INFLUENCE OF SUBSTITUTION OF ARTICHOKE LEAVES FOR CLOVER HAY ON GROWTH PERFORMANCE AND DIGESTIBILITY IN RABBITS.

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ABSTRACT

Seventy five New Zealand White (NZW) rabbits, 5 weeks of age with 700±1.4 g average live body weight (LBW) were allotted at random to five experimental groups (of 15 rabbits each). The aim of the study was to investigate the effects of partial or complete substitution (0, 25, 50, 75 or 100%) of artichoke leaves (AL) for clover hay on growth performance and nutrients digestibility in rabbits. Results indicated that rabbit fed 50% artichoke leaves recorded the highest ($P<0.05$) final body weight (2.148 kg) followed by rabbit fed 75% (2.046 kg). Average daily feed intake increased significantly ($P<0.05$) with the increase of the level of artichoke leaves inclusion throughout the experimental periods. Group fed 50% AL recorded the best FCR throughout the whole period (W5-W12). In addition to the highest nutrients digestibility values were recorded for diets contained 50% AL followed by diet contained 75% AL, while the lowest values were obtained for diet contained 100%AL in comparison to the basal diet. Data also showed that 50% and 75% AL recorded the highest ($P<0.05$) value of Digestible crude protein and Digestible Energy, while rabbit fed diets contained 100% recorded the lowest ($P<0.05$) DCP.50% AL recorded the highest total VFA concentration, cellulolytic bacterial count (8.08 log cfu/ml) and Fibrolytic activity. It could be concluded that substitution of AL in the diet of NZW rabbits at 50% of clover hay had the best growth performance and digestibility of all nutrients.

Key words: rabbits, feeding, digestibility, growth**,** Artichoke leaves.

INTRODUCTION

Waste vegetable materials could be formed the basis of diets for the small scale production of meat rabbits.Artichoke (*Cynarascolymus*) leaves could be used as roughage feedstuffs for rabbits and contributed in lowering the feeding cost and hence increasing the economic efficiency. FAO (2005) reported that Egypt is the second world leader in production of artichoke. Gul et al. (2001) indicated the possibility of using green forage of artichokes in the diet including cereals and other sources of fiber for feeding of rabbits. Radwanet et al. (2007) reported that artichoke leaves meal contained 9.5% CP, 28.0% CF, 46.3% NDF, 32.2% ADF. Bonomi (2001) reported that the substitution of artichoke leaf meal at 5 and 10% of total feed in rabbits diet increased the body weight by 4 and 7%, respectively, without any adverse effects on animal health. De Blas (2013) reported that fibre is the main chemical constituent of rabbit diets, Cell wall constituents are not well digested in rabbits, but this effect is compensated by its stimulus of gut motility, which leads to an increasing rate of passage of digesta. Moreover, the use of diets with high soluble fibre concentrations enhanced the digestive efficiency, growth performance, and caecal fermentation of growing rabbits (Trocino, 2013). The main objective of the present experiment was to investigate the effect of different replacement levels (25, 50, 75 and 100%) of dried Jerusalem artichoke leaves for clover hay in growing rabbits diets on the growth performance and digestibility coefficients.

MATERIALS AND METHODS

Diets, animals and experimental design

The first group of rabbits was basal diet (Zero AL). The other four groups were fed on the diets contained AL at 25, 50, 75 and 100% substitution of clover hay. All the experimental diets were formulated to be iso-nitrogenous, iso-caloric and adequate in all nutrients requirements for growing rabbits, as recommended by Lebas (2004) as shown in Table 1. Seventy five weaned New Zealand white rabbits, six weeks old with an average live body weight 728.2 g were allotted randomly to five groups (fifteen rabbits each). Feed and water were offered ad libtium. Feed intake and weight gain were recorded weekly, while feed conversion was calculated as a ratio of gram of feed per gram of gain.

Table 1: Feed ingredients and chemical composition of experimental diets (%DM basis).

Feed Ingredients (%)	Basal diet	25%AL	50%AL	75%AL	100%AL
Clover hay	34	25.5	17	8.5	0
Artichoke leaves	0	8.5	17	25.5	34
Yellow corn	21	21	20	19	25
Soybean meal (44%CP)	16	16	17	17	17
Wheat bran	24	24	25	25	25
Molasses	3.0	3.0	3.0	3.0	3.0
Di- Ca- phosphate	2.0	2.0	2.0	2.0	2.0
Dl-Methionine	0.4	0.4	0.4	0.4	0.4
Salt	0.3	0.3	0.3	0.3	0.3
Vit.-Min. premix*	0.3	0.3	0.3	0.3	0.3
Chemical composition(%DM basis)					
DM	88.91	88.20	88.68	87.98	87.88
OM	91.78	91.88	91.60	91.79	91.40
CP	17.09	17.00	17.18	17.07	17.08
EE	2.47	2.46	2.45	2.44	2.43
NFE	60.21	60.10	59.95	60.27	60.03
NDF	29.93	30.33	30.42	30.49	30.57
ADF	16.67	16.94	17.11	17.27	17.44
ADL	3.64	3.71	3.74	3.78	3.82
Methionine[1]	0.64	0.64	0.64	0.64	0.64
Lysine[2]	0.83	0.83	0.83	0.83	0.83
Calcium[3]	1.01	1.01	1.01	1.01	1.01
Total Phosphorus[4]	0.68	0.66	0.65	0.65	0.65
Digestible energy[5](Kcal/Kg DM)	2650	2648	2600	2601	2600

***vitamins and minerals premix ,** [1,2,3,4,5]Calculated on the basis of the ingredient composition using NRC, 1977 table.

Digestibility trial

A digestibility trial was performed on twenty five male New Zealand White rabbits (5 rabbit for each treatment), 7 month of age with an average live body weight ranged from 3520 to3750g determine the digestibility's coefficients and the nutritive values of the experimental diets according to European reference method for rabbit digestibility trials (Perez et al., 1995) of the five experimental diets. Rabbits were housed in individual metabolism cages that allowed

separation of feces and urine. Feces produced daily were collected in polyethylene bags and stored at - 20ºC. Feces were collected every 24 hours for five consecutive days (collection period). Total digestible nutrients (TDN) were calculated as follows: % digestible crude protein (DCP) + % digestible crude fiber (CF) + % digestible nitrogène free extract (NFE) + 2.25 % digestible ether extract (EE). Digestible energy (DE, Kcal/Kg diet) was calculated according to Schneider and Flatt (1975).

Cecum fermentation

the cecum was weighted and the pH of the caecal content was measured using pH-meter, pH-meter, HANNA Instruments (Italy). Then the caecal content was collected and divided into two samples, one of them was forthececal appendix fluid and stored at -20°C until estimation of cecum microflora(cellulytic bacteria) by Standard method according to British Standards Institution (1991) and determined the fibrolytic activity according to Chao and Li (2008).The another sample was filtered through four folds of gauze, and used for dertermination of NH_3-N concentration by applying Conway method (1958).Total volatile fatty acids (VFA) were determined according to Eadie*et et al.* (1967), fraction values of VFA were determined using HPLC.

Chemical analysis

The following chemical analyses were carried out on feedstuffs, diets, and feces according to A.O.A.C. (2000) and EGRAN (2001) for determining moisture, crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen free extract (NFE),, while fiber fractionations, neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined according to the sequential method of Van Soest et al. (1991). Tannins were determined as described by Burn (1971).

Statistical Analysis

The results of experimentation were statistically analyzed using GLM (general linear models) procedure of SAS (2000) by one-way ANOVA, The significant differences among treatment means were compared Using Duncan's multiple range of test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical evaluation of Artichoke leaves

Results in Table 2 indicated that both clover hay (CH) and artichoke leaves (AL) are equal in DM while CH was higher in CP and CF content**.** The chemical composition of AL is similar to that reported by Ghanem (2006) and Sallam et al., (2008). Concerning to fiber fractionation content, Clover hay had lower NDF, ADF and ADL content than AL, values of AL are comparable to those values reported by Ghanem (2006). Artichoke leaves contained high content of tannins 2.58 g/100g DM for AL. The presence of tannins found to decrease the nutritional value of feedstuffs for non-ruminant animals by reducing retention of protein (Li and Zahang, 1998).

Table 2.Chemical analysis of Artichoke leaves on dry matter basis

Items (%)	DM	OM	CP	CF	EE	NFE	Ash	NDF	ADF	ADL
CH	90.35	87.17	13.40	26.03	4.03	43.71	12.83	43..20	30.06	5.54
AL	90.30	92. 32	11.52	23.99	1.75	55.46	7.28	50.39	40.17	7.01

CH: Clover hay AL: Artichoke Leaves

Growth performance

The effect of feeding treatments on growth traits is illustrated in Table 2. Data showed that rabbit fed 50% AL recorded the highest (P<0.05) final body weight followed by rabbit fed 75% (2046.33g).

The rabbits group fed 50%AL recorded the highest (P<0.05) body weight gain at the second periods (W9-W12) and at the whole period (W5-W12) ,while the lowest was with rabbits group fed the basal diet. in this connection El-Sayaad et al. (1995) found that rabbits fed 10% artichoke bracts recorded the highest final body weight (2355.0 g) and daily gain (25.75 g). Also, Bonomi, (1989) used dehydrated artichoke leaf meal in rabbit rations at levels of 5% and 10%, in substitution of dehydrated lucerne meal and found an improvement in weight gain 4% and 7%, resp. and the feed utilization 3% and 5%, resp.These findings disagreed with Zeweil (1992). Average daily feed intake increased significantly (P<0.05) with the increase of the level of AL inclusion throughout the experimental periods. These results are in agreement with that obtained by Bonomi, (1989). Data showed that the inclusion of AL at 50, 75 and 100% levels recorded

higher(P<0.05) FCR than the basal diet at the second period the rabbits group fed 50% AL recorded the best FCR throughout the whole period (W5-W12).

Table 3. Growth performance of the experimental growing NZW rabbits.

Item	Basal diet	25%AL	50%AL	75%AL	100%AL	MSE*	P value
Initial bodyweight, g	723.55	724.0	725.33	723.55	727.67	55.48	0.999
Final body weight, g	1969.67^{c}	1974.78^{c}	2148.89^{a}	2046.33^{b}	2025.00^{bc}	66.82	0.0001
Average Weight daily gain, g/d/rabbit							
5 to 8 weeks old	23.13	22.17	23.88	22.75	22.13	2.23	0.442
9 to 12 weeks old	21.59^{c}	22.88$^{b\,c}$	26.98^{a}	24.49^{b}	24.83^{ab}	2.43	0.0005
5 to 12 weeks old	22.36^{b}	22.53^{b}	26.43^{a}	23.62^{b}	23.49^{b}	1.40	0.0003
Average Feed intake, g/d/rabbit							
5 to 8 weeks old	80.44^{c}	81.94^{bc}	84.47^{a}	85.14^{a}	83.51^{ab}	2.47	0.001
9 to 12 weeks old	99.67^{b}	99.80^{b}	105.69^{a}	101.20^{b}	99.29^{b}	2.67	0.0001
5 to 12 weeks old	90.06^{c}	90.87^{c}	95.08^{a}	93.17^{b}	91.40^{bc}	1.89	0.0001
Feed Conversion Ratio (g feed / g gain)							
5 to 8 weeks old	3.51	3.80	3.56	3.75	3.79	0.46	0.537
9 to 12 weeks old	4.70^{a}	4.39^{ab}	3.94^{b}	4.16^{b}	4.04^{b}	0.48	0.011
5 to 12 weeks old	4.05^{a}	4.05^{a}	3.74^{b}	3.95^{ab}	3.90^{ab}	0.29	0.157

a,b,c,… Means values with the same letter within the same row did not differ significantly (P>0.05).
* SEM= Mean Square Error (n=15 rabbits per treatment).

Digestibility and nutritive values

The results obtained on nutrients digestibility of the experimental diets are presented in Table 4.Data revealed that the highest (P<0.05) nutrients digestibility values were recorded for diets contained 50% AL followed by diet contained 75% AL, while the lowest values were obtained for diet contained 100%AL in comparison to the basal diet. This could be attributed to polyphenolic compounds in artichoke leaves. These results are confirmed by Huisman and Tolman (1992) who reported that polyphenolic compounds considered as an anti-nutritional factors that have a depressive effect on protein digestion. Data also showed that digestibility of DM, CP and CF were significantly (P<0.05) increased with replacing clover hay AL at 50% and

75% levels compared to the basal diet. On the other hand, DM, OM, CF, EE and NFE digestibilities not significantly affected (P<0.05) when AL was replaced by AL at 25 and 100%. These results agreed with Zeweil (1992) and Bonanno et al. (1994). Rabbit fed diets contained 50% and 75% AL recorded the highest (P<0.05) value of DCP, TDN and DE, while rabbit fed diets contained 100% recorded the lowest (P<0.05) DCP. These results due to the high proportion of lignin in AL, forming lignifications, and decrease the total protein digestibility (Perez, 1989). These results are in good agreement with those obtained by Zeweil (1992).

Table 4. Digestion coefficients and nutritive value of rabbit diets.

Item	Basal Diet	25%AL	50%AL	75%AL	100%AL	SEM*	P value
DM	66.99^{b}	68.00^{ab}	70.08^{a}	69.99^{a}	67.54^{ab}	1.31	0.047
OM	68.09^{b}	70.08^{ab}	72.17^{a}	70.46^{ab}	67.98^{b}	1.36	0.017
CP	65.95^{c}	67.91^{b}	71.03^{a}	70.32^{a}	65.50^{c}	1.04	0.0002
CF	45.49^{c}	47.09^{bc}	50.20^{ab}	51.74^{a}	45.51^{c}	2.37	0.0028
EE	74.71^{a}	76.49^{a}	72.85^{ab}	71.95^{ab}	68.34^{b}	2.45	0.021
NFE	74.28^{bc}	75.46^{ab}	77.31^{a}	76.29^{ab}	72.43^{c}	1.13	0.003
DCP	11.46^{c}	11.79^{b}	12.33^{a}	12.24^{a}	10.44^{d}	0.17	0.0001
TDN	65.55^{b}	66.69^{ab}	68.19^{a}	67.03^{ab}	63.87^{c}	0.85	0.0011
DE(kcal/kg DM)	2909^{cd}	2960^{bc}	3026^{a}	2975^{ab}	2868^{d}	30.98	0.0009

a,b,c,… Means values with the same letter within the same row did not differ significantly (P>0.05).
*SEM= Mean Square Error (n=15 rabbits per treatment).

Cecum fermentation

Data in Table (5) indicatedthatthecaecum weight, empty caecum (%) were not affected byinclusion levels of artichoke leaves.The NH3-N concentration dropped with the increasing of the inclusion level of AL. While, 50% AL recorded the highest total VFAconcentration increased. This increase in total VFA may be related to higher fiber digestibility and higher cellulolytic count for these experimental diets compared to the control diet. In addition 50% and 75% AL group were the highest (P<0.05) Acetic and propionic (%) concentration while the experimental groups did not significantly different in butyric acid (%). 50%AL group recorded

the highest (P<0.05) cellulolytic bacterial count (8.08 log cfu/ml) and Fibrolytic activity. While, Tao and Li (2006) reported that the fibroltic activity of the caecum in 2-3 month rabbits ascended when the dietary NDF increased and it was consistent with NDF digestion. It It is clearly to notice that incorporating (AL) as fiber sources in rabbit diets stimulating the maturation of cecal flora especially cellulolytic bacteria which secretes enzymes capable of hydrolyzing the cellulose as the main components of dietary fiber. These results are confirmed by those of Trocino*et etal*. (2011); Gidenne*et etal.* (1998),Gidenne and LeBas, (2002)and (Trocino et al., 2013).

Table 5.Effect of the experimental diets on cecum characteristics of growing rabbits

Items	Basal diet	25%AL	50%AL	75%AL	100%AL	RMSE*	Pr<F
Cecum weight (%)	9.39	8.06	9.06	8.03	7.97	2.33	0.90
Empty cecum weight (%)	2.68	2.30	2.59	2.30	2.38	0.66	0.90
pH	6.99 ^{a}	6.54 ^{ab}	6.32 ^{ab}	6.58 ^{ab}	6.24 ^{b}	0.37	0.020
NH_3-N(mg/100ml)	12.83^{a}	12.30^{b}	11.15 ^{c}	10.47^{d}	10.45^{d}	0.23	0.0001
TotalVFA (mleq/100ml)	5.46^{b}	5.15^{b}	6.08^{a}	5.26^{b}	5.01^{b}	*0.26*	*0.005*
Acetic Acid (% total VFA)	48.80 ^{c}	48.83 ^{c}	51.52 ^{a}	50.24 ^{ab}	49.01^{bc}	0.74	0.004
Propionic Acid (% total VFA)	21.50 ^{ab}	21.20 ^{b}	22.47 ^{a}	21.51 ^{ab}	20.02 ^{c}	0.57	0.006
Butyric Acid (% total VFA)	19.43	19.32	19.86	19.19	19.47	0.37	0.32
Fibrolytic activity (IU/g)	31.87 ^{d}	35.20 ^{c}	41.92 ^{a}	39.93 ^{ab}	38.64 ^{b}	0.28	0.01
Cellulolytic count (log cfu/ml)	7.10^{c}	7.70 ^{ab}	8.08^{a}	7.29^{bc}	7.59^{abc}	1.39	0.0001

* SEM = Mean Square Error (n=5 rabbits per treatment).

CONCLUSION

Artichoke leaves could be used successively in formulating diets for weaning rabbits up to 25.5 and 34% of diets without adversely affecting on performance and nutrients digestibility. From nutritional points of view, artichoke leaves may become a new feed ingredient for rabbits.

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