient digestibilities %:					
DM	71.59[a]	67.56[b]	73.97[a]	73.75[a]	0.77
OM	73.88[a]	69.75[b]	75.43[a]	75.56[a]	0.69
CP	67.16[b]	61.81[c]	69.46[b]	73.41[a]	0.75
CF	57.61[b]	59.53[b]	64.56[a]	64.20[a]	0.91
EE	78.21[a]	73.53[b]	77.09[a]	79.07[a]	0.81
NFE	78.68[a]	74.02[b]	80.27[a]	79.95[a]	0.74
NDF	63.68[a]	66.29[ab]	67.63[a]	66.89[ab]	1.02
ADF	55.40[b]	57.29[b]	61.21[a]	62.08[a]	1.07
ADL	35.06[b]	37.11[b]	44.04[a]	46.18[a]	1.48
Nutritive values:					
TDN %	70.45[b]	67.22[c]	75.74[a]	78.03[a]	0.88
TDN g/head/day	797.3[b]	593.1[c]	819.0[b]	942.7[a]	14.46
TDN g/kg BW/day	23.12[a]	16.95[b]	23.18[a]	24.40[a]	0.91
ME, M cal kg/DM	28.70[b]	21.35[c]	29.48[b]	33.93[a]	0.52
DCP %	11.32[c]	10.64[c]	13.71[b]	15.88[a]	0.57
DCPg/head/day	128.1[c]	93.91[d]	148.28[b]	191.9[a]	3.88
DCP g/kg BW/day	3.72[b]	2.68[c]	4.20[ab]	4.97[a]	0.26

a, b, c and d : values with different letters in the same row means statistically significant at(P<0.05)
DM: dry matter; OM: organic matter; CP: crude protein; CF: crude fiber; EE: ether extract; NFE: nitrogen free extract ; NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin; TDN: total digestible nutrients; DCP: digestible crude protein; ME,,M cal/ kg DM = (TDN/ head × 3.6) /100 (Church and Pond, 1982).
R1: control group (Berseem hay + CFM)
R2: group fed on CFM containing untreated Jojoba meal UJM + Berseem hay
R3: group fed on CFM containing treated Jojoba meal with bacteria JMB +Berseem hay
R4: group fed on CFM containing treated Jojoba meal with isopropanol JMI + Berseem hay

Productive performance:

Productive traits of lambs fed tested rations are illustrated in Table (7). Animals fed on R4 gained the highest weight (g) followed by control animals , animals fed on R3 and finally those fed on R2. Although differences are not significant but this result indicated that R4 and R3 are good rations as control traditional ration. The increment in body weight is matching with the corresponding data of DMI in the same animals group. Indeed, animals fed R2 recorded the lowest final body weight and showed the same pattern for DMI. These results could be explained by Verbiscar *et al*., (1981) who reported that simmondsin is broken its aglycon in the intestinal tract by the intestinal bacteria and the aglycon (or its derivatives) is responsible for the feed intake reduction. This aglycon is less hydrophilic and could possibly cross the intestinal wall more easily (El-Kady *et al*., 2008). Medina and Gonjalez (1990) hypothesized that the death and weight loss of rats fed jojoba meal is not due solely to the simmondsin. Phenolic compounds, a trypsin inhibitor and phytic acid are some of the compounds that have been proposed to be toxic constituents (Storey *et al*., 1983 ; Wiseman , 1983). On the other hand, Flo *et al*. (1999) found that simmondsin may increase brown adipose tissue and metabolic rate by stimulating thyroid production which cause lower feed efficiency and decrease growth rate. So untreated JM did not support normal growth of lambs. Van Boven *et al*. (1994) reported that the growth retardation caused by JM supplementation was provoked by an inhibition of appetite linked with the simmondsin content of JM and anti – nutritional compounds affecting digestibility. The present data were in harmony with findings reported by Khalel *et al.* (2008) and El – Kady *et al*. (2008). However, Nagoupay *et al*. (1985) found that JM failed to support normal growth of rabbits. Negative results were also recorded by Manos *et al.* (1986) where they noticed that ewes fed 10% JM and whether fed 5 or 10% JM showed lower weight gain than the control but the differences were not significant. The best values of average daily gain (g/h) (ADG) and DMI are recorded descendingly as follow lambs fed on R4, lambs fed on R1, lambs fed on R3 then lambs fed on R2. Consequently, an improvement in nutritive value were recorded among experimental animal groups in terms of TDN and DCP. Lambs fed on R4 showed highest values of TDNI and DCPI followed by lambs fed on R3 , R1 and the least value was regarded in lambs fed on R2. This improvement attributed to reduction of simmondsin and phenolic compounds in treated JM. Manos *et al*. (1988) and Sabien *et al*. (1997) confirmed our data where they concluded that the presence of tannins and phytate in JM induces an increase in plasma thyroid hormone concentration and reducing feed efficiency. Feed conversion values were slightly differ among groups. The differences were comparable among groups in terms of TDN and DCP.

Table 7. Growth performance and feed conversion of the experimental lambs fed tested rations

Item	Experimental group lambs				± SE
	R1	R2	R3	R4	
Initial body weight, kg	24.40	24.73	24.30	24.83	2.19
Final body weight, kg	43.17	40.76	42.86	44.57	2.61
Total gain, kg	18.77[ab]	16.03[b]	18.56[ab]	19.74[a]	1.04
ADG (g/h)	156.4[ab]	133.6[b]	154.6[ab]	164.5[a]	8.71
Relative gain (%of initial weight)*	76.92[a]	64.82[a]	76.37[a]	79.50[a]	7.07
Feed intake , g/head/day:					
Concentrate	773	594	785	809	-
Roughage	665	636	665	696	-
TDMI	1438	1230	1450	1505	-
Concentrate : Roughage	54:46	48:52	54:46	54:46	-
TDNI	1013.1	826.8	1098.2	1174.4	-
DCPI	162.8	130.9	198.8	239.1	
Feed conversion (kg intake/ kg gain) of :					
Dry matter	9.19	9.20	9.38	9.15	-
TDN	6.48	6.19	7.10	7.14	-
DCP	1.04	0.980	1.28	1.45	-

a, b, c and d : values with different letters in the same row means statistically significant at P<0.05
***Relative gain (% of initial weight) = Gain / initial weight × 100**
ADG: average daily gain ; TDN: total digestible nitrogen ; DCP: digestible crude protein
R1: control group (Berseem hay + CFM) R2: group fed on CFM containing untreated Jojoba meal UJM + Berseem hay
R3: group fed on CFM containing treated Jojoba meal with bacteria JMB +Berseem hay
R4: group fed on CFM containing treated Jojoba meal with isopropanol JMI + Berseem hay

Rumen parameters:

Results of ruminal pH values, volatile fatty acids (VFA's) and ammonia nitrogen (NH3-N) concentrations are presented in Table (8). Data of ruminal pH revealed that values were not affected significantly by the dietary treatments at zero time and slightly affected after 3 and 6 hours with non significant differences among R2 ,R3 and R4 groups were observed, but significant when compared with control one. The highest values of ruminal pH for all dietary treatments were recorded before feeding ,while the minimum were observed at 3 and 6 hrs post feeding . The decrease in pH values at 3 and 6 hrs post feeding could be mainly due to increase in VFA's concentrations in the rumen at that time . The overall average of ruminal pH was significantly higher for groups R2, R3 and R4 than the control (R1).

The lowest ruminal NH_3-N and VFA's concentrations were recorded at zero time and tended to increase thereafter being the highest at 3 hrs post feeding . Based on the Data of overall average ,the highest ruminal

NH_3-N and VFA's concentrations were recoded with R1, R4 and R3, while the lowest values were obtained with untreated group (R2). Complexing of protein in the untreated group with anti-nutritional factors (Tannins and saponins) may be accompanied by a corresponding reduction in nitrogen digestibility. Moreover, lower CP digestibility value in R2 group as well as higher values in R4, R3 and R1 could be supporting this concept (Table 6) . Similar results have been reported by Swingle *et al.* (1985) and Hassan (2009).

Table 8. Rumen parameters of lams fed the experimental rations

Items	R1	R2	R3	R4	± SE
pH					
Zero time	7.18	7.43	7.43	7.50	0.106
3hr	6.30^{b}	6.68^{a}	6.80^{a}	6.77^{a}	0064
6hr	6.45^{b}	7.02^{a}	6.90^{a}	6.80^{ab}	0.124
Overall average	6.64^{b}	7.04^{a}	7.04^{a}	7.02^{a}	0.081
NH_3-N (mg/100ml)					
Zero time	14.47^{a}	13.35^{c}	12.57^{bc}	12.86^{b}	0.457
3hr	15.11^{ab}	13.97^{c}	14.83^{bc}	15.96^{a}	0.321
6hr	14.60^{a}	12.21^{b}	13.04^{ab}	13.56^{ab}	0.568
Overall average	14.72^{a}	12.51^{c}	13.48^{bc}	14.13^{ab}	0.356
TVFA's (meq/100ml)					
Zero time	13.66^{a}	11.09^{b}	$12.01.^{ab}$	12.44^{ab}	0.516
3hr	17.71^{a}	15.88^{b}	16.57^{ab}	17.15^{ab}	0.470
6hr	15.94^{a}	$12\text{-}85^{b}$	13.81^{b}	14.59^{ab}	0.541
Overall average	15.77^{a}	13.27^{c}	14.13^{bc}	14.73^{ab}	0.360

a, b, c and d : values with different letters in the same row means statistically significant at(P<0.05)
TVFA's: total volatile fatty acids NH_3-N : Ammonia nitrogen
R1: control group (Berseem hay + CFM)
R2: group fed on CFM containing untreated Jojoba meal UJM + Berseem hay
R3: group fed on CFM containing treated Jojoba meal with bacteria JMB +Berseem hay
R4: group fed on CFM containing treated Jojoba meal with isopropanol JMI + Berseem hay

Blood Biochemistry:

Blood metabolites and hormonal analysis Table (9) were carried out to monitor nutrient status among lambs fed the experimental rations. The present data showed no significant variations among animal groups in all serum metabolites , except liver enzymes alanine amino transferase (ALT) and aspartate amino transferase (AST), blood ammonia and triglycerides. The elevated enzymatic profile indicated hepatotoxicity. This elevation could be attributed to tannin content of the diet. Reed (1995) and Silanikove *et al*. (1996) reported hepatotoxicity and elevated AST in goats and cattle fed on tanniferous forages, while Romero *et al.* (2000) did n't find such elevation. Elevated AST may be due to muscle dystrophy (Fitcher, 1993). The present results corroborated previous suggestions (El – Kady *et al.* 2008; Manos *et al.* 1986 and Sobhy *et al.* 2003) that they explained the elevated enzymatic profile to problems in liver or damage to a variety of tissues in lambs fed 20% and 30% JM rations which increased blood levels of ALT and AST.

Data in Table (9) there were noticeable but non significant increase in urea-N in lambs fed UJM (R2) as compared with the corresponding studied animals. These findings were in accordance with data reported by El –Kady *et al*. (2008).

There are contradictory findings regarding the effect of JM on blood urea-N. Manos *et al.* (1988) recorded a significant decrease in blood urea –N in lambs fed 10% JM rations, while Sobhy *et al*. (2003) reported a significant increase in blood urea—N in rats fed 3% and 6% JM diets. This increment could be explained by a relative protein shortage as a result of feeding on JM rations which results in breakdown of body tissues to compensate the animals nutritional needs. The breakdown of the body proteins provides this but at the expense of muscle mass and the release of nitrogenous compounds which increase blood urea – N (Payne and Payne, 1987). The present results of creatinine levels showed the same trend with non significant variations . El – Kady *et al*. (2008) agreed with the present results. Concerning serum ammonia concentrations, it recorded significant variations among groups showing the highest values in R1, R4, R3 then R2 at last. Total protein (TP), albumin and globulins levels in addition to total cholesterol, high density lipoprotein (HDL-cholesterol), low density lipoprotein (LDL- cholesterol) and total lipids levels recorded comparable values among lambs of all the studied groups so, ration type had no effect on these parameters. The current results of triglycerides (TG) were affected significantly with isopropanol in R4 where alcohol may be reduce the concentrations of TG. These findings disagreed with El – Kady *et al.* (2008) who reported elevation in total cholesterol and TG levels in lambs fed 30% JM ration. Flo *et al*. (1999) and Sobhy *et al*.(2003) attributed elevation in lipid profile in lambs fed high levels of JM in ration (30%) to different levels of JM in rations. However , Rose *et al.* (1994) attributes this elevation in lipids to mobilization of fatty acids from fat depot which may be due to release of cortisol in response to the stress of nutrition. Indeed tannin and saponin may contribute to the present results where Potter *et al.* (1993) and Matsura (2001) reported that saponin from different sources causing low serum cholesterol levels in a variety of animals as several dietary saponins have a hypocholesterolamic action (Francis *et al*., 2002). Moreover, saponin causes a delaying of intestinal absorption of dietary fat by inhibiting pancreatic lipase activity (Han *et al*., 2000).

On the other hand, tannins play a considerable role in lipids digestibility by complexing with fatty acids (Romero *et al*., 2000) causing a decrease in cholesterol absorption and increase in fat excretion (Bravo *et al*.,1993).

The endocrine function tests included analysis of thyroid hormones triiodothyronine (T_3) and Thyroxin (T_4) in lambs fed the experimental rations. Serum T_3 level showed slight non-significant increase in lambs fed control ration, UJM and lambs fed JMI as compared with those fed JMB. Similar trend have been observed for $T4_{level}$ since it was slightly non significantly increased in lambs fed UJM as compared with other animal groups. Amouts *et al*. (1993) found such hormonal elevation in poultry and Cokelaere *et al*. (1993) and Flo *et al*. (1999) and (1998) found that in rats where they recorded that simmondsin reduces the body weight due to its effect on thyroid hormones and insulin. The increment of T_3 and T_4 could be explained by a relative protein shortage induced by simmondsin (Rothwell *et al*., 1982), and it is an indicator of high heat production (Buyse *et al*., 1992). High energy dissipation causes decreased food efficiency (Tulp *et al*., 1979) which explains the emaciating effect of JM. On the other hand Gueorguieva and Gueorguieva (1997) reported that the serum cholesterol levels generally inversely proportional with thyroid activity but the present results didn't support this results where there was no correlation between these hormones and cholesterol levels as previously demonstrated by Nazifi *et al*. (2007) in sheep and goats.

Table 9. Effect of feeding experimental rations on blood biochemical and hormonal changes of the experimental groups.

Item	Experimental group lambs				± SE
	R1	R2	R3	R4	
Biochemical parameters:					
Urea mg/dl	50.55	53.22	48.35	50.43	4.32
Creatinine mg/dl	1.27	1.48	1.13	1.54	0.14
Ammonia	489.70^{a}	307.17^{c}	361.52^{bc}	410.40^{b}	19.05
Total protein g/dl	6.26	7.03	6.69	6.48	0.33
Albumin g/dl	4.04	4.35	4.09	4.07	0.10
Globulin g/dl	2.22	2.68	2.60	2.41	0.34
AST U/l	77.0^{b}	90.75^{ab}	89.50^{ab}	97.0^{a}	4.74
ALT U/l	22.50^{b}	23.75^{ab}	27.50^{a}	26.0^{ab}	1.28
Total cholesterol mg/dl	77.32	82.71	76.65	78.41	7.0
Triglycerides mg/dl	54.04^{a}	55.35^{a}	54.14^{a}	44.58^{b}	3.97
HDL-cholesterol mg/dl	57.24	53.54	58.13	53.41	2.22
LDL-cholesterol mg/dl	76.97	82.73	76.30	78.06	7.0
Total lipids	270.93	245.82	258.64	268.40	11.08
Hormonal parameters:					
T_3 ng/ml	1.250	1.242	1.221	1.234	.007
T_4 µg/ml	1.402	1.415	1.409	1.411	0.002

R1: control group (Berseem hay + CFM)
R2: group fed on CFM containing untreated Jojoba meal UJM + Berseem hay
R3: group fed on CFM containing treated Jojoba meal with bacteria JMB +Berseem hay
R4: group fed on CFM containing treated Jojoba meal with isopropanol JMI + Berseem hay
a, b, c and d : values with different letters in the same row means statistically significant at P<0.05

Economic efficiency:

Data regarding the feed cost /h/day, the cost /Kg TDN and Kg DCP are presented in Table (10). The results showed that rations R2, R3 and R4 decreased feed cost /h/day by 15.44, 8.08 and 3.43% respectively compared with control ration (R1) i.e. UJM, JMB and JMI were cheaper than the control ration. The average feed cost of one Kg TDN was 5.79, 5.13, 4.94 and 5.05 L.E. for rations R1, R2, R3 and R4, respectively. The lowest cost was recorded for R3 followed by R4. The results revealed that treatments R3 and R4 decreased feed cost of kg TDN by 14.68% and 12.78%, respectively and reduced the cost of kg DCP by 24.6% and 31.3%, respectively comparing with R1. The present findings are in harmony with those reported by Khalel *et al*. (2008).

Table 10. Effect of using Jojoba meal on the economic evaluation of the experimental rations fed to lambs

Item	Jojoba meal			
	R1	R2	R3	R4
Feed Cost (L.E)/ head/day	4.08	3.45	3.75	3.94
Cost of 1 kg DMI (L.E)	3.61	3.91	3.46	3.26
Cost of 1 kg TDN (L.E)	5.79	5.13	4.94	5.05
Cost of 1 kg DCP (L.E)	36.08	32.44	27.19	24.77

Egyptian pound (L.E.) per ton at 2015,berseem hay = 2000L.E/ton
Cotton seed=5500 L.E/ton yellow corn=3500 L.E/ton wheat bran=3100L.E/ton
Soy bean=7200 L.E/ton Jojoba meal=1000L.E / ton Molasses=2.5 L.E Kg

CONCLUSION

It is concluded that , the processing methods of Jojoba meal with isopropanol or with bacteria resulted in reduction of simmondsin and other anti – nutritional factors concentrations compared to untreated JM. Improved acceptability and nutritive value as shown by high feed consumption and increased intake with a slight increase in body weight compared to lambs fed control ration were recorded as a result of treatments. The elimination or reduction of such phenolic compounds permitted utilization of JM as a protein source. Also chemical and biological treatments detoxify and debitter JM , hence reduce the detrimental effect of JM and improved animal performance and physiological state. However, further research works are required for long period of times to clarify the effect of feeding JM (either treated or untreated) on milk and meat yield and their quality with different farm animals.

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الأداء الإنتاجي لحملان البرقي النامية المغذاه علي كسب الجوجوبا تحت الظروف الصحراوية

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مركز بحوث الصحراء – المطرية- مصر

أجريت هذه الدراسة بمركز التنمية المستدامة بموارد مطروح – محافظة مرسي مطروح التابعة لمركز بحوث الصحراء. يعتبر السيموندسين هو العائق الأساسي مع بعض مضادات التغذية الأخري لإستخدام كسب الجوجوبا كمصدر غذائي لحيوانات المزرعة .لذلك تهدف هذه الدراسة الي: تقييم تأثير استبدال ٧٠% من كسب القطن الموجود في العلف المركز بكسب الجوجوبا إما غير معالج (R2) أو معالج بيولوجيا بالبكتريا كما في المجموعة (R3) أو معالج كيميائيا بالأيزوبروبانول ٧٠% كما في المجموعة (R4) و مقارنتهم بالمجموعة المقارنه (R1) و التي تتغذي علي العلف المركز التقليدي و كذلك دراسة تأثير المعالجة البيولوجية و الكيميائية لكسب الجوجوبا علي تركيز مضادات التغذية (السيموندسين) ، و كمية المأكول من المادة الجافة ، و الزيادة في الوزن ، و معاملات الهضم ، و تخمرات الكرش و بعض دلالات الدم و تقييم أداء الحيوان . و أستخدم فى هذه الدراسة عدد ٢٤ حمل برقي عمر (٦ شهور) بمتوسط وزن ٢٤.٥٦ ± ٢.١٩ كجم وزعت عشوائياً بالتساوى فى أربعة مجموعات بحثية (٦ جيوانات فى كل مجموعة) لتغذى على العلائق السابقة . وأظهرت الدراسة نتائج ايجابية لصالح المعاملة البيولوجية و الكيميائية يمكن إيجازها فيما يلى : ١- إنخفضت تركيزات مضادات التغذية بما فيها السيموندسين بينما لم يتأثر التركيب الكيميائي للعلائق المعاملة بدرجة ملحوظة. ٢- أرتفع المأكول من المادة الجافة في مجموعات الجوجوبا المعالجة سواء بالبكتريا أو بالأيزوبروبانول . ٣- إرتفع بدرجة ملحوظة معاملات هضم المكونات الغذائية ٤- تحسن متوسط أوزان الحملان اليومية بالجرام و كانت لصالح الحملان المغذاه علي الجوجوبا المعالجة بالأيزوبروبانول تليها المغذاه علي الجوجوبا المعالجة بالبكتريا ثم حيوانات المجموعة المقارنه و أخيرا الحملان المغذاه علي جوجوبا غير معالجة حيث كانت الأقل في زيادة الوزن.٥- إرتفعت نسبة المركبات الكلية المهضومة و كذلك البروتين المهضوم في مجموعة الحملان المغذاه علي العليقة R4 تلتها الحملان المغذاه علي العليقة R3 ثم حملان المجموعة المقارنه و أخيرا الحملان المغذاه علي العليقة R2 . ٦- تأثرت قياسات الكرش (pH و الأمونيا و الأحماض الدهنية الطيارة) في الحملان المغذاه علي الجوجوبا المعالجة بكلتا المعاملتين بدرجة واضحة. ٧- لم تتأثر دلالات الدم في الحملان المغذاه علي العلائق محل الدراسة بإستثناء انزيمات الكبد AST AlT حيث إرتفع نشاطها في جميع الحملان المغذاه علي الجوجوبا سواء معالجة أو غير معالجة بالمقارنة بحملان المجموعة المقارنه . ٨- أظهرت نتائج الأمونيا الدم و كذلك الدهون الثلاثية فروقا معنوية بين المجموعات محل الدراسة و لم تظهر فروقا معنوية في إختبارات الهرمونات متمثلة في T3 و T4 .ويستخلص من هذة الدراسة أن المعالجة البيولوجية و الكيميائية لكسب الجوجوبا أظهرت نتائج إيجابية فى خفض المضادات الغذائية فى الكسب ، حيث حسنت معاملات الهضم و القيمة الغذائية للعلائق تحت الدراسة ومعدلات النمو اليومية و الكفاءة الغذائية و الأقتصادية كنتجة فاعلة لخفض نسبة السيموندسين السام المر و كذلك بعض الفينولات، و لم يكن لها أى آثار سلبية على صفات سائل الكرش و مكونات الدم وصحة الحيوان بصفة عامة ، و مثل هذة المعاملات لكسب الجوجوبا توفر مصادر علفية غير تقليدية ممكن أن تساهم فى حل مشكلة أسعار مواد العلف بتوفير ذلك البديل مما قد يؤدى الى خفض سعر المنتاجات الحيوانية من لحوم و ألبان