



Milk Yield, Productive and Reproductive Performance of Rabbit Does Fed Different Levels of Arabic Gum in Diet



Kh. Amber¹, Neamt A. Badawy¹, W.A. Morsy^{2*} and Shereen M. El-Desoukey²

¹Dept. of Poultry Production, Fac. of Agric., Kafr El-Sheikh Univ., Egypt

²Animal Production Research Inst., Agric. Research Center, Dokki, Giza, Egypt

THE EFFECTS of Gum Arabic (GA) supplementation in the diet of rabbit does in several physiological states on milk composition, productive and reproductive performance were assessed. Twenty eight Baladi Black rabbit does (7 does per treatment) of about 8-9 months of age with an average live body weight of 3449 ± 31.71 g, were used. Animals were fed the basal diet supplemented with 0 (control), 0.5, 1 and 1.5 % Gum Arabic of the diet. Results revealed that the milk yield (MY, g) increased ($P < 0.01$) by 3.5, 4.9 and 7.7% in rabbit does fed diet containing 0.5, 1 and 1.5% Gum Arabic, respectively, as compared with those fed control diet. Also, litter size at weaning was significantly higher with rabbit fed Gum Arabic in diets than those fed control diet. Mortality rate of the pups during lactation period was higher with control diet compared to diet supplemented with 0.5, 1 and 1.5 % Gum Arabic (4.90 vs. 1.83%; $P < 0.01$, as average). The best value of relative revenue was found in the rabbits fed diet containing 1% Gum Arabic (113%), while the poorest value was recorded with those fed control diet (100%). Conclusively, the present study suggested that supplementing 1 or 1.5% Gum Arabic in rabbit does diet significantly improve productive and reproductive performance of rabbits does during pregnancy and lactation periods and minimal mortality of kits. From the economic point of view, 1% GA is recommended for rabbit does diets, which showed the best results.

Keywords: Gum Arabic, Rabbit, Does, Productive, Reproductive, Mortality, Milk, Economic.

Introduction

Rabbit does are nursing their kits until weaning age (4-5 weeks of age). Kits until 18-19 days of age only feed their mother's milk (Fortun-Lamothe et al., 2000). Rabbits kit needs high energy milk and have low thermal isolation. Therefore, rabbits kit mortality and growth performances are depending on the quantity and quality of the milk suckling (Szendrő and Maertens, 2001). Consequently, milk yield (MY) has a great importance in does performance. When rabbit strains were selected for increased litter size, weaning weight of kits depressed (Rochambeau, 1998). This indicates that the MY improvement was not harmonious with those of litter size, which causing reduction in milk available per kit (Szendrő and Maertens, 2001). Studies have shown that MY of rabbit does is strongly influenced by diet composition

(Pascual et al., 2002 and Maertens et al., 2006). During lactation, the doe's body is subjected to a marked reduction in energy reserves following the mobilization of fat deposits (Xiccato et al., 2004). This energy loss remains constant throughout lactation (Parigi Bini et al., 1990) and no recovery is observed during the final phase due to the milk energy output, which remains high even after 25–30 days of lactation. The simultaneous condition of pregnancy is responsible for a further reduction in fat content and body energy levels. It prevents the return to normal body conditions (Xiccato et al., 2005) and increases protein requirements in response to the elevated demand for protein by the fetuses and the rapid turnover of fetal protein (Xiccato et al., 1995). A little importance has been given to the goal of increasing voluntary feed intake and maintaining the body condition of the females (Theilgaard et al., 2007).

*Correspondence author: wawad74@yahoo.com

DOI: 10.21608/jsas.2020.24080.1206

Received : 15/02/2020 ; Accepted: 1/03/2020

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Gum Arabic (GA) is a dried exudate obtained from the branches and stems of *Acacia senegal* and closely related species (FAO, 1999). It is a complex polysaccharide of high molecular weight, which contains neutral sugars as rhamnose, arabinose and galactose; in addition to acids such as glucuronic acid and also minerals such as calcium, magnesium, potassium, sodium and phosphorous (Tylor *et al.*, 1981 and Osman, 1993). Gum Arabic has wide industrial utilizes such as in food industry (stabilizer, thickening agent and emulsifier), textile, pottery, lithography, cosmetics and pharmaceutical industries (Verbeken *et al.*, 2003). Also, Gum Arabic has been successfully used for inflammation treatment of the intestinal mucosa and externally to cover inflamed surfaces (Gamal El-Din *et al.*, 2003). Moreover, Gum Arabic has anti-oxidant, nephro-protecting effects (Ali *et al.*, 2008). El-khier *et al.* (2010) found that laying hens fed gum Arabic (1%) in diet increased feed intake, as compared to control and also significantly increased albumin, Ca and P in blood serum. Moreover, Abd Razig *et al.* (2010) observed that the performance (bodyweight egg and daily egg production) of laying hens showed significant increase with increasing dietary levels of Gum Arabic (0.1, 0.3, 0.5 and 1%). Also, Tag El-Din *et al.* (2018) observed that supplementing 0.25% citric acid salt by alone or in the combination with 0.05% probiotic (Bioplus) to broiler diets might be used to improve growth performance and physiological status as well as economic efficiency during the fattening period.

Therefore, this study was carried out to evaluate the effects of different levels of Gum Arabic in diets on milk production, productive and reproductive performance of rabbit does.

Materials And Methods

The experiments were performed at the Rabbits Farm of Sakha Station, Animal Production Research Institute, Agriculture Research Center, Egypt. Twenty eight Baladi Black rabbit does about 8-9 months of age with an average live body weight of 3449 g, were used during the period from 1st January to 30th May 2018. Four experimental treatments were used 7 does per each. Animals were fed the basal diet containing 0 (control), 0.5, 1 and 1.5% Gum Arabic of the diet. All diets were formulated according to De Blas and Mateos (1998), containing all the essential nutrients requirements for rabbit does. Gum Arabic chemical composition is 87% DM, 3.71% CP, 0.43% EE, 2.73% ash and 3000 kcal/ kg DE, according to Amber *et al.* (2017).

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The sex ratio was 3: 1 female to male throughout the experiment. Lighting program during the experiment was 16 hours light and 8 hours dark. Mating system was presented rabbit doe to male after parturition at 7 days. Rabbit does were tested for pregnancy by abdominal palpation at ten days after mating. Non-pregnant rabbit does were re-mated. Housing system was individual cages provided with feeders, automatic nipple drinkers and nest boxes.

The milk production experiment was carried out on twenty lactating rabbit does (five per every experimental treatment). Rabbit does were separated from their pups after parturition. During lactation, eight kits were kept constant and dead kits were replaced daily by pups of a similar weight, age and treatment provided from nurse does. Rabbit does daily weight loss after suckling was used to calculate milk yield (MY, g). Rabbit does were allocated in a different cage to prevent free nursing. Suckling allowed once a day, at 09.00 AM in the nest box, for only 8 to 10 minutes. Rabbit does daily feed intake and litters weekly weight were recorded. On the 21st day of lactation, suckling kits ate the same diet like their mother and weaned at 30 days of age.

Analyses of variance were performed on data, using the General Linear GLM Procedure of SAS program (SAS, Institute, Inc., 2003). The application of the least significant ranges among the different treatment means was performed (Duncan, 1955).

Results And Discussion

Milk production

Data of Fig. 1 and 2 show the effect of Gum Arabic supplementation on milk production. The dietary Gum Arabic level had a significant effect on milk production; resulting in higher values for rabbit does fed diets with different Gum Arabic levels than those fed the control diet. The milk yield significantly ($P < 0.001$) increased by 3.5, 4.9 and 7.7 % in rabbit does fed 0.5, 1 and 1.5% Gum Arabic of the diet, respectively, as compared with those fed a basal diet (Fig. 2). Values of milk yield observed here were higher than those obtained by Ashour *et al.* (2016), who found that milk yield of baladi black was 113.8 g. The increase of milk yield may be due to the higher feed intake of rabbit does. Milk production was increased by increasing dietary Gum Arabic level throughout the lactation period.

TABLE 1. Ingredients and chemical analysis of the experimental diets

Ingredient	Control	Gum Arabic level (%)		
		0.5	1.0	1.5
Barseem hay	30.0	30.3	30.5	30.8
Barley	30.0	30.0	30.0	30.0
Soybean meal (44%)	19.8	20.1	20.3	20.6
Wheat bran	16.4	15.3	14.4	13.3
Gum Arabic	0	0.5	1	1.5
Limestone	0.6	0.6	0.6	0.6
Di-calcuim	2.2	2.2	2.2	2.2
Methionine	0.2	0.2	0.2	0.2
Salt	0.3	0.3	0.3	0.3
Premix ⁽¹⁾	0.3	0.3	0.3	0.3
Anti-fungi	0.1	0.1	0.1	0.1
Ati-coccidia	0.1	0.1	0.1	0.1
Total	100	100	100	100
Chemical analysis (%):				
Dry matter	85.83	85.84	85.84	85.85
Ash	5.53	5.54	5.54	5.55
Crude protein	18.00	18.02	18.01	18.02
Ether extract	1.58	1.56	1.53	1.49
Crude fiber	13.37	13.38	13.37	13.38
Lysine ⁽²⁾	0.91	0.92	0.92	0.92
Methionine ⁽²⁾	0.46	0.46	0.46	0.46
Calcium ⁽²⁾	1.22	1.22	1.22	1.23
Phosphorus ⁽²⁾	0.89	0.88	0.87	0.87
Digestible energy (kcal /kg) ⁽²⁾	2452.6	2455	2457.4	2459.8
Metabolizable energy (kcal /kg) ⁽²⁾	2291.1	2293.4	2296	2298.2

1- One kilogram of mineral–vitamin premix provided: Vitamin A, 150,000 UI; Vitamin E, 100 mg; Vitamin K3, 21mg; Vitamin B1, 10 mg; VitaminB2, 40mg; Vitamin B6, 15mg; Pantothenic acid, 100 mg; Vitamin B12, 0.1mg; Niacin, 200 mg; Folic acid, 10mg; Biotin, 0.5mg; Choline chloride, 5000 mg; Fe, 0.3mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1mg; and Zn, 450mg.

2- Calculated according to De Blas and Mateos (1998).

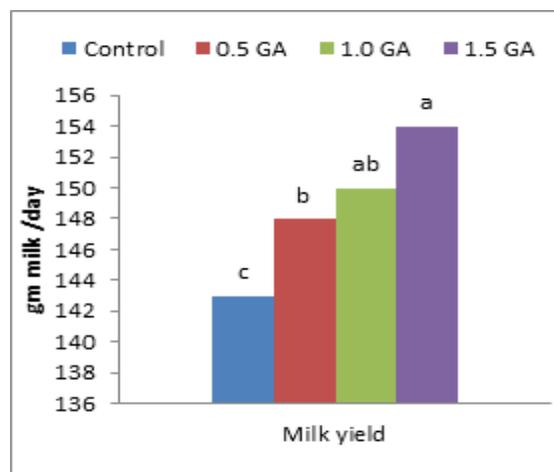
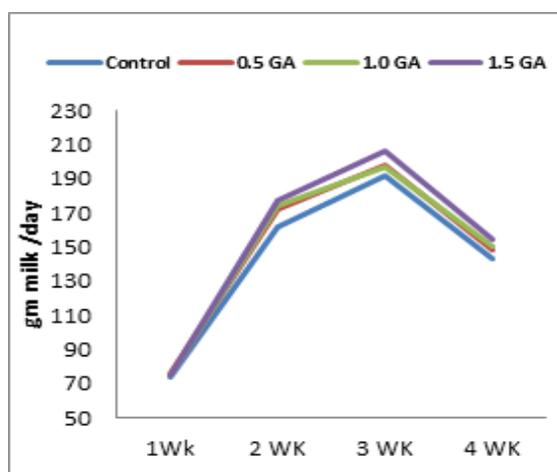


Fig. 1. Effect of dietary Gum Arabic level on milk production **Fig. 2. Effect of dietary Gum Arabic level on milk yield**

In this respect, Amber *et al.* (2017) found that, adding Gum Arabic to the rabbit diet caused an increase of feed efficiency. This may lead to increase milk production and secretion in treating rabbits. Moreover, litter size at birth improved as a result of increasing in milk production (Table 3), where there was a positive correlation between the litter size at birth and milk yield (Lebas *et al.*, 1997 and Rommers *et al.*, 2001).

Productive and reproductive performance

The effects of experimental treatments on the reproductive and productive performance are shown in Tables 2 and 3. It is clear that no significant differences in the live body weight of rabbit does at mating, partum and pre-partum except for weaning, which significantly increased by increasing the level of Gum Arabic in the diet. Does weight gain at gestation significantly increased ($P < 0.001$) with increasing dietary Gum Arabic supplementation. Pregnant rabbit does given diet containing 1.5% Gum Arabic showed the highest weight gain than those fed other dietary Gum Arabic levels during the pregnancy period. The pregnancy weight gain increase mainly due to foetal growth (Parigi Bini *et al.*, 1991). Lactation rabbit does weight decreased about 101-145 g, which was about 3.42% (as an average) of their initial live body weight with low losses for rabbit does fed diets containing 1 or 1.5 % Gum Arabic of the diet. The balance of fat and energy are negative in lactating rabbit does (Xiccato, 1996). Daily feed intake of pregnant rabbit does did not significantly affect by dietary Gum Arabic. While, daily feed intake of lactating rabbit does increased ($P < 0.05$) with increasing dietary Gum Arabic level, where

rabbit does fed diets containing 1 and 1.5 % Gum Arabic achieved the highest values. Moreover, daily feed intake of kits in the period from 22 day of age until weaning increased ($P < 0.05$) as the level of Gum Arabic increased (Table 3). The increase of feed intake during the lactation period compared to that of gestation phase was lower as compared to reported values of 80-90% in the literature (Lebas, 1984); this is probably due to higher ambient temperature during lactation period than that in the literature, resulting in lower feed intake by rabbit does (Prasad and Karim, 1998).

The dietary Gum Arabic level had a significant effect on the milk conversion ratio during the first week of lactation (Table 3). During the second and third weeks of lactation period, no significant differences could be observed among the experimental groups. An increase in the dietary Gum Arabic level increased ($P < 0.05$) feed intake of kits in the last 9 days of the lactation period. Litters fed control diet seemed to compensate for the lower amount of milk available to them with a lower feed intake. Both size and weight of litters at the birth, 21 days and weaning (30 days) were affected by supplementing dietary Gum Arabic (Table 3). Also, litter size at weaning was significantly higher with rabbit fed Gum Arabic in diets than those fed control diet (6.33 vs. 7.07; $P < 0.001$, as average). The improvement in litter traits proved that, the Gum Arabic may be capable to improve the milking ability of the rabbit does which is reflected in her care and ability to suckle her young till weaning.

TABLE 2. Effect of dietary Gum Arabic level on performance of does during gestation and lactation periods of rabbits.

Item	Control	Gum Arabic level (%)			SEM	Sig.
		0.5	1.0	1.5		
Does weight (g) at:						
Mating	3451	3442	3453	3448	31.61	NS
Pre-Partum	3760	3784	3833	3849	30.82	NS
Partum	3439	3460	3492	3510	29.96	NS
Weaning	3294b	3337ab	3385a	3409a	28.41	*
Does weight gain (g) at:						
Gestation	309d	342c	380b	400a	6.419	***
Lactation	-145c	-123b	-107a	-101a	2.330	***
Feed intake (g/d) for:						
Pregnant does	162	163	167	171	9.758	NS
Lactating does	204b	216ab	220a	223a	4.682	*

Sig.= Significance, ***:Significant at 0.1% level of probability, **:Significant at 1% level of probability, *:Significant at 5% level of probability, NS: Non-significant

Means within the same row bearing different letter superscripts (a, b, c) are significantly different ($P \leq 0.05$)

SEM = Standard error means.

The mortality rate of the pups during the lactation period was higher in the control diet compared to diets with 0.5, 1 and 1.5% Gum Arabic (4.90 vs. 1.96, 2.26 and 1.28%; $P < 0.05$, respectively), which could be due to a lower milk yield of rabbit does. This reduction in mortality rate may be attributed to Gum Arabic has been shown in displays antimicrobial activity and to stimulate intestinal absorption thus counteracting diarrhoea (Ali et al., 2009). These results are in accordance with Amber et al. (2017), who found that the concentration of (0.5, 1 and 1.5 %) of Gum Arabic in the diet of growing rabbits decreased mortality rate by 44.4% (As average), as compared with the control diet. They observed also, rabbits received 1.5% Gum Arabic diet had significantly the lowest mortality during the

experimental period, as compared with those received the control treatment (5% vs. 15%, respectively).

During the first three weeks, the weight gain of young rabbit was influenced by milk production, where higher litter weight for diet containing Gum Arabic than for control diet. Moreover, rabbit does fed 1 and 1.5% Gum Arabic of the diets had significantly higher litters weights, as compared with those fed control diet, during the first three weeks. This was observed also at weaning. Similarly, Fouda and Ismail, (2018) observed that Gum Arabic addition significantly increased litter size, bunny and litter weights at birth and weaning, but overall of all reproductive traits and litter characteristics were better at 2nd and 3rd than at the 1st litter.

TABLE 3. Effect of dietary Gum Arabic level on the performance of litter until weaning of rabbits

Item	Control	Gum Arabic level (%)			SEM	P-value
		0.5	1.0	1.5		
Litter size at:						
Birth (alive)	6.67b	7.00ab	7.33a	7.33a	0.169	*
21 days	6.33b	6.86a	7.14a	7.24a	0.173	***
Weaning (30day)	6.33b	6.86a	7.12a	7.24a	0.136	***
Mortality rate (%) at:						
Birth – 21 day	4.90a	1.96ab	2.25ab	1.28b	1.074	*
Birth - Weaning	4.90a	1.96ab	2.25ab	1.28b	1.039	*
Litter weight (g) at:						
Birth	331	334	342	336	5.055	NS
7th day	863c	895b	909ab	922a	8.860	***
14th day	1446c	1497b	1530ab	1546a	11.36	***
21st day	1907c	1984b	2041a	2072a	14.83	***
Weaning (30 day)	2752c	3021b	3244a	3329a	40.85	***
Kit individual BW (g)	4390b	443.9ab	455.3ab	461.4a	5.255	*
Growth rate of kits (%) (21day-weaning)	36.2c	41.3b	45.4a	46.4a	1.276	***
Milk conversion rate (g/g) at (1):						
1st week	0.98a	0.95ab	0.93ab	0.90b	0.023	*
2nd week	1.96	2.01	1.96	1.99	0.047	NS
3rd week	2.96	2.87	2.74	2.76	0.073	NS
Kits (22-30 day) DFI (g/d)	163.5b	172.5ab	175.7a	178.2a	3.919	*

Sig.= Significance, ***:Significant at 0.1% level of probability, **:Significant at 1% level of probability, *:Significant at 5% level of probability, NS: Non-significant

Means within the same row bearing different letter superscripts (a, b, c) are significantly different ($P \leq 0.05$)

SEM = Standard error means.

(1) As milk intake of litter (g) per litter weight gain (g)

The growth rate of pups during the period from 21 days of age until weaning tended to increase with increasing the level of Gum Arabic in diet and the best value was obtained with the higher dietary Gum Arabic level (1 and 1.5 %). Gum Arabic might improve litter performance by increasing milk production.

Relative revenue

Data in Table 4 revealed that the total feed cost increased by increasing levels of Gum Arabic in diets, as a result of increasing of feed intake. However, the selling price was increased by increasing dietary Gum Arabic level, as a result of increasing of average weight gain (kg /head). The same trend was found in the net revenue and relative revenue, which were increased, as the Gum Arabic level increased in the diets. The best

value of relative revenue was found in the rabbits fed diet containing 1% Gum Arabic (113%), followed by those fed diet containing 0.5% Gum Arabic (108%), but the poorest value was recorded with those fed control diet (100%). Similarity, Amber *et al.* (2017) reported that the values of economic efficiency improved with gum Arabic supplementation in rabbit diets, whereas the best value of relative revenue was found in the rabbits received 1.0% GA diet the (112.6%), followed by those received 1.5% GA diet (110.9%), but the poorest value was recorded for the control group (100%). Also, Amber *et al.* (2018) observed that under heat stress, raising rabbits in cages with low density and supplementing of 1% lycopene in diet gave the best productive performance and improving economic efficiency.

TABLE 4. Effect of dietary Gum Arabic level on relative revenue of rabbit does

Item	Control	Gum Arabic level (%)		
		0.5	1.0	1.5
Total feed intake (kg)*	12.461	12.900	13.189	13.423
Price /kg diet (L.E.)	4.60	4.93	5.27	5.60
Total feed cost (L.E.)	57.32	63.60	69.51	75.17
Weaning rabbit produced (kg/ doe)	2.752	3.021	3.244	3.329
Selling price (L.E.)**	96.33	105.73	113.53	116.50
Net revenue (L.E.)	39.01	42.13	44.02	41.33
Relative revenue (%)	100	108	113	106

- Mortality (%) and management are fixed.

- Ingredients price (L.E. per ton) at 2018 were: 4000 barley; 3000 berseem hay; 4000 wheat bran ; 7000 soybean meal (44%) ; 7000 Gum Arabic ; 500 limestone ; 9000 premix ; 80000 methionine ; 1000 Di-calcium phosphate ; 20000 anti-fungi; 20000 anti-oxidant; 1000 salt.

- Adding 200 L.E. /ton for pelleting.

* Total feed intake= (Pregnant does daily feed intake x 30) + (Lactating does daily feed intake x 30) + (Pups daily feed intake x 9)

** Live body weight 35 L.E /kg.

Conclusion

Conclusively, the present study suggested that dietary supplementation of Gum Arabic in rabbit does significantly improved productive and reproductive performance of rabbits does during pregnancy and lactation periods and minimal mortality of kits. Therefore, it could be recommended providing rabbit does diet with Gum Arabic up to 1% is advisable under Egyptian environmental conditions.

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إنتاج اللبن والأداء الانتاجي والتناسلي لامهات الأرانب المغذاة على مستويات مختلفة من الصمغ العربي في العليقة

خيري علي عمير^١، نعمت عبد الغني بدوي^١، وائل عوض مرسى^٢، شرين محمد الدسوقي^٢
 قسم إنتاج الدواجن - كلية الزراعة - جامعة كفر الشيخ - كفر الشيخ - مصر
^٢معهد بحوث الإنتاج الحيواني - مركز البحوث الزراعية - وزارة الزراعة - الدقي - الجيزة - مصر

تهدف الدراسة لتحديد تأثير إضافة الصمغ العربي إلى علائق إناث الأرانب في مراحل فسيولوجية مختلفة على إنتاج اللبن والأداء الانتاجي والتناسلي للأرانب. تم استخدام ثمانية وعشرون أنثى أرنب بلدي اسود (سبعة إناث لكل عليقة) عمر ٨-٩ شهور بمتوسط وزن ٣٤٤٩ جرام خلال الفترة من أول يناير حتى آخر مايو ٢٠١٨م. تمت تغذية الأرانب على العليقة الأساسية مضاف إليها صفر (عليقة مقارنة) - ٥,٠ - ١ - ٥,١٪ صمغ عربي من العليقة. أظهرت النتائج زيادة معنوية في محصول اللبن بمعدل ٣,٥ - ٤,٩ - ٧,٧٪ للأرانب المغذاه على عليقة تحتوي على الصمغ العربي بمعدل ٠,٥ - ١ - ١,٥٪ على الترتيب مقارنة بتلك المغذاه على العليقة الكنترول، لوحظ زيادة معنوية في الوزن المكتسب للامهات خلال فترة الحمل بزيادة مستوى الصمغ العربي في العليقة، كما وجد ان الامهات المغذاه على علائق تحتوي على الصمغ العربي فطمت أرنب أكثر من تلك المغذاه على العليقة الكنترول (٧,٠٧ مقابل ٦,٣٣، كمتوسط عام)، كانت أقل نسبة نفوق للنتاج مع العلائق التي تحتوي مستوى مرتفع من الصمغ العربي من الولادة حتى الفطام، أوضحت النتائج السابقة أن المستوى ١٪ من الصمغ العربي قد حقق أعلى قيمة للعائد النسبي. نستخلص من ذلك أن تغذية إناث الأرانب على الصمغ العربي يحسن من الأداء الانتاجي والتناسلي لامهات الأرانب خلال فترة الحمل والرضاعة ويقلل من نفوق النتاج ولذلك فإنه ينصح بإضافة الصمغ العربي إلى علائق أمهات الأرانب بمعدل ١٪ تحت الظروف المصرية.