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EFFECT OF FEEDING DIETS CONTAINING JOJOBA MEAL ON GROWTH PERFORMANCE OF GROWING RABBITS

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SUMMARY

A total of sixty male New Zealand White (NZW) rabbits weaned at 6 weeks of age, were divided into 6 equal groups (10 rabbits/ group) according to their live body weight (~ 927 g), to evaluate the possibility of feeding growing rabbits on diets containing untreated or treated (by fungus, lactic acid bacteria, isopropanol or heat) jojoba meal (JM) and their response on growth performance, nutrients digestibility, carcass traits, blood plasma parameters as well as economical efficiency. The growing rabbits were fed the control diet (diet without jojoba meal), or the diet containing 10 % either untreated or treated jojoba meal, accordingly, a total of 6 experimental diets were used. The experimental diets were formulated to be iso-nitrogenous (~ 17% CP) and iso-caloric (~ 2500 Kcal DE/kg diet). At the end of the experimental period (19 weeks of age), digestibility trials were carried out to determine the digestibility of feed nutrients, feeding value and nitrogen utilization of the experimental diets. The experimental diets were fed to growing rabbits for 13 weeks post-weaning period. The results revealed that the untreated JM contained 2388 Kcal digestible energy/Kg, 26.04% crude protein, 17.12% crude fiber, 15.40% ether extract, 3.28% ash. The different treatments of treated JM were efficient in reducing the anti-nutritional contents than untreated one. Simmondsin, poly phenolics and phytic acid by fungus lactic acid bacteria, isopropanol or heat respectively were 0.12, 0.15, 0.06 or 0.26% vs. 4.82% for simmondsin; 1.87, 1.75, 0.92 or 2.41% vs. 6.52% for poly phenolics, and undetectable values vs. 0.074 (mg/g) for phytic acid are not detectable. The lowest live body weight and body weight gain were recorded for rabbits fed the untreated jojoba meal. While, the corresponding best values were recorded by rabbits fed fungal or bacterial treated JM. Feed conversion and performance index were statistically ($P<0.01$) improved with fungal or bacterial treated JM diets than untreated one. The highest ($P<0.05$) values of nutrients digestibility were recorded for the diet contained fungal treated jojoba meal followed by the diet contained bacterial treated JM, accordingly nutritive values expressed as TDN and DCP % were significantly higher ($P<0.05$) for diets contained JM treated by fungus or bacteria than other treatments. Feeding rabbits on diets containing 10% dietary JM treated by fungus or bacteria gave the best dressing percentage % compared with the untreated JM and control diets. However, treated jojoba meal had slightly adverse effects on blood constituents of experimental rabbits. The results showed that including 10% treated JM by either fungus or bacteria in rabbits diet can be used and economically feasible. The above mentioned results revealed that treated JM by either fungus; bacteria, isopropanol or heat could eliminate the harmful effect of its content of some anti-nutritional factors.

Keywords: *Rabbits, jojoba meal, fungal and bacterial treatments, performance, digestibility, carcass traits, blood plasma parameters, economical efficiency.*

INTRODUCTION

In Egypt, there is a serious problem resulting from the shortage of protein sources used for animal feed, which results in high feeding cost. Therefore, there is a need to evaluate alternative protein sources to overcome such shortage problem. Jojoba (*Simmondsia chinensis*) is a dioeciously desert shrub that grows in arid or semi arid regions, being cultivated to provide a renewable source of unique high-quality oil (Sabien *et al.*, 1997). Several advantage are favoring jojoba seed to be grown in Egypt such as limited water requirements, high seed yield in new reclaimed soils and relatively high oil content, being 50% (Wisniak, 1987). The meal remaining after oil extraction contains high protein content approximately 30% which could be a new protein source for livestock (Motawe, 2005). The major problem of using jojoba meal is the high level of anti-nutritive compounds; including cyanogenic compounds such as simmondsin and simmondsin-2-ferulate (Van Boven *et al.*, 2000), poly phenolics, phytic acid and trypsin inhibitors, which may contribute to impair food intake and body weight gain of animal fed jojoba meal (Abbott *et al.*, 2004). Also, Ngoupayou *et al.* (1985) found large amounts of simmondsin compound (4.7%) in JM.

Bellirou *et al.* (2005) reported that detoxification of jojoba seed meal could be occurred by different methods; it includes solvent extraction, heat, chemical treatments and microbial fermentation. Simmondsin (Di methyl simmondsin) is a naturally occurring compound in the seed of jojoba plant found to suppress the appetite of animals when it incorporates in feed formula. Simmondsin and several of its analogs are presented at 5-7% in jojoba seed and remain in the press cake.

The main target of the present study was to investigate the effect of biological (fungus or bacteria), chemical (isopropanol), or heat treatments on degrading simmondsin and related cyanogenic toxic compounds in jojoba meal and their effect on growing NZW rabbit performance.

MATERIALS AND METHODS

The experimental work of the present study was conducted at Noubaria Experimental Station, Animal Production Research Institute, Agriculture Research Center. Jojoba meal (JM) samples were graciously supplied by the Egyptian Natural Oil Company (Private Sector).

Fungal treatment:

Pure strain of *Trichoderma reesei* (ATCC28217) obtained from Microbiology Research Center (MIRCEN), Faculty of Agriculture, Ain Shams University, maintained on potato-dextrose-agar (PDA) medium which was activated in a sterilized conical flasks kept in shaker water bath at 28-32°C for 96 hr. The active liquid fungal medium was used to inoculate an amount of ground moistened JM at 10% (v/w) of the jojoba weight and the whole treated amount was kept under aerobic condition for six days to obtain a sufficient amount of a solid state fermented JM. The scaling up of the fungal biomass under the farm condition was carried out as described by El-Badawi *et al.* (2007).

Bacterial treatment:

Jojoba meal was treated with pioneer brand lactic acid bacteria inoculants supplied by pioneer Hi-Bred international, Inc. at the rate of 1g/100kg (JM), stored in plastic containers for 21 days at room temperature, then dried to about 6% moisture and ground to pass a 2 mm screen.

Isopropanol (70%) treatment:

Jojoba meal was sprayed by aqueous solution of isopropanol at the rate of 10% (v/w) to inactivate the anti-nutritional compounds, then stored in plastic containers for 21 days at room temperature. The treated JM was aerated, then ground to pass a 2 mm screen as described by Medina and Gonzales (1990).

Heat treatment:

Jojoba meal was heated in boiling water for 15 min to inactivate the anti-nutritional compounds, treated sample was air dried at room temperature (Gorrill *et al.* 1974), then stored in plastic containers until being used.

Chemical analysis:

Chemical analysis of representative samples of raw and treated jojoba meal, experimental diets and dried feces were carried out according to the methods of the AOAC (1998) to determine dry matter (DM), crude protein (CP), N x 6.25, ether extract (EE), crude fiber (CF) and ash. Nitrogen free extract (NFE) was calculated by difference, i.e., by deducting the sum of the percentages of moisture, CP, EE, CF and ash from 100. Digestible energy (DE) was calculated according to Cheeke *et al.* (1982). The anti-nutritional compounds of jojoba meal (simmondsin (%), poly phenolics and phytic acid (mg/g)) contents were determined according to (Verbiscar and Banigan, 1978), (Joslyn and Goldstein, 1964) and (Wheeler and Ferrel, 1979), respectively.

Experimental animals and diets:

Sixty male New Zealand White (NZW) rabbits weaned at 6 weeks of age were used in this experiment. Rabbits were divided into 6 equal groups (10 rabbits/ group) according to their initial live body weight (~927 g). The experimental period, extended from 6 to19 weeks of age. The growing rabbits were fed the control diet (diet without jojoba meal), or fed diets containing 10% either untreated or treated jojoba meal by fungus, bacteria, isopropanol or heat. Accordingly, a total of 6 experimental diets were conducted. The experimental diets were formulated to be iso-nitrogenous (~ 17% CP) and iso-caloric (~ 2500 Kcal DE/Kg diet). All diets were pelleted and contained adequate levels of nutrients to satisfy the nutrients requirements of growing rabbits according to Agriculture Ministry Decree (1996). The composition and calculated analysis of the experimental diets are shown in Table (1).

Housing and feeding system:

Rabbits of each of the six experimental groups were housed in galvanized wire batteries in a well ventilated building (natural through the window) and offered the experimental diets *ad libitum*. Fresh water was available at all times from automatic drinkers with nipples for each cage. Urine and feces dropped from cages on the floor were cleaned every day in the morning. All rabbits were observed daily, kept under the same

managerial, hygienic and environmental conditions, and vaccinated against common diseases. All rabbits were individually weighed at the beginning of the experiment, then weekly before offering the morning meal until marketing age (19 weeks of age). Feed intake was weekly recorded during the experimental period. The following parameters were recorded: Live body weight (g), weight gain (g), feed intake (g), feed conversion (g feed/g gain), performance index % (final live body weight (Kg) / feed conversion*100) according to North (1981), viability% and economical efficiency.

Digestibility and nitrogen balance trials:

At the end of the experimental period (19 weeks of age), digestibility and nitrogen balance trials were carried out to determine the nutrients digestibility, feeding values and nitrogen utilization of the experimental diets. A total number of 18 male rabbits were taken randomly (3 within each treatment) and allotted in different treatments. Rabbits were housed individually in metabolic cage to facilitate the collection of all droppings throughout the digestibility trial. The same feeding regime used during the feeding trial (6 to 19 weeks of age) was also followed during the digestibility trial. Feed intake was daily recorded. Quantitative collection of feces was started 24 hours after offering the daily feed. Feces and urine of each rabbit were collected every day in the morning for a collection period of 7 days, sprayed with 10% sulphuric acid and toluene for trapping any ammonia released. Then after, feces were dried at 70°C for 72 hours, finally ground and kept with urine for chemical analysis.

Carcass traits:

At the end of the feeding trial (19 weeks of age), three rabbits representing each treatment were randomly taken to study the different carcass traits. Rabbits were fasted for approximately 16 hours, individually weighed (to record the pre-slaughter weight). After complete bleeding and skinning, the empty carcass without head, liver, kidneys, heart and spleen were weighed separately according to Cheeke (1987). Meat was minced, dried, reweighed, ground and stored at 10°C for chemical analysis. Individual blood samples (from the same slaughtered rabbits) were collected in dry clean centrifuge tubes containing few drops of heparin solution and centrifuged at 3000 r.p.m for 20 minutes to separate blood plasma, and then assigned for biochemical analyses using commercial kits.

Economical efficiency:

Economical efficiency was calculated as the ratio between income (price of weight gain) and cost of feed consumed at the different experimental periods (6-8, 6-10, 6-14 and 6-19 weeks of age).

Statistical analysis:

Data were analyzed for all variables using the general linear models procedure to establish the differences between means using SAS software version 9.1 (SAS Institute, 2004). The model used was: $Yij = \mu + Ti + E\,ij$

Where: Yij = the observation of ij. μ = the overall mean. Ti = the effect of i (treatments). Eij = the experimental random error.

Data of percentages were subjected to arc-sin transformation to approximate normal distribution before being analyzed. Variables having a significant F- test were compared

using Duncan's multiple rang test (Duncan, 1955). All statements of statistical significance were based on probability ($P<0.05$).

Table (1): Composition and calculated analysis of the experimental diets (as fed).

Ingredients %	Control	Jojoba meal				
		Untreated	Treated			
			Fungus	Bacteria	Isopropanol	Heat
Clover hay (12% CP)	30.0	30.0	30.0	30.0	30.0	30.0
Jojoba meal(JM)	-	10.0	-	-	-	-
Jojoba meal treated with Fungus (FJM)	-	-	10.0	-	-	-
Jojoba meal treated with bacterial (BJM)	-	-	-	10.0	-	-
Jojoba meal treated with isopropanol (IJM)	-	-	-	-	10.0	-
Jojoba meal treated with heat (HJM)	-	-	-	-	-	10.0
Yellow corn	21.0	16.6	16.0	16.0	16.0	15.6
Soybean meal (44%CP)	19.0	15.0	13.0	15.0	15.0	15.0
Wheat bran	21.6	20.0	22.6	20.6	20.6	21.0
Molasses	6.0	6.0	6.0	6.0	6.0	6.0
DL-Methionine	0.1	0.1	0.1	0.1	0.1	0.1
Vits. & Min. mix.[1]	0.4	0.4	0.4	0.4	0.4	0.4
Common salt (NaCl)	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	0.9	0.9	0.9	0.9	0.9	0.9
Di-Calcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5
Calculated analysis[2]:						
Dry matter (DM), %	89.43	88.39	87.55	87.15	88.53	88.69
Crude protein(CP), %	17.10	17.10	17.10	17.10	17.10	17.10
Ether extract (EE), %	2.58	3.65	3.81	3.66	3.60	3.79
Nitrogen free extract (NFE), %	50.45	47.54	46.84	46.49	47.63	47.50
Ash, %	6.10	5.90	6.10	6.00	6.00	6.00
Organic matter (OM), %	83.33	82.49	81.45	81.15	82.53	82.69
Digestible energy (DE), (kcal/kg)[3]	2530.0	2522.0	2523.0	2528.0	2530.0	2531.0
Crude fiber (CF), %	13.20	14.20	13.70	13.90	14.20	14.30
Calcium, %	1.01	1.00	1.00	1.00	1.00	1.00
Total Phosphorus, %	0.55	0.50	0.50	0.50	0.50	0.50
Methionine,%	0.37	0.33	0.33	0.33	0.33	0.33
Lysine, %	0.80	0.70	0.70	0.70	0.70	0.70
DE:CP	147.6	147.5	147.9	147.0	147.9	147.6

1-Supplied per kg. of diet: Vit. A 2000000 IU; Vit. D3 150000 IU; Vit. E 8.33g, Vit. K 0.33g, Vit. B1 0.33g, Vit. B_2 1.0g, Vit. B6 0.33g, Vit. B12 1.7mg, Vit. B_5 8.33g, Pantothenic acid 3.33g, Zn 11.79, Fe 12.5, Cu 0.5g, Co 1.33mg, Se 16.6 mg, Mg 66.79mg, Niacin 8.33 mg, Biotin 33mg, Folic acid 0.83g, Choline chloride 200g, Mn 5g.

2-According to Feed Composition Tables for Animal and Poultry Feedstuffs Used in Egypt (2001).

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

RESULTS AND DISCUSSION

Chemical analyses of untreated and treated jojoba meal:

Treating JM with fungus resulted in an increase in CP content by about 22%, while increased by about 4% when treated with lactic acid bacteria, however, CP content was decreased by about 2% in other treatments. On the other hand, CF content was decreased by about 37% and 22% by treating JM with fungus and bacteria, respectively. Other treatments had quite similar CF content. Ash content was increased by about 53% and 34% for JM treated with fungus and bacteria, respectively than untreated one (Table 2). The increase in JM nitrogen content was apparently due to the overall loss of weight during

treatment, due to the conversion of carbohydrates to carbon dioxide (Verbiscar *et al.*, 1980; Medina and Gonzales, 1990; Swezey *et al.*, 2000 and El-Shennawy, 2003).

Concentration of anti-nutritive compounds:

Data in Table (2) showed that all treatments had a positive effect in decreasing the anti-nutritive compounds of JM, which considered inhibitors and had negative effects on appetite (Swingle *et al.*, 1985; Bellirou *et al.*, 2005 and El-Shennawy, 2003). Fungal treatment decreased simmondsin as the major toxicant compound by about 98% and poly phenolics by about 71%. While, heat treatment decreased the simmondsin and poly phenolics by about 95% and 63%, respectively. Verbiscar *et al.* (1980) and Ahmed and Satti (2002) reported that moist heating of JM has an effect on lowering levels of toxicants. Incubation of JM with lactic acid bacteria decreased simmondsin and poly phenolics content by about 97% and 73%, respectively. In this concern, Medina *et al.* (1988) noticed that isopropanol treatment can extract up to 86% of poly phenolics compounds in JM. However, phytic acid concentration was not detected in all treatments. Swezey *et al.* (2000) confirmed that fermentation of JM with lactic acid bacteria effectively reduced its content of simmondsin. Aqueous mixture of isopropanol was found to be an effective treatment in improving quality of JM as it decreased content of simmondsin and poly phenolics by about 99% and 86%, respectively.

Growth performance:

Data presented in Table (3) showed significant differences in live body weight, total weight gain, feed intake and feed conversion among the six experimental treatments.

Table (2): Chemical composition (%) and the content of anti nutritive compounds (on DM basis) of untreated and treated jojoba meal.

Item	Jojoba meal				
	Untreated	Treated			
		Fungus	Bacteria	Isopropanol	Heat
Chemical composition:					
OM (%)	96.72	94.99	95.59	96.45	96.86
CP (%)	26.04	31.88	27.01	25.57	25.60
CF (%)	17.12	10.79	13.43	16.83	17.31
EE (%)	15.40	16.78	15.64	14.80	16.92
NFE (%)	38.16	35.54	39.51	39.25	37.03
Ash (%)	3.28	5.01	4.41	3.55	3.14
Digestible energy, (kcal/kg[1]) (DE)	2388	2592	2507	2397	2381
Concentration of anti nutritive compounds:					
Simmondsin (%)	4.82	0.12	0.15	0.06	0.26
Poly phenolics (%)	6.52	1.87	1.75	0.92	2.41
Phytic acid (mg/g)	0.074	ND	ND	ND	ND

[1]Calculated according to Cheeke (1987):
DE (Kcal/g) = 4.36 – 0.0491 (%NDF). %NDF = 28.924 + 0.657 (%CF). ND: Not detectable

The highest live body weight and body weight gain were recorded with diet contained JM treated with fungus followed by JM treated with bacteria in rabbit diets when compared with all the other experimental diets. While, the lowest live body weight and body weight gain were recorded with diet contained untreated JM for all different ages. These results may be due to that JM treated either by fungus or bacteria may induce certain

changes i.e., reduced content of simmondsin as the major toxicants in jojoba meal (Swingle *et al.*, 1985 and Decuypere *et al.*, 1996). Ngoupayou *et al.*, (1985) reported that the diet contained 5, 10 or 15% untreated JM caused no mortality to weanling rabbits but they failed to support normal growth.

Results of feed intake showed that feeding treated JM with various methods significantly increased daily DM consumption compared with untreated JM diet at all

Table (3): Effect of the experimental diets on live body weight, weight gain, total feed Intake, feed conversion (mean± SE) and performance index (%) of NZW rabbits at different ages of the experimental period (6-19 weeks of age).

Item	Control	Jojoba meal				
		Untreated	Treated			
			Fungus	Bacteria	Isopropanol	Heat
Live body weight (g/rabbit)						
Initial wt.	927.0^{a}±35.6	928.0^{a}±42.2	928.0^{a}±28.1	927.0^{a}±35.1	928.0^{a}±23.7	928.0^{a}±43.9
8 weeks	1282.2^{a}±44.4	1085.7^{b}±50.7	1272.2^{a}±67.6	1276.7^{a}±35.0	1218.8^{ab}±16.3	1256.3^{a}±49.7
10 weeks	1600^{ab}± 43.4	1204.3^{c}±52.7	1713.8^{a}±37.5	1614.4^{ab}±37.6	1527.5^{b}±18.8	1560.0^{b}±48.1
14 weeks	2231.1^{bc}±48.9	1325.7^{d}±51.7	2476.3^{a}±35.9	2284.4^{b}±38.0	2128.8^{c}±27.2	2173.8^{bc}±47.7
19 weeks	2993.3^{c}±28.9	1827.1^{d}±46.8	3395.0^{a}± 45.4	3243.3^{b}±18.1	2950.0^{c}±18.2	2972.5^{c}±62.3
Weight gain (g/rabbit)						
6-8 weeks	355.2^{b}±23.0	157.7^{d}±6.11	344.2^{b}±7.30	349.7^{b}±4.44	290.8^{bc}±4.22	328.3^{c}±5.26
6-10 weeks	673.0^{b}±20.9	276.3^{d}±7.46	785.8^{a}±8.00	687.4^{b}±7.26	599.5^{c}±8.85	632.0^{c}±6.10
6-14 weeks	1304.1^{c}±23.3	397.7^{e}±5.71	1548.3^{a}±8.75	1357.4^{b}±9.57	1200.8^{d}±16.4	1245.8^{d}±8.01
6-19 weeks	2066.3^{c}±7.99	899.1^{d}±6.11	2467.0^{a}±32.6	2316.3^{b}±31.7	2022.0^{e}±9.80	2044.5^{e}±16.2
Total feed intake (g/rabbit)						
6-8 weeks	1176.0^{bc}±35.6	854.0^{d}±42.7	1302.0^{a}± 42.2	1260.0^{ab}±33.3	1092.0^{c}±26.7	1106.0^{c}±29.2
6-10 weeks	2940.0^{b}±60.0	2170.0^{d}±65.4	3374.0^{a}±50.0	3290.0^{a}±44.0	2674.8^{c}±65.4	2814.0^{bc}±46.2
6-14 weeks	7204.0^{c}±44.0	4502.0^{f}±37.7	7862.0^{a}±62.6	7666.0^{b}±60.0	6602.0^{e}±70.7	6854.0^{d}±32.7
6-19 weeks	14752.0^{c}±50.0	9976.0^{f}±32.7	15648.8^{a}±42.2	15384.0^{b}±47.1	13946.0^{e}±11.0	14300.0^{d}±50.8
Feed conversion(g feed/g gain)						
6-8 weeks	3.31^{bc}±0.118	5.42^{a}±0.091	3.78^{c}±0.070	3.60^{d}±0.065	3.76^{cd}±0.068	3.37^{b}±0.041
6-10 weeks	4.37^{cd}±0.082	7.85^{a}±0.190	4.29^{d}±0.027	4.79^{b}±0.032	4.46^{c}±0.064	4.45^{cd}±0.046
6-14 weeks	5.52^{b}±0.067	11.32^{a}±0.118	5.08^{d}±0.025	5.65^{b}±0.020	5.50^{c}±0.032	5.50^{b}±0.014
6-19 weeks	7.14^{b}±0.009	11.10^{a}±0.045	6.34^{d}±0.087	6.64^{c}±0.0.085	6.90^{c}±0.033	6.99^{b}±0.052
Performance index[1]%						
6-8 weeks	38.73^{a}	28.83^{b}	33.65^{a}	35.46^{a}	32.41^{a}	37.27^{a}
6-10 weeks	36.61^{a}	15.34^{b}	39.94^{a}	33.70^{a}	34.24^{a}	35.05^{a}
6-14 weeks	40.42^{b}	11.71^{c}	48.74^{a}	40.43^{b}	38.70^{b}	39.52^{b}
6-19 weeks	41.92^{c}	16.46^{d}	53.54^{a}	48.84^{b}	42.75^{c}	42.52^{c}

a, b, c, d, e and f means on the same column at each item with different superscripts are significantly (P = 0.05) different. SE= Standard error.

[1]Calculated according to North (1981): Performance index % = final live body weight (Kg) / feed conversion*100

feeding periods. In this respect, Arnouts *et al.*, (1993) and Van Boven *et al.*, (1994) reported that the growth retardation caused by JM supplementation was provoked by an inhabitation of appetite linked with the simmondsin content of JM as well as other anti-nutritional compounds affecting digestibility. Best feed conversion was observed with diets contained JM treated with fungus, followed by those treated with bacteria, then isopropanol during 6-19 weeks of age. Moreover, the inclusion of JM treated had increased performance index at 6-19 weeks of age. These findings are in agreement with those obtained by Khalel *et al.* (2008).

Digestibility and nitrogen balance trials:

Data presented in Table (4) showed highly significant differences in digestibility of different nutrients, nutritive values and nitrogen utilization of the experimental diets which were determined at the end of the experimental period among the six experimental treatments.

The highest (P<0.05) digestibility values of nutrients were recorded for the diet contained fungus treated jojoba meal followed by diet contained lactic acid bacteria treated JM, while the lowest values were obtained for diet contained untreated JM. Heating JM showed less effect in improving nutrients digestibility compared to other treatments. The improvement in nutrients digestibility followed the biological and chemical treatments could be a result of better feed intake and nutritive value. In this concern, Nelson *et al.* (1979) reported that fermentation of JM clearly improved its palatability, acceptability and digestibility coefficients to ruminants. The mechanism by which simmondsin decreased the feed intake is unknown. Some authors considered simmondsin as a toxic compound. The TDN and DCP values for fungus treated JM containing diet recorded significantly the highest values, while the lowest values were obtained with untreated JM containing diet. Less (P<0.05) nitrogen balance was noticed for rabbits fed untreated JM containing diet, this could be due to the high contents of anti-nutritional substances of JM and its effect on depressing feed intake. These results are in agreement with those obtained by Khalel *et al.* (2008).

Table (4): Effect of the experimental diets on nutrients digestibility, nutritive values and nitrogen utilization of NZW rabbits.

Item	Control	Jojoba meal				
		Untreated	Treated			
			Fungus	Bacteria	Isopropanol	Heat
Digestion coefficients (%):						
DM	59.39^{c}	53.79^{d}	66.00^{a}	62.44^{b}	59.66^{c}	59.29^{c}
OM	61.58^{c}	56.29^{d}	67.56^{a}	64.16^{b}	61.98^{c}	61.46^{c}
CP	59.35^{c}	51.44^{e}	65.20^{a}	60.99^{b}	58.84^{cd}	57.54^{d}
CF	35.96^{c}	27.16^{d}	41.99^{a}	38.72^{b}	34.15^{c}	33.88^{c}
EE	77.22^{a}	67.81^{c}	76.25^{a}	76.00^{a}	72.74^{b}	72.05^{b}
NFE	66.41^{c}	63.11^{d}	72.85^{a}	69.73^{b}	68.18^{bc}	67.94^{c}
Nutritive values (%):						
TDN	59.23^{c}	54.23^{d}	63.76^{a}	61.47^{b}	59.34^{c}	58.74^{c}
DCP	9.34^{c}	8.17^{e}	10.31^{a}	9.62^{b}	9.35^{c}	9.06^{d}
Nitrogen utilization:						
N-intake (g/d)	3.57^{ab}±0.05	3.28^{b}±0.14	3.69^{a}±0.09	3.50^{ab}±0.11	3.50^{ab}±0.14	3.61^{ab}±0.14
N-absorbed (g/d)	2.12^{b}±0.05	1.69^{c}±0.07	2.43^{a}±0.08	2.15^{b}±0.08	2.06^{b}±0.08	2.08^{b}±0.09
N-balance (g/d)	1.15^{bc}±0.01	0.507^{d}±0.04	1.50^{a}±0.03	1.25^{b}±0.05	1.12^{c}±0.03	1.11^{c}±0.06
N-balance as %of N-intake	32.24^{c}	15.64^{d}	40.52^{a}	35.66^{b}	31.93^{c}	30.57^{c}
N-balance as %of N-absorbed	54.34^{b}	30.37^{c}	62.16^{a}	58.45^{ab}	54.25^{b}	53.25^{b}

a, b, c, d and e means in the same column at each item with different superscripts are significantly (P = 0.05) different. Mean ± Standard error.

Carcass traits:

The effect of 10% dietary jojoba meal (treated or not) on carcass traits and chemical analysis of carcass meat are presented in Table (5). Feeding diets containing raw jojoba meal had a significant bad effect on all carcass traits and chemical composition of carcass meat. Mean while, untreated JM had significant enlargement effect on kidneys, heart and Spleen weight of rabbits. Whereas, rabbits fed treated JM diets had higher (P<0.05) liver

weight than that fed untreated JM diet. Weights of different carcass traits varied slightly with treatment effect (Table 5). Diets contained fungal or bacterial treated JM gave higher dressing percentage. Results presented in Table (5) showed that DM, CP, CF, EE and ash contents of rabbit meat differed slightly with treatments but the differences were significantly between raw JM and all other treatments. In this respect, Manos *et al.*, (1986) with lambs fed 5 and 10% jojoba meal supplemented rations, simmondsin was not detected in kidney, liver and muscle. Cokelaere *et al.*, (1993) and El-Shennawy (2003) reported that no differences for proportional organ weight such as, spleen, kidney, adrenal and seminal vesicles weight for rats.

Some blood plasma parameters:

Data presented in Table (6) showed significant differences in blood plasma concentration fed control diet compared to rabbits received diets containing raw or treated jojoba meal after 13 weeks of feeding period. The highest protein fractions

Table (5): Effect of experimental diets on carcass traits (mean± SE) of NZW rabbits.

Item		Control	Jojoba meal				
			Untreated	Treated			
				Fungus	Bacteria	Isopropanol	Heat
Pre-slaughter (g)		3083.3^{b}±31.7	1936.7^{e}±58.1	3263.3^{a}±37.5	3270.0^{a}±23.0	3006.7^{b}±12.0	3146.7^{bc}±89.8
Empty carcass(g)		1748.0^{bc}±26.4	818.0^{d}±31.4	2020.3^{a}±30.0	1982.0^{a}±19.1	1617.0^{c}±24.0	1801.0^{b}±85.7
Dressing percentage%		56.7^{b}	42.2^{d}	61.9^{a}	60.6^{a}	53.8^{c}	57.2^{b}
Total giblets (g)		82.10^{abc}±1.27	80.47^{abc}±1.97	84.73^{a}±1.90	83.87^{ab}±1.41	77.23^{c}±2.04	78.4^{bc}±1.35
	%	2.66^{b}	4.16^{a}	2.60^{bc}	2.56^{bc}	2.57^{bc}	2.49^{c}
Liver	(g)	62.57^{ab}±1.47	58.53^{bc}±1.33	65.37^{a}±1.37	64.57^{a}±0.95	57.53^{c}±1.59	58.80^{bc}±1.00
	%	2.03^{b}	3.02^{a}	2.00^{bc}	1.97^{bc}	1.91^{cd}	1.87^{d}
Kidneys	(g)	13.20^{a}±0.57	14.17^{a}± 0.54	12.87^{a}±0.42	12.70^{a}±0.26	13.40^{a}±0.40	13.20^{a}±0.40
	%	0.43^{bc}	0.73^{a}	0.39^{c}	0.39^{c}	0.45^{b}	0.42^{bc}
Heart	(g)	6.33^{b}±0.09	7.77^{a}±0.26	6.50^{b}±0.15	6.60^{b}±0.25	6.30^{b}±0.21	6.40^{b}±0.23
	%	0.21^{b}	0.40^{a}	0.20^{b}	0.20^{b}	0.21^{b}	0.20^{b}
Spleen	(g)	1.93^{a}±0.26	2.17^{a}±0.07	1.77^{a}±0.07	1.77^{a}±0.03	1.97^{a}±0.12	1.87^{a}±0.03
	%	0.063^{b}	0.11^{a}	0.05^{b}	0.05^{b}	0.07^{b}	0.06^{b}
Head	(g)	142.0^{a}±5.85	148.7^{a}±5.45	136.3^{a}±5.60	141.3^{a}±4.97	139.7^{a}±9.70	145.7^{a}±3.75
	%	4.61^{b}	7.68^{a}	4.18^{b}	4.32^{b}	4.64^{b}	4.64^{b}
Chemical composition of carcass meat on DM basis %							
DM		24.13^{c}	25.85^{a}	25.06^{ab}	24.16^{c}	24.78^{bc}	24.17^{c}
CP		68.63^{a}	65.00^{b}	68.67^{a}	67.70^{a}	66.91^{a}	67.64^{a}
EE		21.09^{a}	14.95^{b}	21.35^{a}	20.91^{a}	19.16^{a}	19.40^{a}
Ash		4.60^{b}	6.10^{a}	5.19^{b}	4.90^{b}	4.64^{b}	4.93^{b}

a, b, c and d means in the same column at each item with different superscripts are significantly (P= 0.5) different.

SE= Standard error. Dressing percentage%= Empty carcass wt. (without head) / Pre-slaughter wt. * 100

Total giblets wt. = Liver+ Kidneys wt. + Heart wt.

Table (6): Effect of the experimental diets on some blood plasma parameters (mean± SE) of NZW rabbits.

Parameters	Control	Jojoba meal				
		Untreated	Treated			
			Fungus	Bacteria	Isopropanol	Heat
Glucose (mg/dl)	83.58^{a}±1.56	71.16^{b}±1.63	82.54^{a}±1.09	82.69^{a}±1.03	80.35^{a}±1.74	80.11^{a}±1.50
Cholesterol(mg/dl)	93.92^{a}±3.15	72.73^{c}±1.08	88.08^{ab}±1.46	82.71^{b}±1.24	84.83^{b}±2.36	86.21^{b}±2.12
Protein fractions:						
Total protein (g/dl)	8.06^{b}±0.14	6.38^{c}±0.21	8.67^{a}±0.24	8.02^{b}±0.17	8.05^{b}±0.15	7.83^{b}±0.19
Albumin (g/dl)	4.67^{a}±0.13	3.94^{bc}±0.06	4.57^{a}±0.21	4.12^{b}±0.07	4.02^{bc}±0.05	3.74^{c}±0.08
Globulin (g/dl)	3.38^{b}±0.10	2.44^{c}±0.14	4.09^{a}±0.04	3.89^{a}±0.10	4.03^{a}±0.10	4.09^{a}±0.14
A/G ratio (g/dl)	1.38^{b}±0.06	1.61^{a}±0.07	1.12^{c}±0.04	1.06^{c}±0.01	0.998^{cd}±0.01	0.914^{d}±0.03
Kidney functions:						
Urea (mg/dl)	37.98^{bc}±0.5	35.71^{c}±1.13	46.23^{a}±0.65	40.85^{b}±0.77	39.57^{b}±1.17	38.24^{bc}±0.75
Creatinine (mg/dl)	0.933^{b}±0.0	0.800^{c}±0.04	1.09^{a}±0.02	1.00^{ab}±0.04	0.950^{b}±0.04	0.940^{b}±0.03
Liver functions:						
AST (I.U/L)	28.17^{b}±0.9	35.23^{a}±0.95	30.66^{b}±0.58	30.68^{b}±0.61	29.55^{b}±0.83	28.93^{b}±0.92
ALT (I.U/L)	39.42^{b}±0.7	46.04^{a}±1.14	39.95^{b}±0.78	39.47^{b}±0.40	40.24^{b}±0.65	40.06^{b}±0.89

a, b, c and d means in the same column of each item with different superscripts are significantly (P = 0.05) different.
SE = Standard error.

(total protein, albumin, globulin and A/G ratio) were obtained with JM treated by fungus while the lowest values were recorded for untreated JM while, liver enzymes (ALT and AST) increased with untreated JM when compared with all the other treatments. However, urea and creatinine as indicators for kidney function were decreased with untreated JM. In this respect, Manos *et al.*, (1986) with lambs fed 5 and 10% jojoba meal supplemented rations, found that simmondsin was not detected in blood. Also, they observed a decrease in blood urea N in ewes given jojoba compared with controls.

Therefore, treating JM with fungus or bacteria may be effective when included in the diet of growing rabbits without adverse effects on their blood biochemical changes.

Economical efficiency and viability rate:

The economical efficiency of the present study was calculated based on input-output analysis of the total feeding cost and the prevailing selling price of live body weight gain. The effect of the control diet and diets containing 10% jojoba meal either untreated or treated by fungus, bacteria, isopropanol and heat on the economical efficiency and feed cost/Kg body gain (LE) of rabbits are summarized in Table (7). The results showed that jojoba meal treated with fungus gave the best economical efficiency, relative economical efficiency and least feed cost/ Kg body gain (LE) at different ages as compared to the control and all treated diets. These findings are in agreement with those obtained by Khalel *et al.* (2008).

From this study, it could be concluded that, treating jojoba meal by either fungus, bacteria, isopropanol or heat can eliminate the harmful effect of its content of the anti-nutritional factors and so the effect on rabbit performance and achieved better net revenue and economical efficiency.

Table (7): Effect of the experimental diets on economical efficiency of NZW rabbits.

Item	Control	Jojoba meal				
		Untreated	Treated			
			Fungus	Bacteria	Isopropanol	Heat
Price / kg diet (LE)	1.50	1.33	1.31	1.34	1.34	1.33
Price / kg weight gain(LE)	20	20	20	20	20	20
6-8 weeks:						
Total feed intake/rabbit (g)	1176.0	854.0	1302.0	1260.0	1092.0	1106.0
Total weight gain/rabbit (g)	355.2	157.7	344.2	349.7	290.8	328.3
Total feed cost/rabbit (LE)	1.76	1.14	1.71	1.69	1.46	1.47
Feed cost / Kg gain (LE)	4.95	7.23	4.97	4.83	5.02	4.48
Total revenue/ rabbit (LE)	7.10	3.15	6.88	6.99	5.82	6.57
Net revenue/rabbit (LE)	5.34	2.01	5.17	5.30	4.36	5.10
Economical efficiency(E. Ef)	3.03	1.76	3.02	3.14	2.99	3.47
Relative E.Ef%	100	58	100	104	99	115
6-10 weeks:						
Total feed intake/rabbit (g)	2940.0	2170.0	3374.0	3290.0	2674.0	2814.0
Total weight gain/rabbit (g)	673.0	276.3	785.8	687.4	599.5	632.0
Total feed cost/rabbit (LE)	4.41	2.89	4.42	4.41	3.58	3.74
Feed cost / Kg gain (LE)	6.55	10.46	5.62	6.42	5.97	5.92
Total revenue/ rabbit (LE)	13.46	5.53	15.72	13.75	11.99	12.64
Net revenue/rabbit (LE)	9.05	2.64	11.30	9.34	8.41	8.90
Economical efficiency(E. Ef)	2.05	0.913	2.56	2.12	2.35	2.38
Relative E.Ef%	100	45	125	103	115	116
6-14 weeks:						
Total feed intake/rabbit (g)	7204.0	4502.0	7862.0	7666.0	6602.0	6854.0
Total weight gain/rabbit (g)	1304.1	397.7	1548.3	1357.4	1200.8	1245.8
Total feed cost/rabbit (LE)	10.81	5.99	10.30	10.27	8.85	9.12
Feed cost / Kg gain (LE)	8.29	15.06	6.65	7.57	7.37	7.32
Total revenue/ rabbit (LE)	26.08	7.95	30.97	27.15	24.02	24.92
Net revenue/rabbit (LE)	15.27	1.96	20.67	16.88	15.17	15.80
Economical efficiency(E. Ef)	1.41	0.327	2.01	1.64	1.71	1.73
Relative E.Ef%	100	23	143	116	121	123
6-19 weeks:						
Total feed intake/rabbit (g)	14752.0	9976.0	15648.0	15384.0	13946.0	14300.0
Total weight gain/rabbit (g)	2066.3	899.1	2467.0	2316.3	2022.0	2044.5
Total feed cost/rabbit (LE)	22.13	13.27	20.50	20.61	18.69	19.02
Feed cost / Kg gain (LE)	10.71	14.76	8.31	8.90	9.24	9.30
Total revenue/ rabbit (LE)	41.33	17.98	49.34	46.33	40.44	40.89
Net revenue/rabbit (LE)	19.20	4.71	28.84	25.72	21.75	21.87
Economical efficiency(E. Ef)	0.868	0.355	1.41	1.25	1.16	1.15
Relative E.Ef%	100	41	162	144	134	132

Based on prices of the Egyptian market during the experimental period (2008).
The price of one ton of clover hay (12%CP), yellow corn, soybean meal (44%CP), wheat bran, molasses, methionine, vitamins & minerals mix., salt, lime stone and Di-cal. phosphate were 1050, 1300, 2800, 1100, 515,
3000, 2000, 150, 50 and 200 LE, respectively. Initial price of rabbit 20 LE.
The prices of one ton untreated jojoba meal, treated jojoba meal (fungus, bacteria, isopropanol and heat) and body
weight on selling were 200(100, 16, 20 and 5) and 20 LE, respectively. Add 100 LE for mixed and pelleted.
Net revenue / rabbit (LE) = (Total revenue / rabbit (LE)) – (Total feed cost / rabbit (LE)).
Economical efficiency= (Net revenue/rabbit (LE)) / (Total feed cost/rabbit (LE).
Feed cost / kg gain= Total feed cost/rabbit (LE) *1000 / Total weight gain/rabbit (g).

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تأثير التغذية علي علائق تحتوي علي كسب الجوجوبا على أداء الأرانب النامية

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[2]قسم الإنتاج الحيواني ـ كلية الزراعه ـ جامعة الإسكندريه ـ مصر.

تم توزيع ٦٠ أرنب ذكر نيوزيلندي أبيض مفطومة عند عمر ٦ أسابيع عشوائيا إلي ٦مجموعات (١٠ أرنب لكل مجموعة) بمتوسط وزن حي ٩٢٧ جم تقريبا وذلك لدراسة امكانية تغذية الأرانب علي علائق تحتوى علي كسب الجوجوبا غير المعامل أو المعامل (الفطر أوالبكتريا أو الأيزوبروباتول أو الحراره) ومدي تأثير ذلك علي أداء النمو و الهضم وخصائص الذبيحه وصفات الدم بالاضافه الي الكفاءة الاقتصادية. تم تكوين العلائق التجريبية بحيث تحتوي علي ١٠% كسب الجوجوبا من إجمالي الطيفه المأكوله سواء غير المعامل أو المعامل (بالفطر أوالبكتريا أو الأيزوبروباتول أو الحراره) بالإضافه إلي عليقه المقارنه الخاليه من كسب الجوجوبا (الكنترول) وكانت العلائق الست المستخدمه متساوية تقريبا في محتواها من البروتين الخام (حوالي١٧٪) والطاقة المهضومة (حوالي ٢٥٠٠ كيلو كالوري/ كجم عليقة) بحيث تغطي الاحتياجات الغذائية للأرانب الناميه تبعا لمقررات وزارة الزراعة. وفى نهاية مدة التجربة (عند عمر١٩أسبوع) أجريت تجربة هضم لتقدير معاملات الهضم والقيمة الغذائية لعلائق التجربة. وقد تم تغذية الأرانب النامية على العلائق التجريبية لمدة ١٣ إسبوع بعد الفطام.

أوضحت النتائج أن كسب الجوجوبا غير المعامل يحتوى علي ٢٣٨٨ كيلو كالوري طاقة مهضومة / كجم, ٢٦,٠٤٪ بروتين خام, ١٧,١٢٪ ألياف خام, ١٥,٤٠٪ دهن خام, ٣,٢٨٪ رماد ويعض المثبطات الغذائيه مثل السيموندسين (٤,٨٢٪) والبولي فينول (٦,٥٢٪) وحمض الفيتك (٠,٠٧٤ملليجم/جم). وقد أدت المعاملة (بالفطر أوالبكتريا أو الأيزوبروباتول أو الحراره) لكسب الجوجوبا الى خفض مركبات السيموندسين و البولي فينول وحمض الفيتك مسجلة ١٢,٠ ، ١٥,٠ ، ٠٦,٠ ، ٢٦,٠٪ سيموندسين و ١,٨٧، ١,٧٥ ، ٩٢,٠ ، ٤١,٢٪ بولي فينول علي التوالي أما حمض الفيتك فلم يتأكد وجودة بعد المعاملات المختلفة. وعموما سجلت علية كسب الجوجوبا غير المعامل أقل القيم لوزن الجسم والزيادة في وزن الجسم في حين أن العلائق التي إحتوت علي كسب الجوجوبا المعامل سجلت أفضل القيم، وقد حققت العلائق التي إحتوت علي ١٠% من كسب الجوجوبا المعامل (بالفطر أو البكتريا) أفضل القيم لوزن الجسم والزيادة في وزن الجسم وكذلك كميه الغذاء المأكول ومعامل التحويل الغذائي ودليل الأداء الإنتاجي. لم يكن هناك تأثير ضار علي معاملات الهضم نتيجة احتواء العلائق علي كسب الجوجوبا المعامل بل تحسنت معاملات هضم كل من البروتين الخام والألياف الخام وكذلك المركبات المهضومة الكلية مع جميع معاملات كسب الجوجوبا المعامل والتي سجلت أيضا أعلي نسبه تصافي للذبيحه مع المعاملة بالفطر أو البكتريا لكسب الجوجوبا مقارنة بكسب الجوجوبا غير المعامل والكنترول كما كان التأثير علي صفات الدم طفيفا . أظهرت النتائج أنه يمكن استخدام كسب الجوجوبا المعامل بالفطر أو البكتريا فى علائق الأرانب النامية للحصول علي أفضل كفاءة اقتصادية وصافي ربح مقارنة بالعليقة الكنترول.

تخلص هذة الدراسة إلي أن المعاملة بالفطر أو البكتريا لكسب الجوجوبا قد أدت الى خفض محتواة من المثبطات الغذائية الضارة وأن إحلاله فى علائق الارانب بمستوي ١٠% لم يكن له أى تأثير ضار على أداء الأرانب فضلا عن تحقيق كفاءة انتاجية واقتصادية جيدة.