WALAILAK JOURNAL
http://wjst.wu.ac.th Agricultural Technology and Biological Sciences

Performance and Carcass Characteristics of Rabbits Fed Oil Supplemented Diets

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Received: 21 December 2014, Revised: 28 October 2015, Accepted: 26 November 2015

Abstract

The objective of this study is to investigate the effects of feeding different dietary fat supplements in the finisher rations of Baladi rabbits, including sesame oil (SO), olive oil sediments (OOS), and poultry grease (PG), in comparison to the traditional oil supplement, the soybean soap stock oil (SS), on growth performance, blood lipid profile, dressing percentage and carcass cut, and meat quality: water holding capacity (WHC) and cell forming unit (CFU). A total of 48 Baladi rabbits were used, with individual body weights (BW) of 519 ± 22 g at the beginning of the experiment. Rabbits were randomly divided into 4 groups of 12, and those in each group were individually fed cereal grain-soybean meal (SBM) with a fixed amount (*i.e.* 30 g/kg dry matter (DM)) of oil, being either soybean oil (SOY), olive oil sediments (OOS), recycled restaurant oil (RRO), or poultry grease (PG). All rations were isonitrogenous and contained iso-metabolizable energy (ME). At the end of the 44 day feeding trial, all animals were slaughtered. Rabbits fed a SOY supplemented diet consumed more ($P < 0.05$) feed than those fed the OOS, RRO, or PG supplemented diets. However, rabbits fed the SOY had a better ($P < 0.05$) feed conversion ratio than rabbits fed the OOS, PG, or RRO diets. Oil source had no effect on carcass components weights. Liver was heavier ($P < 0.05$) in rabbits fed the SOY supplemented diet. However, the RRO fed rabbits had heavier ($P < 0.05$) small intestine, large intestine and cecum. In conclusion, the positive effects of the tested oil supplements (*i.e.* RRO, OOS, PG) on the studied performance and carcass traits is encouraging, but more investigation is needed to identify the optimal levels for these supplements in various diets of local rabbits.

Keywords: Rabbits, performance, supplemental oil, carcass cuts, visceral organs

Introduction

In the intensive feeding of farm animals, fat is added to increase feed energy value and to improve the consistency and palatability of the feed. However, animal performance and lower feeding costs are one of the main concerns for researchers all over the world. In the diets for nonruminants (*i.e.* broilers, rabbits), vegetable fats such as soybean oil, sunflower oil, and rapeseed oil, as well as animal fats such as beef tallow, bone and poultry fat, are used [1]. Soybean oil (SOY) is the main source of vegetable fat used in poultry feeding, because of the favorable fatty acid composition and high content of metabolizable energy [2], but its cost is relatively high. Studies have shown that rabbits have the ability to utilize significant amounts of dietary fat as a source of energy; however, the efficiency of its utilization largely depends on the composition of fatty acids [1,3-10]. Olive oil sediments (OOS), poultry grease (PG), and recycled restaurant oil (RRO) are cheap potential alternative energy sources that are available locally, allowing cutting of the feeding costs. However, information on the influence of these fat sources on rabbit performance, carcass cuts, visceral organs, and health status of the rabbits is not available. The unsaturated fatty acid enriched vegetable oils are better digested by poultry, compared to fatty acid enriched animal fats [1,8]. In Pigs, feeding CLA increased the rate of gain [11,12], and improved feed efficiency [12-15]. However, in several other investigations, no growth-enhancing effect of CLA in pigs was observed [14,16-18]. Body weight gain and feed intake of broiler chickens were significantly reduced by dietary CLA [19]. An increase in weight gain and feed intake was reported by Bolukbasi [20], whereas Sirri *et al*. [21] found no influence of dietary CLA on productive performance in poultry.

Therefore the objective of the study was to compare the effect of SOY as a traditional fat supplement to OOS, PG, and RRO on performance, carcass cuts, and visceral organs of local *Baladi* rabbits.

Materials and methods

Study site

The study was conducted at the farm of An Najah National University, Tulkarm city, Palestine, which is a semi-arid area, after approval of the University Animal Care and Use Committee.

Animals, design, dietary treatments and analytical methods

48 male *Baladi* rabbits (a medium size local rabbit breed), with initial body weights (BW) = 519 ± 22 g (mean ± SD) at 45 day of age were used. Rabbits were individually placed in 40×30 cm cages in a shaded pen and treated with IVOMEC (Merial Limited, Luluth, GA, USA) and Cogla Vac (Cogla Laboratories, Libourne, France) against internal and external parasites and enterotoxaemia, respectively, immediately prior to the start of the experiment.

Rabbits were assigned to one of 4 dietary treatments (**Table 1**), being a soybean oil diet containing 30 g/kg DM sesame oil (SOY; n = 12), and 3 additional diets containing similar levels of olive oil sediment (OOS; n = 12), restaurant recycled oil (RRO; n = 12), and poultry grease (PG; n = 12). The duration of the experiment was 44 day. Vitamin E (DL-α-tocopherol acetate, BASF), which protects the polyunsaturated fatty acids (PUFA) from oxidation by regulating lipoperoxidase production, was used as a natural antioxidant. Oil was added to the complete diet during pelleting.

Diets were composed of forage (*i.e*. 100 g/kg DM wheat straw) and a concentrate (*i.e*. 900 g/kg DM of a mixture of cereals, soybean meal, by-product feeds, and a mineral premix) (**Table 1**). Oils were obtained from local commercial venders and mixed into the concentrate, which was later mixed and pelleted with the straw and delivered as rabbit pellets. All diets were formulated to be isonitrogenous and iso-ME (CP 180 g/kg; ME 11.2 MJ/kg DM), and to meet all nutrient requirements for rabbits [22].

Chemical analysis

The experimental rations were analyzed (three samples from each ration) according to the procedures of AOAC [23] for DM (105 °C in a forced-air oven for 24 h), organic matter (OM; weight loss upon ashing at 550 °C for 8 h), crude protein (CP; Kjeldahl procedure), and ether extract (EE; Soxhlet procedure, Soxtec System, TECATOR, Hoganas, Sweden), **Table 1**). The ME values were calculated based on NRC [22] feed composition tables. The blood fatty acids profile was measured using the procedure related by Nkizou *et al*. [24]. The fatty acid composition is shown in **Table 2**.

Slaughtering procedure, carcass characteristics, and meat quality

At the end of the experiment (age of 90 day), all rabbits were slaughtered after an 18 h fast, according to routine procedures, at local commercial slaughter facilities. Directly after slaughter, non-carcass components (*i.e*. lungs and trachea, heart, liver, kidneys) were removed, and weighed and recorded as g/kg body weight. Dressing proportion was calculated as the hot carcass weight proportion of fasted BW. Data were recorded of empty body weight and weight of edible parts (carcass without head, liver, heart, kidneys and lungs). Empty stomach, cecum, and small and large intestine weights were recorded as g/kg body weight.

Table 1 Ingredient and chemical composition of dietary treatments[1] fed to local *Baladi* rabbits (n = 12).

Item	Dietary treatment[2]			
	SOY	**RRO**	**OOS**	**PG**
Ingredient composition (g/kg DM)				
Wheat hay	200	200	200	200
Wheat bran	83	83	83	83
Soybean meal	261	261	261	261
Yellow corn	327	327	327	327
Barley	79	79	79	79
Limestone	10	10	10	10
Salt	5	5	5	5
Rabbit premix[3]	5	5	5	5
Fat	30	30	30	30
Chemical composition (g/kg DM)				
Crude protein	180	180	180	180
Crude fiber	117	117	117	117
Ether extract	29	29	29	29
Ash	42	42	42	42
Metabolizable energy (MJ/kg DM)	11.2	11.2	11.2	11.2

[1]composition values obtained from the analysis of final diets.
[2]SOY = soybean oil, OOS = olive oil sediment, RRO = recycled restaurant oil, and PG = poultry grease. All were added at 30 g/kg on DM basis.
[3]analyses per 1 kg: vitamin A,12,000 IU; vitamin D3, 1500 IU; vitamin E, 50 mg; vitamin K3, 5 mg; vitamin B1, 3 mg; vitamin B2, 6 mg; vitamin B6, 5 mg; vitamin B12, 0.03 mg; niacin, 25 mg; Ca-D pantothenate, 12 mg; folic acid, 1 mg; D-biotin, 0.05 mg; apo carotenoic acid ester, 2.5 mg; Choline chloride, 400 mg.

Table 2 Fatty acid[1] composition of experimental rations fed to local *Baladi* rabbits (n = 12).

Item (g/kg)	**SOY**	**RRO**	**OOS**	**PG**
14:0	0.8	0.1	0.7	-
16:0	9.0	13.4	16.4	22.9
16:1	-	0.8	2.2	0.9
18:0	4.8	2.5	3.3	8.6
18:1	37.7	61.9	20.2	39.7
18:2	45.8	18.0	48.5	33.8
18:3	0.1	1.3	2.8	-
Total	98.2	98.3	94.4	96.2
SFA[b]	14.2	16.9	19.7	31.6
MUFA[c]	39.7	63.3	22.5	40.7
PUFA[d]	41.7	19.6	51.4	23.8
(MUFA+PUFA):SFA	5.7	4.8	3.7	2.0
PUFA:SFA	2.9	1.1	2.6	0.7

[1]SOY = soybean oil, OOS = olive oil sediment, RRO = recycled restaurant oil, and PG = poultry grease.
[b]SFA = saturated fatty acids.
[c]MUFA = monounsaturated fatty acids.
[d]PUFA = polyunsaturated fatty acids.

Statistical analyses

Data (rabbit measures) were subjected to analysis of variance using the GLM procedure of SAS [25]. An least significant difference (LSD) test was used to assess significance among treatment means. Each rabbit was considered as a statistical unit. The model was;

$$Y_{ij} = \mu + T_i + e_{ij} \quad (1)$$

where Y_{ij} is the observation on the j^{th} rabbit receiving i^{th} treatment (dietary supplement), μ is the overall mean, T_i is the effect of i^{th} treatment (dietary supplement), and e_{ij} is the random residual for the j^{th} observation receiving i^{th} treatment (dietary supplement).

Results and discussion

Feed intake

Type of dietary supplement had significant effect on feed intake. Rabbits fed the SOY consumed more ($P < 0.05$) feed, compared to rabbits in other experimental groups (**Table 3**). Rabbits fed the control diet (*i.e.* SOY) consumed more feed (5 %) compared to RRO fed rabbits; however, the OOS and PG fed rabbits consumed 3 and 5 % less feed, respectively, compared to those fed SOY or RRO.

Weight gain

Heavier ($P < 0.05$) final average body weights were observed in rabbits fed the RRO, compared to rabbits fed the other oils (**Table 3**). The average daily gain in rabbits ranged from 25.1 to 27.3 g/day. The OOS rabbits had the highest daily gain (27.3 g) and were 7 % lower, compared to the daily gain of rabbits fed the RRO.

Feed conversion ratio

Dietary treatments had an effect on FCR (**Table 3**).

Carcass cuts and visceral organs

Type of supplemented fat had no effect on carcass cuts (**Table 4**). However, there were significant differences among diets in carcass components. Rabbits fed the OOS oil had heavier ($P < 0.05$) livers, compared to rabbits fed other treatments. Small intestine, large intestine, and cecum were heavier ($P < 0.05$) in rabbits fed the OOS, compared to those in rabbits fed other oil supplements. Dressing proportion was the lowest in rabbits fed the SOY or OOS, however, the differences were not significant (**Table 3**).

Table 3 Effect of feeding different oil supplements on the performance and feed intakes of local *Baladi* rabbits (n = 12).

	Treatment[1]				SEM[2]	P value
	SOY	**RRO**	**OOS**	**PG**		
Initial weight (g)	520	510	534	539	12	0.83
Final weight (g)	1690^b	1650^b	1736^a	1681^b	32	< 0.05
Weight gain (g)	1170^b	1140^b	1202^a	1142^b	25	< 0.05
Average daily gain (g/day)	26.6^b	25.9^b	27.3^a	26.0^b	0.4	< 0.05
Feed intake (g)	4281^a	4142^b	4082^b	4154^b	54	< 0.05
FCR[3]	3.66^a	3.63^a	3.39^b	3.63^a	0.21	< 0.05
Dressing proportion (%)	51.0	52.5	50.0	53.0	3.6	

[1]SOY, OOS, RRO and PG refer to dietary treatments containing 30 g/kg soybean oil, 30 g/kg olive oil sediment, 30 g/kg recycled restaurant oil, and 30 g/kg poultry grease on DM basis, respectively.
[2]Standard error of the mean (SEM).
[3]Feed conversion ratio = DM intake/ADG (g/g).
[a,b]Means within rows with different superscript differ significantly (P < 0.05).

Table 4 Effect of feeding different oil supplements on carcass cuts and visceral organs weights (g/kg body weight) of local *Baladi* rabbits (n = 12).

	Treatment[1]				SEM[2]	P value
	SOY	**RRO**	**OOS**	**PG**		
Neck	52	52	55	54	2.00	0.91
Back	422	391	373	411	22.8	0.21
Shoulder	135	133	145	140	15.9	0.14
Thigh	293	292	314	304	18.4	0.23
Non carcass components						
Lungs	13	11	12	11	0.9	0.43
Heart	6	5	6	5	0.8	0.56
Liver	47^b	49^b	72^a	47^b	1.9	< 0.05
Kidneys	14	14	13	12	1.2	0.22
Pancreas	1	1	1	1	0.1	0.78
Stomach	20	19	19	18	1.4	0.69
Cecum[3]	40^b	38^b	61^a	41^b	1.9	< 0.05
Small intestine[3]	309^b	303^b	380^a	311^b	9.8	< 0.05
Large intestine[3]	32^b	33^b	59^a	32^b	1.0	< 0.05

[1]SOY, OOS, RRO and PG refer to dietary treatments containing 30 g/kg soybean oil, 30 g/kg olive oil sediment, 30 g/kg recycled restaurant oil, and 30 g/kg poultry grease on DM basis, respectively.
[2]SEM = standard error of the mean.
[3]Empty tissue weight.
[a,b]Means within rows with different superscript differ significantly (P < 0.05).

Discussion

Supplemental fats had no significant harmful effect on rabbit health, as no mortalities were observed throughout the experiment. Fat supplemented diets have had changeable effects on animal performance [25], which may be related to conditions such as the composition of the basal diet, ME density, level of fat inclusion, fat source (*i.e.* level of saturated fatty acids), and whether diets were formulated to be iso-ME, as well as animal species [27]. This study showed that rabbits fed the OOS had less feed consumption, heavier final weights, and more gain, but best FCR, compared to rabbits in other experimental groups (*i.e*. SOY, RRO, PG). However, SOY oil, the conventional local oil supplement, RRO or PG, resulted in less efficient feed conversion.

Many studies have investigated effects of conjugated linoleic acid (CLA) on body composition and, although results vary by species, Whigham *et al*. [26] found that CLA at levels 1 - 10 g/kg of diets affected nonruminant (*i.e*. rats and pigs) performance.

Body weight gain and feed intake of broiler chickens were significantly reduced by dietary CLA [19]. An increase in weight gain and feed intake was reported by Bolukbasi [20], whereas Sirri *et al*. [21] found no influence of dietary CLA on productive performance in poultry. The proportion of saturated fatty acids (SFA) was increased by CLA when fed to rabbits, at the expense of monounsaturated fatty acids (MUFA) in RRO and SOY supplemented diets; this might be due to more efficient use of ME, compared to that of OOS or PG, as SOY may have increased the rate of fat metabolism [27]. The poorer performance of the OOS supplemented rabbits could be due to its negative effects on digestion of other nutrients, such as fiber, with negative consequences on intake and performance. It is well documented that unsaturated vegetable oils are more digested by poultry, compared to animal fats with high levels of saturated fatty acids [1,8]. Pig rates of gain was increased by CLA feeding [11,12], CLA improved feed efficiency [12-15]. However, in several other investigations, no growth-enhancing effect of CLA in pigs was observed [14,16-18]. Studies have shown that rabbits have the ability to utilize significant amounts of dietary fat as a source of energy; however, the efficiency of its utilization largely depends on the composition of fatty acids [1,3-10].

This study showed that source of supplemented fat had no effect on carcass cuts. However, rabbits fed the OOS oil had heavier livers and lower weights of small intestine, large intestine, and cecum, compared to rabbits in other treatments.

Dietary oil supplementation was found to have a significant effect on carcass fatness. Fat deposition in the body is affected by the degree of saturation of dietary fatty acids. Low saturated fats can have an effect on lower fatness. Low fatness may also result from the stimulating effect of polyunsaturated acids on enzymes that degrade fatty acids (β-oxidation).

Conclusions

Studies with local rabbit breeds, especially the medium size *Baladi* rabbits are limited. Our results, the first in our region, show some advantages of feeding other fat supplements (*i.e*. RRO, PG, OOS) to rabbits, in comparison with SOY. However more research is needed to investigate the effects of the feeding level and duration of feeding of these sources on fat deposition, meat characteristics, visceral organs, mass intra, and nutrient digestibility in rabbits.

Acknowledgements

The authors thank Dr. Hassan Abu Qaoud from the Faculty of Agriculture, An-Najah National University, for help with statistical analysis.

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