EFFECT OF SUPPLEMENTAL MANNAN OLIGOSACCHARIDE TO RABBIT DIETS ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF DOES DURING SUMMER SEASON IN EGYPT

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SUMMARY

The objective of this study was to evaluate the effects of dietary mannan oligosaccharide (Bio-Mos) supplementation on reproductive, productive performance and milk production of APRI line rabbit does under high ambient temperature. A total of 40 APRI line rabbit does, 8-9 months old, were divided into four experimental treatments (10 each). Rabbit does were fed *ad libitum* the basal diet supplemented without (control), with 0.5, 1 or 1.5 g mannan oligosaccharide (Bio-Mos) /kg diet. Animals were provided with water freely. The average daily temperature and relative humidity inside the rabbitry were 31.6±3.8 °C and 77.5±4.8%, respectively. Under heat stress conditions, does weight gain at gestation significantly increased (P<0.001) with increasing dietary MOS supplementation. Pregnant rabbit does given diet containing 1.5 g MOS /kg diet showed the highest weight gain than those fed other dietary MOS levels during the pregnancy period. Daily feed intake of pregnant and lactating rabbit does increased (P<0.05) with increasing dietary MOS level, where rabbit does fed diet containing 1.5 g MOS /kg diet recorded the highest values. The feed conversion ratio was significantly improved (P<0.001) with rabbit does fed diets containing different MOS level (0.5, 1.0 and 1.5 g) during lactation period. The mortality rate of the pups during the lactation period was higher in the control diet compared to diets with 0.5, 1.0 and 1.5 g MOS (32.11 % *vs.* 25.82, 18.37 and 17.77%; P<0.01, respectively), which could be due to lower milk yield of rabbit does fed unsupplemented diet. Rabbit does fed 1.0 and 1.5 g MOS/kg diet recorded the highest values of letters weights, during the first three weeks. The same trend was obtained at weaning. Rabbit does fed 1.5 g MOS/kg diet recorded the highest net revenue, followed by those fed 1.0 g MOS/kg diet. It could be concluded that supplementing MOS in rabbit does diet significantly improve the overall productive and reproductive performance of rabbits does during pregnancy and lactation periods, in addition to depressing the mortality of pups under high ambient temperature during summer season in Egypt. Therefore, it could be recommended providing rabbit does diet with MOS up to 1.5 g/kg diet is advisable in hot climates, Egypt.

Keywords*: Rabbit, Mannan oligosaccharide, Heat stress, Reproductive performance.*

INTRODUCTION

Climatic heat is the major factor restricting animal productivity. Rabbits are very sensitive to high environmental temperature, where the dense fur and lack of sweat glands make heat loss very difficult above the zone of thermal neutrality. Exposure of adult female rabbits to severe heat stress (30–31 ºC) adversely affects their growth and reproductive rates (Marai *et al.*, 2001). In female rabbits, conception rate, embryonic development, litter size, litter weight and milk production decrease, while age at puberty and pre- and post-weaning mortality increase by exposure to heat stress (Habeeb *et al.*, 1999). The drastic changes that occur in rabbits' biological functions are depression in feed intake, feed efficiency and feed utilization, disturbances in metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites (Marai *et al.*, 2002).

The concept of prebiotics in feed is fairly recent. Some of the prebiotics, which are currently used in animal feed, are Mannan-oligosaccharides (MOS). Mannan-oligosaccharides are mainly obtained from cell walls of *Saccharomyces cerivisae* and interferes with the colonization of the pathogens. Cell surface carbohydrates are primarily responsible for cell recognition. Bacteria have lectins (glycoprotein) on the cell surface that recognize specific sugars and allow the cell to attach to that sugar. Binding of *Salmonella, E.coli* and *Colostridia* sp. is shown to be mediated by a mannose specific lectin (receptor) like substance present on the bacterial cell surface. So, MOS exhibits an anti-adhesive effect where it binds to *E. coli* and *Salmonella* instead of binding to mucosal receptor and flushes them from the digestive tract, before the pathogens cause problems by anchoring themselves to the colon wall and improve intestinal health in other species (Spring *et al.*, 2000; Fairchild *et al.*, 2001; and Fernandez *et al.*, 2003). Prebiotics can stand high pelletizing temperatures in the feed and also have a long shelf life (Huyghebaert, 2003 and Kembhavi, 2004).

Through improving gut health and the immune status MOS has shown to improve animal performance in broilers (Hooge, 2004a), turkeys (Hooge, 2004b), piglets (Miguel *et al.*, 2002). Moreover, some studies have shown that MOS is as effective as other antimicrobial growth promoters (Savage *et al.*, 1996; White, *et al.* 2002). While extensive information on MOS as a feed additive in available in different animal species, little researches have been conducted in rabbits. Morsy and Abd El-Lateif (2014) observed that supplementing of 1 or 1.5 gm Bio-Mos/ kg diets of growing rabbits improve growth performance and reduce mortality.

The objective of this study was to evaluate the effects of dietary mannan oligosaccharide supplementation on productivity, reproductive performance and milk production of APRI line rabbit does under high ambient temperature.

MATERIALS AND METHODS

Animals and experimental design:

This study was carried out at Sakha Research Station, Animal Production Research Institute, Agriculture Research Center, Egypt. Forty multiparous lactating and non-lactating APRI line rabbit does (Egyptian line selected for litter weight at weaning according to Abou Khadiga *et al.* 2010) of about 8-9 months old with an average live body weight of 3023 g, were used during a period from 1st May 2016 to 30th September 2016. Four experimental diets (10 does per diet) were used in this experiment. The basal diet composition (Table 1) was formulated to cover all essential nutrient requirements for rabbit does according to De Blas and Mateos (1998). Chemical analyses of the basal diet were carried out according to AOAC (2000) for crude protein, crude fiber, organic matter and ether extract. Rabbit does were fed *ad libitum* the basal diet without (control), with 0.5, 1 or 1.5 g mannan oligosaccharide (Bio-Mos) /kg diet. Bio-Mos® (Alltech Inc., USA) is thermostable prebiotic containing mannan-oligosaccharides. Rabbit bucks were fed on control basal diet without any supplementation.

Sex ratio was included to give a female: male ratio 3: 1 throughout the experiment. A cycle of 16 hours of light and 8 hours of dark were applied. All does were kept under the same managerial conditions and were presented to the males 7 days after parturition. Ten days after mating, the does were tested for pregnancy by abdominal palpation. Non-pregnant rabbit does were remated directly after abdominal palpation. The experimental period included three reproductive cycles. Feed intake of rabbit does was recorded daily and the weight of litters was measured weekly. Suckling pups were allowed to eat the same diet of their mother at the 21st day of lactation and were weaned at 30 days of age. During this period, solid feed intake of litters was recorded. Animals were housed in individual cages provided with feeders, automatic nipple drinkers and nest boxes. The rabbit house was open air with electric exhaust fans on the sides.

During the experimental period, ambient temperatures and relative humidity were measured in the rabbitry twice a day at 06:00 h and 15:00 h and the temperature humidity index (THI) was calculated according to Marai *et al.* (2001):

$$THI = db°C - [(0.31 - 0.31RH) \times (db°C - 14.4)]$$

Where, db°C is dry bulb temperature in Celsius, and RH is the relative humidity as a percentage. The values obtained are then classified as follows: < 27.8 =absence of heat stress, 27.8–28.9 =moderate heat stress, 28.9–30.0 =severe heat stress and 30.0 and more =very severe heat stress (Marai *et al.*, 2002).

To measure milk production, twenty lactating rabbit does (five per diet) were used. Rabbit does were separated from their pups after parturition and controlled suckling was applied. To prevent free nursing, does were placed in cages next to the nest box. Suckling took place once a day, (around 09.00) in the nest box, for a short period (8 to 10 min.). Litter size of eight pups was kept constant throughout lactation and dead pups were replaced daily by pups of a similar weight and age provided from nurse does. Milk production was estimated daily from weight loss of rabbit does after suckling.

Statistical analysis:

Data were subjected to analysis of variance, using the general linear GLM procedures of SAS program (SAS, Institute, Inc., 1985). The application of the least significant ranges among the different treatment means was done according to Duncan (1955). The fertility rate was analysed by chi square test.

RESULTS AND DISCUSSION

Temperature humidity index (THI):

Means of ambient temperature, relative humidity and temperature humidity index (THI) inside the building were 31.6±3.8 °C, 77.5±4.8% and 30.4, respectively, which indicate severe heat stress. According to Marai *et al.* (2002) there is very severe heat stress when THI is higher than 30.0.

Does performance:

The effect of experimental treatments on does performance is shown in Tables 2. It is clear that no significant differences in the live body weight of rabbit does at mating, partum and weaning, while at pre-partum the live body weight of rabbit does significantly increased by increasing level of mannan oligoscharides (MOS) in diet. Does weight gain at gestation significantly increased (P<0.001) by increasing dietary MOS supplementation (1 or 1.5 g). Pregnant rabbit does given diet containing 1.5 g MOS /kg diet showed the highest weight gain (414.3 g) than those fed other dietary MOS levels during the pregnancy period. The increase in the weight gain was due to the foetal growth as evident by almost similar body weight of rabbit does at the mating and partum (Parigi Bini *et al.,* 1991). During the lactation period, the rabbit does irrespective of the experimental diets lost weight ranging from 87.1 to 110.7 g, which was about 3.24% (as average) of their initial live body weight with low losses for rabbit does fed diets containing 1.0 or 1.5 g MOS/kg diet (-90.7 and -87.1 g, P<0.001, respectively). The fat and energy balance are always negative in the lactating rabbit does (Xiccato, 1996). Daily feed intake of pregnant and lactating rabbit does increased (P<0.05) with increasing dietary MOS level, where rabbit does fed diet containing 1.5 g MOS /kg diet recorded the highest values, as compared with those fed control diet (151.3 and 216.8 *vs.* 131.2 and 191.8 g, P<0.05, respectively). Moreover, daily feed intake of pups in the period from 22 day of age until weaning increased linearly (P<0.001) as the level of MOS increased. Daily feed intake of lactating rabbit does increased by 44.77% (as average) as compared to that of pregnant rabbit does to compensate for the higher serve losses of body weight reverses.

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 the low feed intake by rabbit does (Prasad and Karim, 1998). Similar results were recorded by Morsy (2007) who found that daily feed intake of lactating rabbit does increased by 43.3% (as average) as compared to that of pregnant rabbit does.

Milk production:

The effect of experimental treatments on milk production is shown in Tables 3. The dietary MOS level had a significant effect on milk production; resulting in higher values for rabbit does fed diet with different supplemented levels of MOS than those fed the control diet. The milk yield increased (P<0.001) by 11.48, 27.65 and 32.65% in rabbit does fed 0.5, 1.0 and 1.5 g MOS /kg diet, respectively. The same trend was observed for milk production in relation to week of lactation, which was increased by increasing dietary MOS level throughout the lactation period. The feed efficiency of milk yield was improved (P<0.001) with supplementing MOS in the diet, where rabbit does fed 1.0 and 1.5 g MOS/ kg diet recorded significantly the best values, as compared with those fed control diet (0.577 and 0.588 *vs.* 0.500 g/ g, P<0.001, respectively). The increase of milk yield may be due to the higher feed intake of rabbit does. In cows, Nour El-Din (2015) found that both Tonilisat yeast and Grow yeast products have favorable impacts on the productivity of dairy cows during early lactation.

Letter performance:

The effect of experimental treatments on letter performance is shown in Tables 4. Both size and weight of litters at the birth, 21 days and weaning (30 days) were affected by supplementing dietary MOS. The rabbit does fed diet containing high levels of MOS (1.0 and 1.5 g/ kg) weaned more rabbits than those fed control diet (5.86 *vs.* 4.14; P<0.01, respectively). The mortality rate of the pups during the lactation period was higher in the control diet compared to diets with 0.5, 1.0 and 1.5 g MOS (32.11 % *vs.* 25.82, 18.37 and 17.77%; P<0.01, respectively), which could be due to lower milk yield of rabbit does fed unsupplemented diet. The recorded high values for pre-weaning mortality rate in this study may be attributed to the direct effect of heat stress on the sensitive offspring, in addition to a reduction of milk production (Ayyat *et al.*, 1995) due to the general depression of metabolic activity in such conditions (Shafie *et al.*, 1984). Also, Mateos *et al.* (2010) indicated that supplementation of rabbit feeds with certain oligosaccharides and increases volatile fatty acids in the caecam of weanling rabbits, decreasing the caecal ammonia concentration. In addition, to stimulate the beneficial microflora of the gut, prebiotics may prevent the adhesion of pathogens to the mucosa and stimulate the immune response (Forchielli and Walker, 2005).

These results agreed with those of Fonseca *et al.* (2004) and Hooge *et al.* (2004a & b) who reported that, the prebiotics reduced mortality with about 50% reduction compared with the control. In addition, Lactomannan as prebiotic may be had a role in reduced mortality rate by its role in modify pH of rabbit digestive tract promoting useful bacteria and inhibit the harmful ones (Pinheiro *et al.*, 2004). It is, however, claimed that the mannan oligosaccharides from yeast cell wall work by providing specific binding sites (D-mannose) to enteric pathogens, thus reducing their chances to attach to the intestinal tract (Finucane *et al*., 1999). Since mannan oligosaccharides are not digested by the endogenous enzymes, they pass through the gut with the pathogens attached. There is also a "cleaning up" effect, i.e., they detach pathogens already attached to the gut (Newman, 1994). Furthermore, the possible antimicrobial activity of the prebiotics may be accounted for by their growth-promoting effects on bifidobacteria and lactobacilli. These bacteria can reinforce the barrier function of the intestinal mucosa, helping in the prevention of the attachment of pathogenic bacteria, essentially by crowding them out. These bacteria may also produce antimicrobial substances and stimulate antigen specific and nonspecific immune responses (Macfarlane and Cummings, 1999; and Roberfroid, 2000). On the other hand, the milk available per kit may also have a pronounced effect on the mortality of young rabbits (Rommers *et al.*, 2001).

Until 3 weeks, the weight gain of young rabbit was affected by milk production, showing higher values of litter weight for diet supplemented with MOS than for unsupplemented diet. Moreover, rabbit does fed high levels of MOS recorded the highest values of letters weights, during the first three weeks. The same trend was obtained at weaning, where rabbit does fed diet containing 1.0 and 1.5 g MOS/ kg recorded the highest values of letters weights at weaning, as compares with those fed control diet (2494.3 and 2612.9 *vs.* 1444.3 g, P<0.001, repectively). Also, kit weight at birth was significantly increased by 17.67% for rabbit does feed 1.5 MOS g/ kg diet, as compared with those fed control diet. Moreover, rabbit does fed 1.0 and 1.5 g MOS/ kg diet recorded the highest values of kit weight at weaning, as compared with those fed control diet (433.8 and 446.5 *vs.* 349.5 g, P<0.001, respectively).

The dietary MOS level had a significant effect on the feed and milk conversion ratio during the first three weeks of lactation. The feed conversion ratio was significantly improved (P<0.001) with rabbit does fed diets containing different MOS level (0.5, 1.0 and 1.5 g) during lactation period. Also, milk index was significantly improved with increasing dietary MOS content; where rabbit does fed control diet recorded the lowest value, as compared with those fed diets containing different levels of MOS (3.370 *vs.* 3.603, 3.621 and 3.606, P<0.01, respectively). An increase in the dietary MOS level increased (P<0.001) feed intake of pups 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. Also, the feed conversion ratio was better (P<0.01) for the high MOS level (1.0 and 1.5 g) than control group, during the last 9 days of lactating period (3.940 and 3.959 *vs.* 6.054 g/ g, P<0.01, respectively). During this stage, the differences were more evident than those observed during the first three weeks of lactation.

In this respect, Alves *et al*. (2003) and Mourão *et al.* (2004) observed that, the prebiotic additives lead to increase feed efficiency in rabbits, which may lead to increased milk secretion and its yield in treated rabbits. Besides that, the increase in milk production may be due to increase in litter size at birth, where there was a positive correlation between the litter size at birth and milk yield (Lebas *et al.*, 1997 and Rommers *et al.*, 2001). Generally, the improvement in litter traits proved that, the MOS treatment is capable to improve the milking ability of the doe which is reflected in her care and ability to suckle her young till weaning.

Growth rate of pups in the period from 21 days of age until weaning tended to increase with increasing the level of MOS in diet and the best value was obtained with the high dietary MOS level (1.5 g), as compared with control group (44.48 vs. 35.42%, P<0.05, respectively). The improvement in growth performance resulted from the addition of MOS could be due to the selectively stimulates the growth and/or activity of intestinal bacteria associated with health and wellbeing (Gibson, 1999). Furthermore, the increase in growth performance in treated rabbits may be due to the role of prebiotic oligosaccharides in increasing the concentrations of calcium and magnesium in the colon. Elevated concentrations of these cations in the colon may help to control the rate of cell turnover (Grizard and Barthomeuf, 1999). Prebiotics may have anticarcinogenic, antimicrobial, and glucose-modulatory activities (Hughes and Rowland, 2001). They may also have activity in improving mineral absorption and balance (Grizard and Barthomeuf, 1999 and Roberfroid, 2000).

Relative revenue:

Data of the growth performance (weight gain of pups in the period from birth until the weaning and feed intake of does during pregnancy and lactation periods) were subjected to economic study according prices of materials and products in Egyptian market at the time of experiment (Table 5). Total feed cost increased by increasing levels of MOS in diets, as a result of improves of feed intake and increase price of feed. However, weaning rabbit produced (kg/ doe) increased by 80.96% for rabbit does fed 1.5 g MOS/ kg diet, as compared with those fed control diet. Also, selling price was increased by increasing dietary MOS level, as a result of increase of weaning rabbit produced (kg /doe). The same trend was found in the net revenue and economic efficiency, which were increased, as MOS level increased in the diets. The best value of economic efficiency was found in the rabbits fed diet containing 1.5 g MOS/kg diet (56.45%), while the poorest value was recorded with those fed control diet (3.71%).

CONCLUSIONS

Supplementing MOS in rabbit does diet significantly improve the overall productive and reproductive performance of rabbits does during pregnancy and lactation periods, in addition to depressing the mortality of pups under high ambient temperature during summer season in Egypt. Therefore, it could be recommended providing rabbit does diet with MOS up to 1.5 g/kg diet is advisable in hot climates, Egypt.

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تأثير المنان اوليجوسكريد المضاف لعلائق الأرانب على الاداء الانتاجى والتناسلى للأمهات خلال فصل الصيف فى مصر

وائل عوض محمود مرسى و عطية ابراهيم عبداللطيف

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تهدف الدراسة لتحديد تأثير اضافة المنان أوليجوسكريد الى علائق أناث الأرانب على الاداء الانتاجى والتناسلى وتركيب اللبن تحت ظروف الصيف المصرية. تم أستخدام أربعين أنثى أرنب من خط الأبرى (عشرة أناث لكل عليقة) عمر ٨-٩ شهور. تمت تغذية الأرانب على العليقة الأساسية مضاف اليها صفر (عليقة مقارنة) – ٠.٥ – ١.٠ – ١.٥ جرام منان أوليجوسكريد / كجم علف. المتوسط اليومى لدرجة الحرارة والرطوبة النسبية داخل العنبر كانت على التوالى ٣١.٦±٣.٨ درجة سيلزية و ٧٧.٥±٤.٨%. تحت ظروف الاجهاد الحرارى ، أظهرت النتائج وجود اختلافات معنوية فى الزيادة فى وزن الحسم المكتسب والعلف المستهلك خلال فترة الحمل والرضاعة وحققت الأرانب المغذاة على مستوى مرتفع من المنان أوليجوسكريد (١.٥ جرام / كجم علف) أحسن النتائج، كما لوحظ وجود تحسن معنوى فى كفاءة التحويل الغذائى خلال فترة الرضاعة باضافة مستويات مختلفة من المنان أوليجوسكريد للعليقة (٠.٥ – ١.٠ – ١.٥ جرام)، سجلت الارانب المغذاة على العليقة الكنترول أعلى معدلات نفوق للنتاج خلال فترة الرضاعة مقارنتا بالعلائق المضاف اليها المنان أوليجوسكريد بمعدلات ٠.٥ – ١.٠ – ١.٥ جرام (٣٢.١١% مقابل ٢٥.٨٢ – ١٨.٣٧ – ١٧.٧٧% ، على التوالى). سجلت الامهات المغذاه على علائق مضاف اليها المنان أوليجوسكريد أعلى قيم لوزن النتاج حتى ثلاث اسابيع من الولاده مقارنتا بتلك المغذاة على عليقة بدون اضافات. سجلت الامهات المغذاه على ١.٠ و ١.٥ جرام منان أوليجوسكريد/ كيلوجرام علف أعلى قيم لوزن النتاج عند ثلاث اسابيع وعند الفطام. أوضحت النتائج السابقة أن ١.٥ جرام منان أوليجوسكريد/ كيلوجرام علف قد حققت أعلى قيمة للعائد النسبى، يليه مستوى ١.٠ جرام منان أوليجوسكريد/ كيلوجرام علف.

نستخلص من ذلك أن تغذية اناث الأرانب على المنان أوليجوسكريد يحسن من الأداء الانتاجى والتناسلى لامهات الأرانب خلال فترة الحمل والرضاعة ويقلل من نفوق النتاج تحت ظروف درجة الحرارة المرتفعة خلال الصيف فى مصر ولذلك فانه ينصح باضافة المنان أوليجوسكريد الى علائق أمهات الأرانب بمعدل ١.٥ ملجرام / كجم علف تحت ظروف الجو الحار.

Table (1): Composition and chemical analysis of the basal diet.

Ingredient	%	Chemical analysis (% as DM):	%
Berseem hay (*Trifolium alexandrinum*)	30.05	Dry matter (DM)	85.81
Barley grain	24.60	Crude protein (CP)	17.36
Wheat brain	21.50	Organic matter (OM)	91.42
Soybean meal (44% CP)	17.50	Crude fiber (CF)	12.37
Molasses	3.00	Ether extract (EE)	2.229
Limestone	0.95	Metabolizable energy (ME, kcal/kg)(2)	2257
Di-calcium phosphate	1.60	Calcium(2)	1.243
Sodium chloride	0.30	Phosphorus(2)	0.808
Mineral-vitamin premix(1)	0.30	Methionine(2)	0.454
DL-Methionine	0.20	Lysine(2)	0.862

[1]Mineral–vitamin premix provided the following per kilogram of diet: Vitamin A, 150,000 UI; Vitamin E, 100 mg; Vitamin K3, 21mg; Vitamin B1, 10 mg; Vitamin B2, 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).

Table (2): Effect of dietary mannan oligoscharides (MOS) supplementation on does performance during gestation and lactation periods of APRI line rabbits.

Items	MOS levels (g/kg diet)				SEM	P-value
	0	0.5	1.0	1.5		
Does weight (g) at:						
Mating	3024	3024	3022	3022	25.51	0.9999
Pre-Partum	3340[c]	3356[bc]	3425[ab]	3436[a]	26.34	0.0316
Partum	2993	2999	3004	3022	19.73	0.8260
Weaning	2882	2896	2914	2935	19.13	0.3707
Does weight Gain (g) at:						
Gestation	316.4[b]	331.4[b]	402.9[a]	414.3[a]	15.90	0.0001
Lactation	-110.7[b]	-102.9[b]	-90.7[a]	-87.1[a]	3.998	0.0009
Feed intake (g/d) for:						
Pregnant does	131.2[b]	137.4[ab]	146.3[ab]	151.3[a]	4.304	0.0370
Lactating does	191.8[b]	199.5[ab]	211.6[a]	216.8[a]	6.119	0.0373
Pups (22-30 day)	94.0[b]	157.6[a]	167.1[a]	171.3[a]	4.834	0.0001

a, b, c, Means in the same row with different superscripts are significantly different (P<0.05).
SEM = Standard error of means.

Table (3): Effect of dietary mannan oligoscharides (MOS) supplementation on milk production of APRI line rabbits.

Items	MOS levels (g/kg diet)				SEM	P-value
	0	0.5	1.0	1.5		
Milk production (g/d) at:						
1st week	70.00[b]	75.71[ab]	92.14[a]	92.86[a]	5.861	0.0707
2nd week	96.43[c]	107.5[bc]	122.1[ab]	127.1[a]	6.349	0.0057
3rd week	144.3[b]	158.6[ab]	174.9[a]	180.1[a]	6.764	0.0059
4th week	72.86[c]	85.71[b]	100.4[a]	108.6[a]	4.185	0.0001
Milk yield (g/d)	95.89[b]	106.9[b]	122.4[a]	127.2[a]	4.938	0.0001
Feed efficiency (g/g)(1)	0.500[b]	0.536[b]	0.577[a]	0.588[a]	0.011	0.0002

a, b, c, Means in the same row with different superscripts are significantly different (P<0.05).
SEM = Standard error of means.
(1) Milk yield (g) /does feed intake (g)

Table 4: Effect of dietary mannan oligoscharides (MOS) supplementation on letter performance of APRI line rabbits.

Items	MOS levels (g/kg diet)				SEM	P-value
	0	0.5	1.0	1.5		
Litter size at:						
Birth (alive)	6.14	6.57	7.14	7.14	0.340	0.1176
21 days	5.00^{b}	5.43^{ab}	6.14^{a}	6.29^{a}	0.369	0.0463
Weaning (30day)	4.14^{b}	4.86^{b}	5.86^{a}	5.86^{a}	0.261	0.0010
Mortality rate (%) at:						
Birth – 21 day	18.50	17.57	13.95	12.42	2.046	0.1997
Birth - Weaning	32.11^{a}	25.82^{ab}	18.37^{b}	17.77^{b}	2.585	0.0052
Litter weight (g) at:						
Initial	293.6^{b}	323.6^{b}	387.1^{a}	401.4^{a}	15.57	0.0004
7th day	562.1^{b}	680.7^{b}	821.4^{a}	870.0^{a}	36.93	0.0001
14th day	785.7^{c}	996.4^{b}	1237.1^{a}	1260.0^{a}	30.25	0.0001
21st day	1011.4^{c}	1328.6^{b}	1616.4^{a}	1652.1^{a}	49.84	0.0001
Weaning (30 day)	1444.3^{c}	1892.9^{b}	2494.3^{a}	2612.9^{a}	77.67	0.0001
Kit weight at birth (g)	47.87^{c}	49.65^{bc}	54.35^{ab}	56.33^{a}	1.718	0.0066
Kit weight at weaning (g)	349.50^{c}	392.2^{b}	433.8^{a}	446.5^{a}	10.91	0.0001
Growth Rate of Pups (%) (21day-weaning)	35.42^{b}	34.90^{b}	42.64^{ab}	44.48^{a}	2.170	0.0506
Milk Index (1)	3.370^{b}	3.603^{a}	3.621^{a}	3.606^{a}	0.036	0.0030
Feed conversion rate (g/g):						
1 to 21 days of lactation (2)	5.708^{a}	4.185^{b}	3.648^{b}	3.644^{b}	0.157	0.0001
22 to 30 days of lactation (3)	6.054^{a}	6.121^{a}	3.940^{b}	3.959^{b}	0.355	0.0028

a, b, c, Means in the same row with different superscripts are significantly different (P<0.05).
SEM = Standard error of means.
(1) As [(Litter weight (g) at 21 days after birth - Litter weight (g) at 24 hours after birth)/ (21 X Litter weight (g) at 21 days after birth)] X 100 (Calculated according to Niedzwiadek, 1981).
(2) As feed intake of does from 1 to 21 days (g) per litter weight gain from 1 to 21 days (g).
(3) As feed intake of does from 22 to 30 days (g) per litters weight gain from 22 to 30 days (g).

Table (5): Effect of dietary mannan oligoscharides (MOS) supplementation on relative revenue of rabbit does.

Items	MOS levels (g/kg diet)			
	0	0.5	1.0	1.5
Total feed intake (kg)(1)	10.536	11.526	12.239	12.584
Price /kg diet (L.E.)	3.304	3.314	3.324	3.334
Total feed cost (L.E.)	34.81	38.19	40.68	41.95
Weaning rabbit produced (kg/ doe)	1.444	1.893	2.494	2.613
Selling price (L.E.)(2)	36.11	47.32	62.36	65.32
Net revenue (L.E.)(3)	1.29	9.13	21.68	23.68
Economic efficiency (%)(4)	3.71	23.91	53.29	56.45

- Other conditions like mortality (%) and management are fixed.
- Ingredients price (L.E. per ton) at 2016 were: 3500 barley; 1600 berseem hay; 2900 wheat bran ; 6000 soybean meal (44%) ; 2000 molasses ; 25 limestone ; 9000 premix ; 40000 methionine ; 1000 di-calcium phosphate; 1000 salt; 20000 Bio-MOS.
- Adding 100 L.E. /ton for pelliting.
(1) Total feed intake= (Pregnant does daily feed intake X 30) + (Lactating does daily feed intake X 30) + (Pups daily feed intake X 9)
(2) Price of kg live body weight was 25 L.E. *(3) Net revenue= Selling price – total feed cost.*
*(4) Economic efficiency = (Net revenue/ total feed cost)*100*