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IMPACT OF BIOLOGICALLY TREATED JOJOBA MEAL WITH OR WITHOUT *Alpinia galanga* AS A PARTIAL SUBSTITUTE OF SOYBEAN MEAL PROTEIN ON REPRODUCTIVE PERFORMANCE OF DOE RABBITS UNDER NORTH SINAI CONDITIONS

Walaa A. Amer*, I.M.M. Ibrahim, E.O.A. Bakr, A.M. Abdelsamee and M.M. Shetaewi

Dept. Anim. and Poult. Prod., Fac. Environ., Agric. Sci., Arish Univ., Egypt.

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ABSTRACT

The objective of this work was to assess the effects of replacing 10% of diet protein, equivalent to about 40% soybean protein with a bacteria-treated jojoba meal (JML) of a level of 10% with or without *Alpinia galanga* on reproductive performance of New-Zealand White rabbit (NZW) does. A total number of 42 NZW rabbit does aged 8 months. and weighed about 3.34 ± 0.079 kg were randomly allotted into three groups (14/each). The 1st group (CON) was provided with the basal diet. The 2nd group (JML) was provided with diets containing jojoba meal treated with (*Lactobacillus acidophilus*) at a level of 10% without *Alpinia galanga* and the 3rd group (JMLA) was provided with diets containing jojoba meal treated with (*Lactobacillus acidophilus*) at a level of 10 % plus 0.25% *Alpinia galanga.* Results showed that doe rabbits fed *Alpinia galanga* (JMLA) and bacteria-treated jojoba meal (JML) slightly improved body weight and fertility of does compared with those fed the control diet but results were not significant. Litter size at weaning did not increase significantly, but was the highest in JMLA and JML compared with CON group. Litter weight of doe rabbits from birth to weaning of JMLA and JML groups did not increase significantly, but was higher than the CON group. Results revealed that milk production was higher ($P<.05$) in JML and JMLA groups as compared with the CON group. Total feed intake in JML and JMLA treatment groups tended to be higher ($P>.05$) than that of the CON. Conculosively, the results of the current study underscore the importance of using biologically treated jojoba meal as a partial substitute of soybean meal protein in addition to the use of some medicinal plants such as *Alpinia galanga* to improve the reproductive performance of doe rabbits in North Sinai

INTRODUCTION

Raising rabbit plays a crucial role in overcoming the food shortage resulting from a lack of animal protein. This is mostly attributed to their high fertility, early sexual maturity, fast growth rate, and short generation intervals.

The main problem of animal production in Egypt is the shortage and high cost of animal feed. This prompted us to consider alternative forms of feed that have good nutritional value but are more affordable.

The present study suggested that jojoba meal can achieve our goal. It is rich in protein, containing about (24-31%) (**El-Saidy *et al.*, 2017; Rafaat *et al.*, 2017**), it has the ability to substitute soybean meal in animal diets. Nevertheless, the jojoba meal contains certain anti-nutritional components, such as simmondsin, trypsin inhibitors, phytic acid, polyphenols and bitter compounds.

* **Corresponding author: E-mail address:** walaa.hakim15@gmail.com

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These ingredients may lead to reduced feed intake and hinder weight gain in animals that were fed jojoba **(Abbott *et al.*, 2004)**. Various techniques have been demonstrated to decrease the levels of harmful and unpleasant substances in jojoba, such as employing biological interventions with microorganisms **(Rafaat *et al.*, 2017).**

Alpinia galanga is a medicinal plant containing some vitamins such as A, B, and C, as well as naturally occurring antioxidants and flavonoids like alpinin, galangin, 3-dioxy-4-methoxy and kampferide **(Mayachiew *et al.*, 2010)**. Hence, it can be utilized to enhance the reproductive performance of rabbits does **(El-Speiy *et al.*, 2022)**.

The aim of this study was to evaluate biological treated jojoba meal with or without *Alpinia galanga* as a partial substitute of soybean meal protein.

MATERIALS AND METHODS

The current experiment has been conducted at the Rabbitry Farm, Department of Animal and Poultry Production, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt, from September to November 2023.

Experimental Animals, Design and Treatments

A total number of 42 New Zealand White (NZW) rabbit does aged 8 months, with an initial body weight (IBW) of (3.347 ± 0.079 kg.) were randomly allotted into 3 groups (14/each). The 1st group served as control (CON) group and fed the basal diet (Table 1). The 2nd group (JML) was fed a diet containing 10% jojoba meal treated with *Lactobacillus acidophilus* equivalent to about (40% soybeans protein), and the 3rd group (JMLA) was fed a diet containing 10% jojoba meal treated with *Lactobacillus acidophilus* and a 0.25% *Alpinia galanga* was added. The main goal of this experiment was to assess the influence of experimental diets on the reproductive performance of does NZW rabbits.

Preparation and source of jojoba meal, *alpinia galanga* and *Lactobacillus acidophilus*

Jojoba meal (*Simmondsia chinensis*) was obtained from the Oil Mill at Sadat City in Menoufia Governorte, Egypt. In addition, *Alpinia galanga* was obtained from Ragab El Attar Market, Cairo, Egypt.

Bacterial strain (*Lactobacillus acidophilus*) was obtained from Friendly Human Bacterial Unit – National Research Center, Dokki, Cairo, Egypt. This strain was selected based on the available knowledge regarding its impact on food mutagens and its frequent utilization in the food sector **(Verbiscar *et al.*, 1981)**. Lactobacilli were grown in MRS broth (De Man–Rogosa–Sharpe). The working culture was grown in skimmed milk (120 mg skimmed milk powder / 1-liter distilled water) under sterile conditions. Then placed in the incubator at a temperature of 37˚C for 48 hours and allowed to curdle. One day prior to the application of detoxification, bulk cultures were prepared (**Verbiscar *et al.*, 1981)**.

Detoxification of jojoba meal by biological treatment

This method was carried out according to **Verbiscar *et al.* (1981)**. The jojoba meal was sterilized by autoclaving it for 20 min. at 125°C and a pressure of 1.05 kg/cm^2. The resulting culture was sprayed onto sterilize jojoba meal (equivalent to 10% of the in polyethylene bags and sealed tightly. The sprayed jojoba meal was incubated for 21 days at 26˚C under anaerobic and dark conditions until assayed.

After the incubation time, the biologically treated jojoba meal was sun-dried, ground into powder and a sample was placed in plastic bags for chemical analysis of both untreated and treated jojoba meal (Table 1).

Table 1. Components of the experimental diets used in this study

Component (%)	Experimental diets[1] (%)		
	CON	JML	JMLA
Yellow corn	10	8.5	8.5
Wheat bran	22	24.5	24.25
Soybean meal (46%)	15	9.7	9.7
JoJoba meal	0	10	10
Alfalfa hay	31	31	31
Barley grains	16.7	11	11
Molasses	3	3	3
Dicalcium Phosphate	0.5	0.5	0.5
Limestone	0.9	0.9	0.9
Sodium chloride (salt)	0.3	0.3	0.3
Premix * (Vitamins & Mineral)	0.3	0.3	0.3
Antifungus	0.1	0.1	0.1
Lycine	0.1	0.1	0.1
Methionine	0.1	0.1	0.1
Alpinia galanga	0	0	0.25
Total	100	100	100

***** 1 Kg. of premix contains vitam. A 12000 000 IU, Vitam. D_3 2200 00 IU, Vit. E 1000 mg, Vitam. K_3 2000 mg, Vitam. B_1 1000 mg, vitam. B_2 4000 mg, Vitam. B_6 100 mg, vitam. B_{12} 10 mg, Pantothenic acid 3.33 g, biotin 33 mg, Folic acid 0.83 g, choline Chloride 200 g, Zn 11.79 g, Mn 5 g, Fe 12.5 g, Cu 0.5 g, I 33.3 mg, Se 16.6 mg and Mg 66.7 g.

[1]**,** Experimental diets **CON**= Control, basal diet, **JML** =10% Treated Jojoba meal.., **JMLA** =10% Treated Jojoba meal and 0.25% *Alpinia galanga*

Experimental Diets

The experimental diets were formulated to adhere to the nutrient needs of rabbits outlined in the **NRC (1977)**. Ingredient and chemical analysis of experimental diets utilized in the current investigation are shown in Tables 1 and 2.

Housing and Management

The rabbits utilized in the current investigation were in excellent physical condition and showed no signs of external or internal parasites. The animals were raised in well-maintained flat deck batteries with strict sanitary control and standardized requirements. Each cage had a feeder and a stainless nipple for drinking.

The rabbit does were housed in individual galvanized wire maternity cages of commercial type (40 x 55 x 60 cm). Each cage was equipped with a nest box for kindling and nursing offspring during lactation period. Electronic fans, air suction, cooling cells and a 16-hour light cycle followed by an 8-hour dark period were maintained. The rabbits were subjected to identical managerial, hygienic and environmental conditions.

Table 2. Chemical analysis (%) of jojoba meal, *Alpinia galanga* and the diets of experimental

Item	% DM basis								
	DM	**OM**	**CP**	**EE**	**CF**	**NFE**	**ASH**	**DE (kcal/kg)****	**Simmondosin**
Untreated Jojoba Meal	91.60	87.46	31.42	15.88	14.48	25.68	12.54	2476	2.75
Treat Jojoba Meal	91.10	88.03	31.67	14.91	12.21	29.24	11.97	2550	0.5
Chemical composition of experimental diets*									
Diet (1): CON	90.4	90.40	18.04	4.56	13.04	54.76	9.60	2523	
Diet (2): JML	90.5	90.97	18.45	5.35	16.32	50.85	9.03	2417	
Diet (3): JMLA	90.5	90.96	18.42	5.37	16.31	50.86	9.04	2413	

*****Diet (1): **CON**, Control, basal diet, Dite (2): **JML**, 10% Treated jojoba meal, Dite (3): **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga.*

******Calculated according to **Cheeke (1987): DE (Kcal/kg)** = 4.36 – 0.0491 (%NDF). **NDF%** = 28.924 + 0.657 (CF%).

Measurements

Doe rabbits were mated naturally with healthy bucks. This was done by transferring the doe to the buck cage for copulation and then returning to her cage. A pregnancy test was conducted on day 14 post-mating by palpation (**Shetaewi *et al.*, 2000**). Upon kindling, the size and weight of the litter were recorded. Subsequently, nests were checked in the morning to remove any deceased offspring. The kit rabbits were weaned on day 28.

Measurements such as body weight at different periods (body weight after breeding, body weight pre-kindling and body weight post-kindling) of the does reproductive cycle, fertility and feed intake were evaluated. In addition, number kits born (litter size at birth) and kits weight (litter weight at birth) of does were also evaluated.

The milk production of doe rabbits was assessed weekly. Milk yield and milk composition according to **Maertens *et al.* (2006)**, commencing from the 7th day after giving birth and continuing until the offspring were weaned on the 28th day. Milk production was determined using the suckling-weigh technique, which quantifies the volume of milk ingested by the juvenile rabbits following a period of fasting **(Shetaewi *et al.*, 2001)**.

Statistical Analysis

Data of doe rabbits underwent analysis using the general linear model procedure according to **Steel and Torrie (1980)** using SAS software **(SAS, 2004)**. The following categorical data, such as fertility rate, No. kits born at birth, kits livability at birth, stillbirths, kits weaned/doe kindled, and kits weaned/kits born alive, were analyzed by conducting Chi Square tests. These tests examine the hypothesis that the distribution is consistent by various groups **(Steel and Torrie, 1980)**.

The significance of differences across treatment means was evaluated using Duncan's Multiple Range Test **(Duncan, 1955)**.

RESULTS AND DISCUSSION

Productive Performance

Body weight changes of doe rabbits

Live body weights of doe rabbits did not show significant differences (P>.05) as a result of the treatment (Table 3). Doe rabbits weights were within the normal level of NZW does at this age. They were similar to those obtained by **Morsy *et al.* (2011) and Shetaewi *et al.* (2021)**.

Feed intake throughout reproduction periods of doe rabbits

The results shown in Table 4 indicate that there were no statistically variations seen among the different treatments in terms of feed consumption during the periods of pregnancy and lactation in doe rabbits.

Jojoba meal contains 24-31% of protein **(El-Saidy *et al.*, 2017; Rafaat *et al.*, 2017)**. Hence, it can serve as a substitute for soybean meal in animal diets. Nevertheless, jojoba meal contains several anti-nutritional components, including polyphenols, simmondsin, trypsin inhibitors, phytic acid and stinging compounds, which have the potential to hinder the consumption of feed and the increase in body weight in animals fed with jojoba **(Abbott *et al.*, 2004)**. To overcome these problems we applied biological treatments upon jojoba meal using *Lactobacillus acidophilus* bacteria which reduced anti-nutritional factors and improved feed intake (Table 4). However, the biological treatments using bacteria that occurred to jojoba meal in this study reduced anti-nutritional factors and improved the intake of jojoba meal. After treating jojoba meal with bacteria (*Lactobacillus acidophilus*), percentage of simmondosinin in this study became 0.5% instead of 2.75%. **Arya and Khan (2016)** reported that after extracting the oil from jojoba meal, the remaining meal becomes a highly valuable source of fiber. It can contain about 25-30% crude protein. While, this is lower compared to protein content in other feed meals such as cottonseed and soybean meals, it still contains essential nutrients and has great potential as a dietary supplement for animal feed.

Reproductive Performance

Fertility of rabbit does and kits viability at birth

Fertility results shown in Table 5 reveled that conception rate was higher in JMLA (78.57) and JML (78.57) groups than the control (64.29). **Mayachiew *et al.* (2010)** reported that *Alpinia galanga* contains vitamins such as Vitam. E, A, B and C, as well as naturally occurring antioxidants and flavonoids, which might increase fertility rate **(Ghasemzadeh *et al.*, 2010; Fedder *et al.*, 2014)**. **Rabeh (2016) and El-Zaher *et al.* (2021)** reported that reproductive performance of rabbits can be improved by using medicinal plants such as *Alpinia galanga.*

In addition, jojoba meal is considered a good source of protein which can replace soybean meal in animal diets. In addition, it contains 24-31% of protein **(El-Saidy *et al.*, 2017; Rafaat *et al.*, 2017)**. **Richard *et al.* (2008)** reported that jojoba meal has high levels of unsaturated fatty acids, which can enhance antioxidant mechanisms and minimize mitochondrial depolarization. Furthermore, Jojoba meal protein contained all the essential amino acids in adequate concentrations (**Gaafer, 2002)**.

Results in Table 5 indicate that there was no significant difference (P>.05) in total litter size at birth among the treatments. However, the JMLA and JML groups had slightly higher average litter size (8.55 and 8.36) compared to the control group (8.11). Similarly, there was no significant difference (P>0.05) in total litter weight at birth among the treatments. Nevertheless, the JMLA and JML groups had slightly higher average litter weights (470.82 and 431.36) compared

Table 3. Body weight changes of rabbit does during periods of their reproductive cycle

Item	Treatment group [1,2]			S.E.[3]	Sig. test
	CON	JML	JMLA		
Initial body weight (BW), kg.	3.375	3.323	3.347	0.171	NS
BW after breeding time …. (1)	3.487	3.680	3.698	0.142	NS
BW pre-kindling time …. (2)	4.005	4.186	4.198	0.159	NS
BW gain due to pregnancy (g).. (2) – (1)	518	506	500		
BW post-kindling (kg)	3.570	3.737	3.686	0.152	NS

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]NS: No differences significantly were found among treatments (P>.05)
[3]S.E.= Largest standard error of the mean, Sig. test: Significance test

Table 4. The impact of treatments on feed intake (Kg) throughout reproduction periods of doe rabbits

Item		Treatment groups [1,2]			S.E.[3]	Sig. test
		CON	JML	JMLA		
Total Feed intake (Kg)	**Pregnancy period**	4.944	5.271	5.354	0.161	NS
	Lactating period	6.462	6.749	6.906	0.182	NS
	Total	11.406	12.020	12.261	0.336	NS

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% Alpinia galanga .
[2]NS: No differences significantly were found among treatments (P>.05)
[3]S.E.= Standard error of the mean. Sig. test: Significan ce test.

Table 5. Effects of dietary treatments on fertility of rabbit does and kits viability at birth

Item	Treatment groups [1,2]			Sig. test
	CON	JML	JMLA	
No. does bred…………..(1)	14	14	14	
No. does kindled. ……(2)	9	11	11	
Kindling (%)	64.29	78.57	78.57	NS
Total No. kits born.	73	92	94	
Litter size at birth/deos	8.11 ± 0.73	8.36 ± 0.71	8.55 ± 0.24	NS
Total No. kits born alive	64	86	88	
Prolificacy	7.11	7.81	8	NS
Viability at birth (%)	87.67	93.47	93.61	NS
Stillbirths (No. kits born dead)	9	6	6	
Stillbirths (%)	12.32	6.52	6.38	NS
Total Litter birth wt (alive & dead), g	397.22 ± 34.31	431.36 ± 33.25	470.82 ± 21.89	NS
Litter weight at birth (alive), g	355.77 ± 38.04	410.27 ± 35.03	436.54 ± 21.48	NS

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]**NS**: No differ significantly were found among treatments (P>.05**) Sig. test** : Significance test, **Kindling %** = (2) x 100 / (1), Prolificacy (No. kits born alive /does Kindled), **Viability at birth** (%) No. Kits born alive x 100 / kits born, **Stillbirths**, % (No. kits born deadx100/total no. kits born).
[3]S.E.= Standard error of the mean.

to the control group (397.22) as shown in Table 5. This effect could be attributed to the fact that *Alpinia galanga* contains vitamins such as vitam. E, A, B and C, as well as naturally occurring antioxidants and flavonoids **(Mayachiew *et al.*, 2010; El-Speiy *et al., 2022*)**. **Ghasemzadeh *et al.*, (2010) and Fedder *et al.* (2014)** reported that mendicant plants such as *Alpinia galanga* can increase fertility rate and optimize the quality of sperm. **Gaafer (2002)** found that jojoba protein contains an adequate quantity of all the essential amino acids. Additionally, once simmondsia is removed, jojoba protein can act as a supplement to proteins that are deficient in essential amino acids. The results obtained in the current study align with the findings of **Morsy *et al.* (2011) and Shetaewi *et al.* (2021)**. However, kits viability did not differ significantly among treatments (Table 5).

The results given in Table 5 demonstrate that there were no significant differences among groups in stillbirths at birth. However, the levels of this variable were generally lower in the JML and JMLA groups as compared to the control group. The averages of the stillbirths were 6.38, 6.52 and 12.32 in JMLA, JML and CON groups, respectively.

Raviraja and Monisha (2015) reported that the extract of rhizome of *Alpinia galanga* is used as an anti-fungal and antiviral. **Mayachiew *et al.* (2010), Zhang *et al.* (2010) and Ouyang *et al.* (2018)** reported that *Alpinia galanga* is an antibacterial and antimicrobial diterpeneand. which makes it highly advantageous as a natural ingredient for animal feed **(Hosoda *et al.*, 2006)**. **Quynh *et al.* (2004)** found that dried rhizomes containing essential oils effective against microorganisms.

Sobhy *et al.* (2015) showed that the defatting process of jojoba seeds led to the increase of the crude fiber content in jojoba meal. Therefore, jojoba meal can be used as a good source of dietary fiber. Fiber consumption leads to protection against cardiovascular disease, diabetes, and digestive tract diseases. In addition, it lowers the glycemic index of food and serum cholesterol levels **(Vadivel *et al.*, 2012)**.

Post-natal survival of kits and overall reproductive performance of does

Results in Table 6 show that number of kits weaned per doe kindling did not differ significantly among treatments, it tended to be higher in the JML and JMLA groups (6.18 and 6.45) as compared with the control (5.55). Kits liviability at weaning followed the same trend, being insignificantly higher (P>.05) in JMLA and JML groups compared with the CON (80.68, 79.06 and 78.12%, respectively (Table 6). Results in the present study align with those obtained by **Shetaewi *et al.* (2021)**. These results may be partially due to differences in milk yield of their does. Doe rabbits of the JML and JMLA groups produced more milk than the CON group (Table 9), and litter size and birth weights of the kits at birth, also had significant effects on perinatal kit mortality (%).

The weight of kits weaned per doe kindling did not significant differences (P> 0.05) among treatments but tended to be higher in the JMLA and JML groups (2.137 and 2.123 kg.) compared with CON (1.839 kg.) (Table 6). These results are consistent with **Morsy *et al.* (2011)** and higher than those reported by **Shetaewi *et al.* (2021)**.

Alpinia galanga and bacteria-treated jojoba meal improved litter weight because *Alpinia galanga* contains antioxidants and flavonoids (**Ghasemzadeh *et al.*, 2010; Fedder *et al.*, 2014)**. Jojoba meal contains 24-31% of protein **(El-Saidy *et al.*, 2017; Rafaat *et al.*, 2017)**, therefore, it can be used to replace soybean meal in animal diets.

Table 6. Impact of different diet treatments on postnatal survival of bunny offspring and does overall reproductive performance

Item	Treatment groups [1,2,3]		
	CON	JML	JMLA
No. does bred.	14	14	14
No. does kindled.	9	11	11
No. kits born alive	64	86	88
No. kits weaned.	50	68	71
No. kits weaned/doe kindled	5.55	6.18	6.45
kits liveability at weaning (%)*	78.12	79.06	80.68
Weight of kits weaned /doe kindled. (kg)	1.839 ± 0.140	2.123 ± 0.127	2.137 ± 0.123

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*

[2]No differences significantly were found among treatments (P>.05), [3]Means ± standard error,

*kits liveability at weaning (%)= (No. kits weaned x 100/ kits born alive)

Litter weight of rabbit does

Results in Table 7 show that no significant differences (P>0.05) in litter weight at birth to weaning among treatment groups, but tended to be higher in the JML and JMLA groups (431.36 to 2123.55 and 470.82 to 2137.55) when compared with the control (397.22 to 1839.78). These results are consistent with **Morsy *et al.* (2011)** and higher than those reported by **Shetaewi *et al.* (2021)**.

Alpinia galanga and bacteria-treated jojoba meal improved the litter weight because *Alpinia galanga* contains antioxidants and flavonoids **Mayachiew *et al.*, (2010)**. In addition, jojoba meal is considered a good source of plant protein in animal diets, because it contains 24-31% of protein **(El-Saidy *et al.*, 2017; Rafaat *et al.*, 2017)**. However, the biological treatments using bacteria that occurred to jojoba meal in this study reduced anti-nutritional factors (**Rafaat *et al.*, 2017)** and improved the intake of jojoba meal. **Richard *et al.* (2008)** reported that jojoba meal has high levels of unsaturated fatty acids, which can enhance antioxidant mechanisms and minimize mitochondrial depolarization.

Milk production of doe rabbits

Table 8 shows the daily milk yield of rabbit does at (d.7, d. 14, d. 21 and d. 28) during the milk production period. The daily milk yield means of JMLA and JML groups were improved significantly (P<.05) as compered with the control, whereas JMLA and JML did not differ. Although daily milk yield in (d-14) and (d- 28 as weaning age) in JML and CON groups did not differ significantly but tended to be higher in the JML (157.45 and 126.00g) and (92.18 and 76.44g).

Weekly milk yield of rabbit does from 1st wk to 4th wk were significantly different (P<0.05) among treatments. The daily milk yield means of JMLA and JML groups were significantly higher than those of the control, while there was no significant difference between JMLA and JML. Although weekly milk yield in 2nd and wk 4th wk in JML and CON groups did not differ significantly, it

Table 7. Impact of treatments on the litter weights from birth to weaning age of doe rabbits

Live litter weight (g) at different days	Treatment groups [1,2]			S.E.[3]	Sig. test
	CON	JML	JMLA		
No. does kindled	9	11	11		
D 1 (Birth)	397.22	431.36	470.82	34.31	NS
D 7	585.44	650.82	660.73	62.73	NS
D 14	984.22	1122.27	1128.91	71.94	NS
D 21	1343.33	1582.55	1617.73	109.75	NS
D 28 (Weaning)	1839.78	2123.55	2137.55	140.88	NS

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]NS: No differences significantly were found among treatments (P>.05), **D**: Day, Sig. test: Significance test
[3]S.E.= Standard error of the mean.

Table 8. Impact of dietary treatments on daily milk production (g) of rabbit does.

Week	Treatment groups [1]			S.E.[2]
	CON	JML	JMLA	
1	106.89[b]	121.09[a]	126.82[a]	9.37
2	126.00[b]	157.45[ab]	164.36[a]	13.30
3	134.89[b]	187.55[a]	195.55[a]	15.78
4	76.44[b]	92.18[ab]	96.27[a]	7.12

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]S.E.= Largest standard error of the mean.
[a,b]Means in the same row differ significantly (P<.05).

tended to be higher in the JML (1102.18 and (882.00 g) and (645.27 and 535.11 g) as presented in Table 9.

Results presented in Tables 8, 9 show that milk production in the 1st week was higher than that of 4th wk. of the lactation period, the rate of milk production increased in the 2nd wk. and reaches the maximum in the 3rd wk. and then it declincd in the 4th wk. (weaning). These results are consistent with those reported by **Morsy *et al.* (2011) and Shetaewi *et al.* (2021)**.

Total milk yield of rabbit does during the whole period of milk production was significantly different (P<.05) among treatment groups as shown in (Table 10). Treatment means of JMLA and JML groups were (4081 and 3907g) which were significantly higher than those of the CON (3109 g).

Milk conversion rate and milk index did not differ significantly (P>.05) among treatments (Table 11). These results are consistent with the results obtained by **Shetaewi *et al.* (2021)**.

Table 9. Impact of dietary treatments on weekly milk production (g) of rabbit does

Week	Treatment groups[1]			S.E.[2]
	CON	JML	JMLA	
1	748.22[b]	847.64[a]	887.73[a]	65.64
2	882.00[b]	1102.18[ab]	1150.55[a]	93.12
3	944.22[b]	1312.82[a]	1368.82[a]	110.49
4	535.11[b]	645.27[ab]	673.91[a]	49.89

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
S.E.[2] = Largest standard error of the mean.
a,bMeans in the same row differ significantly (P<.05).

The JML and JMLA groups showed increased milk production, correlating with higher feed intake during lactation.

Rabbit milk yield is determined by different factors including body weight gain of kits and the state of health of the doe **(Poornima *et al.,* 2002)**, number of suckling kits **(Taranto *et al.,* 2003)**, survival of kits towards weaning **(Di Meo *et al.,* 2004)**, physiological status **(Xiccato *et al.,* 2005)**, lactation stage **(Casado *et al.,* 2006)**, nutrition and improved feed intake the deo **(Maertens *et al.,* 2006; Effiong and Wogar, 2007)** besides the breed and genotype of the doe **(Jimoh and Ewuola, 2017)**.

This effect could be attributed to the fact that *Alpinia galanga* contains vitamins such as vitam. E, A, B, C as well as naturally occurring antioxidants and flavonoids, which might increase milk production **(Mayachiew *et al.,* 2010; El-Speiy *et al.,* 2022)**. **Rabeh (2016) and El-Zaher *et al.* (2021)** reported that reproductive performance of rabbits can be improved by using medicinal plants such as *Alpinia galanga*. **Imchen *et al.* (2022)** reported that *Alpinia galanga* contains rich minerals and trace elements, which play an important role in improving physiological and nutritional performance **(Khalifah *et al.,* 2022)**.

In a study conducted by **Gaafer (2002)**, it was found that jojoba protein contains all the necessary amino acids in sufficient amounts. Additionally, after removing simmondsia, jojoba protein can provide a supplementary source of proteins lacking certain important amino acids. These results align with the discoveries made by **Morsy *et al.* (2011)**.

Economical Efficiency

The results of Table 12 shows that the Price/kg diet and Total feed cost (L.E.)/doe of rabbit-fed diet JML were lower than those of the other two treatment groups (CON and JMLA). The decreasing total feed cost of the JML group was reflected in net revenue and economic efficiency for the same group (JML) compared to the other two groups (CON and JMLA). while net revenue and economic efficiency of JMLA were intermediate between CON and JML. This is may be due to low price of treated jojoba meal (12 L.E /Kg) comperd to price of soybean meal (29.5 L.E /Kg). while net revenue and economic efficiency of JMLA were intermediate between CON and JML.

In conclusion, the results of the current study underscore the importance of using biologically treated jojoba meal as a partial substitute of soybean meal protein in addition to the use of some medicinal plants such as *Alpinia galanga* to improve the reproductive performance of doe rabbits in north Sinai.

Table 10. Impact of treatments on total milk production of rabbit does

Item	Treatment group[1]			S.E.[2]
	CON	JML	JMLA	
Total milk yield (kg/d 28)	3.109[b]	3.907[a]	4.081[a]	0.230

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]S.E.= Largest standard error of the mean.
[a,b]Means in the same row differ significantly (P<.05).

Table 11. Impact of dietary treatments on milk conversion rate and milk index of doe rabbits

Item	Treatment groups [1,2]				Sig.test
Milk Conversion Rate (g/g) at	CON	JML	JMLA	S.E.[3]	
1st week	3.22	3.10	3.09	0.57	NS
2nd week	2.17	2.38	2.39	0.24	NS
3rd week	2.70	2.84	2.95	0.39	NS
Milk Index	3.49	3.51	3.39	0.19	NS

[1]Treatment, **CON**, Control, basal diet, **JML**, 10% Treated jojoba meal, **JMLA**, 10% Treated jojoba meal and 0.25% *Alpinia galanga*
[2]NS: No differences significantly were found among treatments (P>.05)
[3]S.E.= Largest standard error of the mean. **Milk conversion** = as milk intake of litter (g) per litter weight gain (g). **milk index** = [slitter gain weight (birth to d.21) / litter wt. d.21× litter wt. at birth] × 100.

Table 12. Impact of the experimental diets on the economic efficiency of rabbit does

Item	Experimental diets of does		
	CON	JML	JMLA
Total feed intak (kg) / doe	11.41	12.02	12.26
Price/kg diet (L.E.)	14.56	13.42	14.32
Total feed cost (L.E.) /doe*	166.13	161.31	175.56
Weaning rabbit produced (kg/doe)	1.84	2.12	2.14
price/ kg gain (L.E)	100	100	100
Selling price (L.E.)**	184	212	214
Net revenue (L.E.)***	17.87	50.69	38.44
Economic efficiency (%)	10.76	31.43	21.89
Relative revenue (%) *****	100	292.14	203.52

* Based on prices of the Egyption market during the experimental period (2023)
* Total Feed cost = Total feed intak (kg) / Price/kg of diet (L.E)
**Selling price (L.E) = Weaning rabbit produced (Kg/doe) × Price/kg gain (L.E)
*** Net revenue = different between selling price (L.E) and Total feed cost (L.E)
**** Economic efficiency (E. EF) = (Net revenue / Total feed cost) × 100
***** Relative Economic efficiency (R. E. E.), assuming control treatment = 100%

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الملخص العربي

تأثير كسب الجوجوبا المعالج بيولوجيا مع او بدون الخولنجان كبديل جزئي لبروتين كسب فول الصويا على الأداء التناسلي لإناث الأرانب تحت ظروف شمال سيناء

ولاء عبد الحكيم عامر، ابراهيم محمد محمد ابراهيم، السيد عثمان عبد النبي بكر، عبد الشافي محمد عبد السميع، مسعد مسعد شتيوي

قسم الإنتاج الحيواني والداجني، كلية العلوم الزراعية البيئية، جامعة العريش، مصر

تهدف هذه الدراسة إلي تقييم تأثير استبدال كسب الجوجوبا jojoba meal المعالج بالبكتريا بنسبة 10% من بروتين العليقة (اي ما يعادل 40% من بروتين فول الصويا) بدون الخولنجان *Alpinia galanga* او مع الخولنجان علي الأداء التناسلي لإناث الأرانب، حيث تم تقسيم عدد 42 انثي بالغة من الأرانب النيوزيلاندي الأبيض، متوسط أعمارها حوالي (8 شهور) وبمتوسط وزن (3.347 ± 0.079) كجم، وتم توزيعها عشوائيا الي ثلاث مجموعات (14 لكل مجموعة). تم تغذية المجموعة الأولي وهي المجموعة الكنترول (CON) علي العليقة الأساسية فقط، والمجموعة الثانية (JML) تم تغذيتها علي العليقة الأساسية بعد استبدال 10% منها بكسب الجوجوبا المعالج بالبكتريا، وتم تغذية المجموعة الثالثة (JMLA) علي العليقة الأساسية بعد استبدال 10% منها بكسب الجوجوبا المعالج بالبكتريا و0.25% بالخولنجان. وقد أوضحت النتائج أن الأرانب في مجموعة JML و JMLA حسنت من أوزان الأمهات والخصوبة مقارنة بمجموعة الكنترول. كان حجم الخلفة عند الفطام أعلي بشكل غير معنوي في مجموعة JMLA يليها مجموعة JML ثم مجموعة الكنترول، وكان وزن الخلفة من الولادة حتي الفطام أعلي بشكل غير معنوي في مجموعة JMLA و JML من مجموعة الكنترول. وأظهرت النتائج أيضا وجود فروق معنوية بين المعاملات في إنتاج اللبن الكلي، بينما لا توجد فروق معنوية بين مجموعة JMLA و JML. بالاضافة إلي ان معدل استهلاك العلف الكلي كان اعلي بشكل غير معنوي في مجموعة JMLA و JML مقارنة بالمجموعة الكنترول. تؤكد نتائج هذه الدراسة على أهمية استخدام كسب الجوجوبا jojoba meal المعالج بيولوجيا كبديل جزئي لبروتين كسب فول الصويا بالإضافة إلى استخدام بعض النباتات الطبية مثل الخولنجان *Alpinia galanga* لتحسين الأداء التناسلي لإناث الأرانب في شمال سيناء.

الكلمات الاسترشادية: الأرانب، التناسل، كسب الجوجوبا، *Alpinia galangal - Lactobacillus Acidophilus*.

REVIEWERS:
Dr. Ahmed H. Daader | ahmedhd38@gmail.com
Dept. Animal Production, Fac. Agric., Zagazig Univ., Egypt.
Dr. Mostafa Tawfeek | mostawms@hotmail.com
Dept. Animal Production, Fac. Tech.and Develop., Zagazig Univ., Egypt