Egyptian J. Nutrition and Feeds (2024), 27(1): 21- 30

A COMPARATIVE STUDY FOR ADDING ALMOND HULLS OR ITS EXTRACT IN THE DIETS ON THE PERFORMANCE OF GROWING RABBITS

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(Received 6/3/2024, accepted 20/4/2024)

SUMMARY

The aim of current study was to evaluate the impact of addition two levels of dried almond hulls (DAH) or its extract (AHE) in growing rabbits diets on body weight change, nutrients digestibility, cecum parameters and microbiota count, carcass characteristics, blood constituents, and liver antioxidant enzymes. Seventy-five male NZW rabbits (aged 42 days in average) were randomly and equally allocated for five groups and fed individually on the experimental diets as follow, basal diet which was the control diet (C), basal diet with 200 ppm (DAH1) and 400 ppm (DAH2) dried almond hulls addition, basal diet with added 200 ppm (AHE1) and 400 ppm (AHE2) almond hulls extract in feeding trial lasted 70 days, followed by digestibility trial. The results indicated that all of additions increased rabbits weight gain compared to C group and the best weight gain was observed with AHE2 followed by AHE1, DAH2 and DAH1. The same trend was found with nutritive values and digestibility parameters which were higher ($P<0.05$) for all nutrients, except for the digestibility of nitrogen free extract of the diets containing different levels of AHE followed by DAH compared to the C group, without significant effect of addition levels. Addition of DAH or AHE decreased microbiota count in the cecum ($P<0.05$) and increased carcass weight compared to C. All blood parameters were within normal range, and at the same time DAH or AHE increased serum total antioxidant capacity and hepatic antioxidant enzymes. It can be concluded that adding dried almond hulls or its extrcte up to 400 ppm are beneficial additives as growth promoters in growing rabbits' diets and have high economical efficiency.

Keywords: *Almond hulls, NZW rabbits, performance, microbiota count, carcass traits, blood constituents and liver antioxidant enzymes.*

INTRODUCTION

The native of almond tree is in Mediterranean areas and was spread in ancient times to Southern Europe and recently to other area of the world such as Spain, Australia, and California (U.S.A.) (Ferrandez-Villena *et al.,* 2019). Almond (*Prunus dulcis*) fruits have three various parts: flesh, inner core; shell, hard middle part and hull which being outer covering of the shell and generates a huge amount of waste (Ferrandez-Villena *et al.,* 2019). The total almond fruits contain about 53% almond hull (AH) in average (Prgomet *et al.,* 2017 and Curtis *et al.,* 2019). The almond hull mainly consists of 9–14% acid detergent lignin, 18–25% acid detergent fiber, 28–32% neutral detergent fiber, 5–6% nonfibrous carbohydrate, 2–3% protein, and 3–4.5 % total phenolic compound including flavanol glycosides and phenolic acids (An *et al.,* 2020) and 2–2.5% total tannin. Almond hull could be classified as Herbaceous biomass and could be used as animal feed, but its possibility applications didn't discover (Tursi, 2019 and Najari *et al.,* 2022). Tannins and flavonoids included in AH as bioactive phenolic compounds scavenge free radicals and give it antibacterial, antioxidant properties and beneficial effect on inhibition low-density lipoproteins (LDL) oxidation (Pinelo *et al.,* 2004; Amarowicz, 2016 and Bolling, 2017). Also, Omar and Abdallah (2019) reported that feeding lambs on dietary ensiled almond hull resulted in lower feed cost and enhanced feed efficiency without effect on final weight and daily gain. It's known that plant extract with polyphenols and phenolic compounds protect against lipid oxidation and harmful bacteria development (Caponio *et al.,* 2019). Most abundant phenolic compounds in the AH extract are catechin, protocatechuic acid and isorhamentin-3-O-rutinoside. Antioxidant properties of almond hull were determined in some recent studies as another option to evaluate and valorize its biological effects (Najari *et al.,* 2022 and Timón *et al.*, 2022). In this respect the purpose of this study was concerned to investigate the impact of dried almond hull or its extract in growing rabbits' diet on growth performance, nutrient digestibility, cecum microbiota content and blood constituents.

MATERIALS AND METHODS

Ethics statement:

All in vivo trials involving animals confirmed by the Institutional Animal Care and Use Committee (ARC-IACUC), Agriculture Research Centre (ARC), Egypt (ARC-APRI- 69-23). The experimental work was conducted at Animal Production Research Institute, Agricultural Research Center (ARC), Egypt. The laboratory analysis proceeded at laboratories of National Research Centre and ARC, Egypt.

Plant material:

Hulls were separated from the nut of almond fruits, then, it was grounded to fine powder, some powder was stored until use and the other was used for extract.

Almond hulls extract:

Extraction of almond hulls (AH) was done according to Azadeh (2016) as follow, 10 g of dried AH with 100 mL solution (70 ethanol/ 30 water), and was conducted in orbital shaker (at 60 rpm) under constant rotary agitation for 6 h at 50 °C. Then centrifuged on 25 °C at 5600 × g for 5 min. The supernatants were filtered through nylon membrane filter (0.45-µm). Then the extract was dried at 60°C and the dried extract was mixed with diets.

Experimental diets:

The control diet of growing rabbits was created to provide all their nutritional requirements according to NRC (1994). There were five experimental diets, basal diet (control diet without additives, C), control diet with addition two levels of dried almond hulls, 200 ppm (DAH1) and 400 ppm (DAH2), or almond hulls extract, 200 ppm (AHE1) and 400 ppm (AHE2) per kg diet. The chemical analysis of control diet and its ingredients was demonstrated in Table (1).

Table (1): Ingredients and chemical composition of the basal experimental diet.

Ingredients, %		**Chemical analysis (as DM basis), %**	
Barley	30.27	DM	89.91
Soybean meal (44% CP)	18.12	OM	90.33
Wheat bran	18.39	CP	17.77
Clover hay (12% CP)	27.06	CF	12.96
Molasses	3.00	EE	2.17
Di-calcium phosphate	2.20	Ash	9.67
NaCl	0.30	NFE	57.43
*Premix	0.30	DE (kcal/kg)	2517
Limestone	0.21	Calcium	1.10
DL-Methionine	0.10	Total phosphorus	0.84
Anticoccidial (Diclazuril)	0.05	Methionine+ cyst	0.64
Total	100	Lysine	0.90

**Premix (Each 3 kg of premix contains: Vitamins (B_1 1000 mg, B_2 5000 mg, B_6 15000 mg; B_{12} 10 mg, A 10.000.000 IU, K_3 1000 mg, E 10.000 mg, D_3 2.000.000 IU), Folic acid 1.0 g, Biotin 50 mg, Nicotinic acid 30.000 g, Pantothenic acid 10.000 mg, choline chloride 200 mg, Cu 4 g, Mn 60 g, Iodine 0.3 g, Se 0.1 g, Fe 30 g, Zn 50 g and CO 0.1 g.*

Animals' management and growth trial:

To conduct the growth trial, 75 males growing NZW rabbits were randomly splitted equally into 5 groups (aged 42 d. and 553.2 g body weight in average) and fed on the above-mentioned diets, respectively. Rabbits were separately preserved individually in feeding units and were kept in the same managerial and sanitary settings for 70 days of the growth trial. Diets and water were available *ad libitum*. Feed intake and live body weight were recorded every week, while body weight gain (BWG) and feed conversion (feed intake/gain) were calculated.

Digestibility trail:

Seven rabbits from each group were prepared for digestibility trial at the end of feeding trial, over 7 days. Daily collected feces were weighed, dried and ground for chemical analysis. Nutrients digestibility and nutritional values as digestible crude protein (DCP) and total digestible nutrients were calculated using data of chemical analysis and amount of feces and feed intake according to Pérez *et al.*, (1995). Digestible energy (DE), Kcal/kg diet was calculated by formula: DE = 44.3 X TDN % (Flatt and Schneider, 1975).

Carcass characteristics:

After digestibility trial, randomly five rabbits (each group) were slaughtered to esteem carcass traits. The dressing % was calculated as % of pre-slaughter animal, and organs % were calculated as % of carcass weight.

Cecum parameters:

Cecum contents samples were collected from slaughtered rabbits and filtrated and cecum pH was measured immediately using a digital pH meter and kept for determine total volatile fatty acids (TVFA's) and ammonia nitrogen (NH_3-N) concentration. Microbiota count in cecum samples as *Bacillus cercus,* was determined according to Kim and Goepfert (1971), *Enterobacter*, *Enterococcus* and *yeasts* was done according to Baired-Parker (1962) and *Clostridium* was estimated according to Difco (1989).

Blood constituents and antioxidant enzymes:

From the slaughtered rabbits, blood samples individually were collected and centrifuged at 4000 rpm for 10 minutes to separate serum, then stored until chemical analysis at -20°C. Blood serum parameters were total protein (TP), Urea, albumin (Alb), creatinine, triglycerides, cholesterol, low density lipoprotein (LDL), alanine aminotransferase (ALT) high density lipoprotein (HDL), and aspartate aminotransferase (AST). Globulin (Glob) was calculated as formula of Glob=TP- Alb. Also, Blood antioxidant enzymes were determined as total antioxidant capacity (TAC) and malondialdehyde (MDA). The livers were obtained from slaughtered rabbits to measure hepatic catalase (CAT), glutathione peroxidase (GPx) and superoxide dismutase (SOD). All parameters were determined by using kits of Biodiagnostec, Egypt.

Chemical analysis:

Duplicate samples of feed and feces were analyzed as dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and Ash as described by AOAC (2005) and calculation nitrogen free extract (NFE) was by the difference. Concentration of NH_3-N was determined according to Conway (1958) technique and TVFA's according to Eadie *et al.,* (1967).

Economic efficiency:

- Economic efficiency during growth trial was calculated according to price marketing (Egyptian pound, L.E) during 2023 per experimental group as following formula:
- Total feed cost (TFC) = feed cost of diet + additives cost
- Total return = BWG, kg × price of selling kg rabbit
- Net profit = Total return - TFC
- Economic efficiency = Net return / TFC

Statistical analysis:

Data were analyzed statistically by one-way analysis of variance according to SPSS (2011) as follow:

$$Yej = \mu + Te + Eej$$

Where μ = general mean, Te = effect of feed additives, Eej = experimental error. The test of Duncan's Multiple range was used to reveal differences among the mean of experimental groups at 5% level of probability (Duncan 1955).

RESULTS AND DISCUSSION

Using almond hulls and its extract as feed additives in rabbit diets have not been applied before, most of authors were interested to use it as unconventional feed in animal feeding. So, this study may be considered as a new investigation.

Nutrients digestibility:

Data in Table (2) indicated that all of nutrient's digestibility were significantly increased ($P<0.05$) with DAH and AHE additions compared with C diet.

Table (2): Nutrients digestibility and nutritive values of experimental diets.

Digestibility, %	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
DM, %	73.32^{d}	74.33^{c}	75.49^{b}	76.69^{a}	76.86^{a}	0.37	0.000
CP, %	74.42^{c}	76.58^{b}	77.63^{b}	80.74^{a}	81.80^{a}	0.73	0.000
CF, %	39.71^{c}	42.78^{b}	43.91^{b}	46.43^{a}	47.48^{a}	0.75	0.000
EE, %	71.07^{c}	72.76^{b}	72.93^{b}	74.43^{a}	75.08^{a}	0.38	0.000
NFE, %	75.95^{b}	76.95^{ab}	77.24^{a}	77.53^{a}	77.57^{a}	0.19	0.006
DE, Kcal/kg diet	2899.72^{c}	2963.54^{b}	2986.19^{b}	3035.53^{a}	3052.43^{a}	14.74	0.000
Nutritive values							
TDN	65.46^{c}	66.90^{b}	67.41^{b}	68.52^{a}	68.90^{a}	0.33	0.000
DCP	13.22^{c}	13.61^{b}	13.80^{b}	14.35^{a}	14.54^{a}	0.13	0.000

$^{a, b, c, d}$ *Mean in the same row having different superscripts differ significantly at level (P<0.05).*

The highest nutrients digestibility values were recorded with both AHE2 and AHE1 followed by DAH2 and DAH1 then C. The TDN and DCP take the same trend of the nutrient's digestibility. Calculated DE was higher ($P<0.05$) in the diets added with AHE compared to diets added with DAH and C diet and also was higher in DAH compared to C. The same result for DM digestibility was reported by Yalchi and Kargar (2010) and Jafari *et al.* (2015) that ruminal degradable DM of AH diet was significantly higher compared to alfalfa hay in the *in-situ* trial of lambs. Also *In vitro* DM disappearance was higher in diet of AH compared to alfalfa hay (Yalchi, 2011). Also, Aydin (2023) recorded that addition of AH to the corn silage increased the values of *in vitro* OM digestibility compared with the control group. The enhancement of the nutrient digestibility might be related to the biological activities of almond hulls extract (An *et al.*, 2020 and Najari *et al.*, 2022).

Cecum properties:

Almond hulls in rabbits' diets increased cecum pH and TVFA's concentration ($P<0.05$) and decreased the NH_3-N concentration and microbiota count (*Enterococcus, yeast, Enterobacter, Bacillus cercus, and Clostridium*) (Table 3).

Table (3): Effect of Almond hulls addition on the cecum properties and microbiota count.

Items	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
pH	5.63^{c}	6.00^{ab}	6.00^{ab}	6.30^{a}	6.40^{a}	0.10	0.088
NH_3-N, mg/100 ml	11.55^{a}	10.46^{b}	10.42^{b}	10.42^{b}	10.43^{b}	0.13	0.000
TVFA's, mg/100 ml	3.78^{c}	4.05^{bc}	4.26^{b}	4.59^{a}	4.58^{a}	0.09	0.000
Microbiota count ((log^{-1} CFU/ml).							
Enterococcus	7.26^{a}	6.33^{b}	6.60^{b}	6.56^{b}	6.62^{b}	0.09	0.000
Yeasts	6.08^{a}	5.65^{b}	5.53^{b}	5.50^{b}	5.47^{b}	0.07	0.014
Enterobacter	4.45^{a}	4.07^{b}	3.67^{c}	3.11^{d}	3.05^{d}	0.15	0.000
Bacillus cercus	3.40^{a}	2.78^{b}	2.25^{c}	2.04^{c}	2.00^{c}	0.15	0.000
Clostridium	1.71^{a}	1.12^{b}	1.09^{b}	1.04^{b}	1.03^{b}	0.07	0.000

$^{a, b, c, d}$ *Mean in the same row having different superscripts differ significantly at level (P<0.05).*

These results may be attributed to the antibacterial effect of phenolic compound included in the almond hulls and its extract which can be used as feed additives to enhance animals' productivity by increasing the digestive enzymes activity (Hassan *et al.*, 2019 and Najari *et al.*, 2022).

Growth performance:

As demonstrated in Table (4) there were significant differences (P<0.05) in final body weight (FBW), total BWG and average daily gain (ADG) among experimental groups, and the highest values were recorded with rabbits fed C diet with 400 ppm AHE addition followed by other treatments and the lowest value recorded with C group.

Table (4): Growth performance of rabbits fed experimental diets.

Items	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
IW, g	555.00	552.67	553.00	552.67	552.67	0.91	0.916
FBW, g	2609.67 ^{e}	2675.53 ^{d}	2728.20 ^{c}	2717.67 ^{b}	2774.27^{a}	7.66	0.000
TWG, g	2054.67 ^{d}	2122.86 ^{c}	2175.20 ^{b}	2165.00 ^{b}	2221.60 ^{a}	7.83	0.000
ADG, g/d	29.35 ^{d}	30.33 ^{c}	31.07 ^{b}	30.93 ^{b}	31.74 ^{a}	0.11	0.000
FI, g/h/d	101.82 ^{a}	100.09 ^{a}	99.55 ^{ab}	95.32 ^{b}	99.68 ^{ab}	0.57	0.005
FCR	3.47 ^{a}	3.30 ^{ab}	3.20 ^{bc}	3.08 ^{c}	3.14 ^{bc}	0.02	0.000

$^{a, b, c, d}$ *Mean in the same row having different superscripts differ significantly at level (P<0.05).*

These results may be related to the beneficial compounds in the extract which are more concentrated than in the powder and were supported by nutrients digestibility and cecum properties results. Also, these results showed the beneficial effects of dried AH and AH extract on the diets, which may be related to the presence of triterpenoids, phenolics and antibacterial agents in almond hulls (Durmic *et al.,* 2014). Feed intake (FI) of the rabbits were comparable, which mean that addition of AH did not affect FI. These results agree with Swanson *et al.* (2020) who found that there was no significant difference in FI of cows fed different levels of AH. Improving Feed conversion ratio with DAH and with AHE addition related to low FI and high ADG compared to C, and this agree with Abo Omar and Abdallah (2019) who found that using ensiled AH as a replacement with wheat straw increased ADG being 295.7 vs 288 g and significantly enhanced FCR being 5.9 vs 6.4.

Carcass characteristics:

Data in Table (5) demonstrated that the pre-slaughter weight was differed (P<0.05) among experimental rabbits' groups and this reflects the carcass weight which was significantly higher (P<0.05) in rabbits fed DAH and AHE diets compared with those fed C diet. Meanwhile the highest dressing % was recorded in DAH1 compared with other groups.

Table (5): Carcass characteristics of rabbits fed diets with almond hulls or its extract.

	Experimental groups					±SEM	P value
	C	DAH1	DAH2	AHE1	AHE2		
Pre-Slaughter Wt., g	2629.00^{b}	2628.33^{b}	2703.00^{ab}	2719.00^{a}	2758.67^{a}	15.44	0.002
Carcass Wt., g	1328.00^{b}	1382.00^{a}	1389.67^{a}	1403.33^{a}	1418.3	8.84	0.000
Dressing, %	50.51^{b}	52.59^{a}	51.41^{b}	51.61^{b}	51.42^{b}	0.20	0.003
Organs as percentage from carcass weight, %							
Gastrointestinal tract	30.73^{b}	31.83^{ab}	29.38^{b}	34.80^{a}	32.92^{ab}	0.66	0.064
Liver	5.87	6.44	6.47	6.35	6.28	0.17	0.854
Kidney	1.36	1.38	1.51	1.52	1.41	0.03	0.473
Heart	0.72	0.77	0.79	0.75	0.84	0.03	0.882
Abdominal Fat	2.13	2.00	1.93	1.78	1.97	0.06	0.572
Spleen	0.14	0.17	0.16	0.14	0.15	0.01	0.449
Stomach	8.74	9.35	7.40	9.14	8.66	0.41	0.662
Intestine	6.76	7.22	7.78	8.17	7.85	0.22	0.283
Cecum	8.49	8.56	8.38	8.54	8.52	0.07	0.959

$^{a, b}$ Mean in the same row having different superscripts differ significantly at level (P<0.05).

These results may be related to the high levels of antioxidant compounds included in AH such as flavonoids (Scerra *et al.*, 2022). The gastrointestinal tract (GIT) had comparable different among groups and the highest GIT percentage (P<0.05) was observed with AHE1 compared to C and DAH2, and without significant differences compared to DAH1 and AHE2. Also, there were no differences (P>0.05) among groups C, DAH1, DAH2 and AHE2. Meanwhile, there were not significant differences in the percentage of other organs among all groups. These results show the beneficial effects of DAH and AHE on the diets, which may be related to the presence of phenolic and triterpenoids compounds in almond hulls (Durmic *et al.*, 2014).

Blood serum constituents:

The results of blood serum parameters (Table 6) indicated that the lowest value (P<0.05) for serum TP and Alb were reported in the C group. No differences (P>0.05) were detected among groups in serum Glob, Alb/ Glob ratio, HDL, AST and ALT. Meanwhile adding DAH or AHE increased serum urea concentration. the highest blood urea concentration (P<0.05) was noted in rabbits' group fed AHE1 diet followed by rabbits' groups fed both AH1 and AHE2 diets.

Table (6): Blood serum constituents of rabbits fed experimental diets.

Items	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
TP, g/dL	6.13 ^{b}	7.17 ^{a}	7.10 ^{a}	7.27 ^{a}	7.07 ^{a}	0.12	0.001
Alb, g/dL	3.98 ^{b}	4.61 ^{a}	4.58 ^{a}	4.67 ^{a}	4.73 ^{a}	0.09	0.013
Glob, g/dL	2.15	2.56	2.52	2.60	2.33	0.07	0.230
Alb / Glob	1.92	1.81	1.83	1.80	2.05	0.07	0.801
Urea, mg/dL	33.33 ^{c}	37.00 ^{b}	32.00 ^{c}	45.00 ^{a}	37.00 ^{b}	1.23	0.000
Creatinine, mg/dL	1.14 ^{a}	1.07 ^{b}	0.95 ^{d}	1.00 ^{c}	0.99 ^{c}	0.02	0.000
Cholesterol, mg/dL	29.00 ^{a}	25.00 ^{ab}	24.67 ^{ab}	24.00 ^{b}	23.33 ^{b}	0.64	0.014
Triglyceride, mg/dL	69.00 ^{a}	61.00 ^{ab}	61.67 ^{ab}	48.33 ^{b}	48.00 ^{b}	2.46	0.002
LDL, mg/dL	19.33 ^{a}	17.67 ^{ab}	18.33 ^{ab}	15.67 ^{ab}	14.67 ^{b}	0.57	0.021
HDL, mg/dL	25.00	25.00	27.33	26.67	26.67	0.38	0.149
AST, IU/L	46.37	45.86	45.58	45.64	46.20	0.15	0.427
ALT, IU/L	58.06	57.97	58.18	58.00	57.41	0.14	0.498
TAC, mmol/L	1.02 ^{b}	1.47 ^{a}	1.63 ^{a}	1.67 ^{a}	1.81 ^{a}	0.09	0.017
MDA, µmol/L	12.64	12.34	13.36	13.34	12.65	0.29	0.798

$^{a, b, c, d}$ *Mean in the same row having different superscripts differ significantly at level (P<0.05).*

The addition of almond hulls or its extract to rabbits' diets significantly decreased their blood serum creatinine compared to the C group. The lowest creatinine value was recorded in DAH2. All blood parameters reported in this study were similar with described by Hewitt *et al.* (1989) and Özkan and Pekkaya (2019) for healthy New Zealand rabbits. Blood total protein is considered as an indicator for good immune status and hepatic function (White et al., 2002). Increasing synthesis of Glob in the liver is a source of antibody production for immunologic action and diseases resistant (Sunmonu and Oloyede, 2007). The immunity action of almond hulls might be related to its content of flavonoids and polyphenolic compounds which impulse immunity system. Serum cholesterol and triglyceride significantly (P<0.05) decreased in the AHE group compared with C group, and were decreased numerically with DAH groups without significant difference compared to C group. Rabbits fed 400 ppm AHE showed reduction in blood serum LDL (P<0.05) compared with control group. There were insignificant differences among C, DAH1, DAH2 and AHE1 groups in serum LDL concentration. The reduction of the blood cholesterol concentration by adding dried almond hulls or its extract help in preventing a number of chronic diseases which mean enhancing animal health (Chang and Gershwin, 2000; Yousef, 2004). The antimicrobial properties of DAH or AHE increased the ability of the treated animals' immune system to suppress the pathogenic bacterial growth, which lead to optimum enzyme activity. Dietary DAH or AHE significantly increased TAC of rabbits compared with those fed diet without additives which reflects the beneficial effect of dietary AH on animal health. The highest TAC value was recorded with rabbits fed diets fortified with 200 and 400 ppm almond hulls extract followed by those fed DAH1 and DAH2, while the value of MDA was not significantly different among groups.

Antioxidant status:

Antioxidant enzymes in the liver tissue (Table 7) as SOD, CAT and GPx were higher (P<0.05) in DAH and AHE groups than C group. The highest value of GPx was recorded in AHE2 followed by AHE1, DAH2 and then DAH1group. Increasing liver antioxidant enzymes concentrations refer to that the antioxidant activity of dried AH or AH extract regarded to their content of polyphenolic compounds

(Wijerante *et al.,* 2006 and An *et al.,* 2020). Also, Scerra *et al.* (2022) reported that partial replacement of cereals by dried AH improved lambs' meat oxidative stability.

Table (7): Effect of experimental diets on Liver antioxidant enzymes of rabbits.

Items	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
SOD (mmol/g)	0.53[b]	0.72[a]	0.75[a]	0.76[a]	0.85[a]	0.04	0.043
CAT (U/g)	0.47[b]	0.60[a]	0.61[a]	0.63[a]	0.63[a]	0.02	0.055
GPx (U/g)	136.00[c]	142.00[b]	144.33[ab]	146.67[ab]	149.00[a]	1.35	0.003

[a, b, c, d] Mean in the same row having different superscripts differ significantly at level ($P<0.05$).

Economic efficiency:

As presented in Table (8) the economic efficiency of using DAH or AHE as feed additives for rabbits' diets was higher ($P<0.05$) compared with the control diet, and this result related to the high of their net profit. The highest net profit was recorded by AHE2 followed by AHE1, DAH2, DAH1 then control. This result showed the beneficial effect of almond hulls as feed additives on the profit of rabbits raising.

Table (8): Feed cost and economic efficiency of experimental diets.

Items	Experimental groups					±SEM	P-value
	C	DAH1	DAH2	AHE1	AHE2		
Total feed cost/rabbit, LE[1]	57.02[a]	56.05[a]	55.75[a]	53.38[b]	55.83[a]	0.32	0.005
Total return/rabbit, LE	164.37[d]	169.83[c]	174.02[b]	173.20[b]	177.73[a]	0.63	0.000
Net profit, LE	107.35[d]	113.78[c]	118.26[b]	119.82[ab]	121.90[a]	0.77	0.000
Economic efficiency	1.88[c]	2.03[b]	2.12[ab]	2.24[a]	2.18[a]	0.02	0.000

Feed cost was calculated according to the price raw material and feed additives in the market on 2023, [1]LE: Egyptian Pound, price of feed = 8000 LE/ tonne, price of feed additives= 200 LE/ tonne, selling price of rabbit = 80.00 LE/kg live body weight.

CONCLUSION

The current study indicated that addition of powder or extract of almond hulls to rabbits' diets have a good nutritional impact on growth performance, nutrients digestibility, cecum microbiota count and liver antioxidant enzymes of rabbits. Moreover, rabbits fed the diet containing 400 ppm AHE showed an optimum weight gain with higher feed conversion and higher carcass weight. Up to 400 ppm of addition level of dried almond hulls or almond hulls extract did not show any negative effects on the rabbits' blood constituents.

ACKNOWLEDGMENTS

The authors express their gratitude to Professor **Dr. Alaa-Eldin Yehia El-Badawi**, Professor of Animal Production Department, National Research Centre, Egypt. For his advice.

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دراسة مقارنة لإضافة قشور اللوز أو مستخلصه في العليقة على أداء الأرانب النامية

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الهدف من الدراسة الحالية هو تقييم تأثير إضافة مستويين من قشور اللوز المجفف (DAH) أو مستخلصه (AHE) في علائق الأرانب النامية على تغيرات وزن الجسم، وهضم العناصر الغذائية، ومقاييس الأعور وعدد الكائنات الحية الدقيقة، وخصائص الذبيحة، ومكونات الدم، والانزيمات المضادة للأكسدة في الكبد. تم تخصيص خمسة وسبعين ذكر من ارانب NZW (متوسط العمر 42 يوما) بشكل عشوائي ومتساوي لخمس مجموعات وتم تغذيتهم بشكل فردي على العلائق التجريبية على النحو التالي، العليقة الأساسية التي تمثل المجموعة الكنترول (C)، العليقة الأساسية مع إضافة قشور اللوز المجفف بنسبة 200 جزء في المليون (DAH1) و 400 جزء في المليون (DAH2)، العليقة الأساسية مع إضافة مستخلص قشور اللوز بنسبة 200 جزء في المليون (AHE1) و400 جزء في المليون (AHE2) وقد استمرت تجربة النمو 70 يومًا، تليها تجربة الهضم. أشارت النتائج إلى أن جميع الإضافات أدت إلى زيادة وزن الارانب مقارنة بمجموعة الكنترول، وسجلت أفضل زيادة وزنية للأرانب مع AHE2 تليها DAH1، DAH2 ثم AHE1. وقد أوضحت النتائج نفس الاتجاه مع القيم الغذائية ومعاملات الهضم التي كانت أعلى (P<0.05) لجميع العناصر الغذائية، باستثناء هضم المستخلص الخالي من النيتروجين وذلك في العليقة التي تحتوي على مستويات مختلفة من AHE تليها DAH مقارنة بالمجموعة الكنترول دون وجود تأثير معنوي بين مستويات الإضافة. كما أدت إضافة DAH أو AHE إلى انخفاض عدد الكائنات الحية الدقيقة في الأعور (P<0.05) وزيادة وزن الذبيحة مقارنة بالمجموعة الكنترول. كانت جميع مؤشرات الدم ضمن المعدل الطبيعي، بالإضافة الي ان اضافة DAH أو AHE أدي الي تحسن محتوي الدم من المركبات الكلية المضادة للأكسدة وكذلك الإنزيمات المضادة للأكسدة في الكبد. وبناء علي ذلك يمكن الاستنتاج بأن إضافة قشور اللوز المجفف أو مستخلصه بنسبة تصل ل 400 جزء في المليون لعليقة الارانب النامية تعتبر من الإضافات المفيدة كمحفزات للنمو كما ان لها جدوي اقتصادية مرتفعة.