Influence of dietary citric acid and acidulated palm oil soapstock supplementation on growth response, nutrient utilization, blood metabolites, carcass traits and reproductive efficiency of NZW rabbits

Tawfeek M.I., El Gaafary M.N., Abd El Rahim M.I., Soad S.A.

in

Baselga M. (ed.), Marai I.F.M. (ed.).
Rabbit production in hot climates

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 8

1994
pages 197-211

Influence of dietary citric acid and acidulated palm oil soapstock supplementation on growth response, nutrient utilization, blood metabolites, carcass traits and reproductive efficiency of NZW rabbits

M.I. TAWFEEK, M.N. EL-GAAFARY,
M.I. ABD EL-RAHIM & SOAD, S. AHMED
DEPARTMENT OF ANIMAL WEALTH,
INSTITUTE OF EFFICIENT PRODUCTIVITY,
ZAGAZIG UNIVERSITY, ZAGAZIG, EGYPT

SUMMARY - The present study was conducted to determine the efficacy of citric acid and acidulated palm oil soapstock (APS) supplementation on improving the nutritive value of the commercial rabbit rations. Three groups of 51 weanling rabbits (average body weight, 686 ± 40 g) received a basal diet without (control) or supplemented with either 0.5% citric acid (group 2) or 1% acidulated palm oil soapstock (group 3). The feeding experiment was extended from the rabbit weaning (5 weeks old) and up to the obtaining of 3 parturitions.

Supplementation with either citric acid or APS increased ($P < 0.05$) the digestibility of CP, CF, percentage of N-retained and DCP. While, the digestibility of EE, OM, DM and the TDN values of the given diets were unaffected significantly by the dietary treatments. Levels of total cholesterol, total lipids and alkaline phosphatase in the blood serum increased ($P < 0.05$ or 0.01) by addition of APS, while the levels of such constituents were decreased by citric acid supplementation. The levels of calcium and inorganic phosphorus were increased ($P < 0.05$) by the two supplements. The levels of serum GOT, GPT and creatinine were not differed ($P < 0.05$) between the treatment groups. Daily weight gain, feed conversion ratio, viability, carcass traits and semen characteristics showed in general, insignificant improvement by the dietary supplementation. However, milk yield, bunny weight from birth up to 21 days of age and viability of offsprings from birth to 7 days of age were increased ($P < 0.05$) by addition of acidulated palm oil soapstock.

Key words: citric acid, palm oil soapstock, growth, digestibility, blood metabolites, carcass, reproductive efficiency.

Introduction

Many researchers (Falkowski and Aherne, 1984; Giesting and Easter, 1985 and Risley, 1990) observed an improvement in postweaning growth rate and efficiency of feed utilization of pigs when starter diets were supplemented with organic acids such as citric or fumaric acids. The improvement in growth performance has been hypothesized to be related to the lowering of gastric P^H and subsequent modification of the intestinal microflora by these acids (Burnell *et al,* 1988 and Radecki *et al,* 1988). The beneficial effects of organic acids on

growth performance of pigs have been also explained through the different effects of organic acids on intermediary metabolism (Grassmann and Klasna, 1986). Moreover, Kirchgessner and Roth (1982) reported that organic acids could be used as an energy source for pigs with efficiency equal to that of glucose.

The necessity of addition of fats to the diets of animals or poultry in high-temperature environments is to aid the animal to withstand the effects of heat stress by reducing the heat increment resulting from the conversion of carbohydrates and protein to fatty acids (Edwards, 1969 and Lipstein and Bornstein, 1974). Furthermore, fat supplementation is required to increase the energy, density of the diet, facilitate supply and absorption of the fat soluble vitamins (Clarcke *et al*, 1977) and to improve the diet palatability (Finzi and Verita, 1976).

The results obtained concerning the effect of addition of organic acids to the rabbit diets are conflicting, furthermore, very little information are available about the evaluation of some wastes of oil refining such as the acidulated palm oil soapstock as cheap supplemental fat in the rabbit rations.

The present work aimed to investigate the effects of addition of either 0.5% citric acid or 1% acidulated palm oil soapstock to the commercial rations on growth response, nutrient utilization, blood serum metabolites, carcass traits and reproductive efficiency of NZW rabbits.

Materials and methods

The present experiment was carried out at the Rabbits Research Farm, Institute of Efficient Productivity, Zagazig University, Zagazig, Egypt, during the period from January to October, 1993.

A total of 51 weanling NZW rabbits of both sexes weighing initially 686±40 g and of 5 weeks old, were allotted to 3 experimental groups. One group was given a basal diet (control), which was a commercial pelleted ration. The other two groups were given a basal diet supplemented with either 0.5% citric acid (CA) or 1% acidulated palm oil soapstock (APS). The composition of the basal diets and the analyzed fatty acids composition in APS are presented in Table 1 and 2, respectively. The feeding experiment extended from the rabbit weaning up to the fulfillment of 3 parities. The basal diets were purchased from Atmida Company for Animals and Poultry feeds, Dakahlia Governorate, Egypt. The acidulated palm

TABLE 1

COMPOSITION AND CHEMICAL ANALYSIS OF BASAL DIETS OFFERED TO RABBITS DURING THE PERIOD OF EXPERIMENT

Items	The basal diets	
	(1)*	(2)**
Ingredients (%)		
Ground barley	23.00	22.00
Ground clover hay	30.00	17.00
Wheat bran	26.20	15.00
Soybean meal	16.00	16.00
Ground clover straw	-	10.70
Corn gluten meal (60% protein)	-	4.00
Corn gluten meal (16% protein)		10.00
Molasses	3.00	3.00
Lime stone	1.00	-
Bone meal	-	1.50
Vitamins & Minerals premix***	0.30	0.50
Common salt	0.35	0.30
DL. Methionine	0.15	-
Total	100	100
Chemical composition (%) as fed basis:		
Dry matter	86.73	89.39
Crude protein	17.48	18.51
Ether extract	2.33	2.29
Crude fiber	12.32	13.57
NFE	46.62	45.79
Ash	7.98	9.23
Ca	0.73	0.79
P	0.51	0.71
Lysine	0.90	0.87
Methionine + Cystine	0.63	0.65

*Basal diet was offered to rabbits during the period, from 5-12 weeks of age.

**Basal diet was offered when rabbits aged 13 weeks.

*** One kilogram of premix provides: Vit. A, 2000000 IU; Vit. D_3; 150000 IU; Vit. E, 8.33 g; Vit K, 0.33 g; Vit B_1, 0.33 g; Vit B_2, 1.0 g; Vit B_6, 0.33 g; Vit B_5, 8.33 g; Vit B_{12}, 1.7 mg; Pantothenic acid, 3.33 g; Biotine 33 mg; Folic acid 0.83 g; Choline chloride, 200 g; Zn. 11.7 g; Fe, 12.5 g; Cu, 0.5 g; I, 33.3 mg; Se 16.6 mg, Mg 66.7 g; and Mn, 5 g.

TABLE (2)

ANALYZED FATTY ACIDS COMPOSITION OF ACIDULATED PALM OIL SOAPSTOCK (APS)

The fatty acid	%*
Palmitic	35.36
Stearic	10.34
Oleic	24.48
Linoleic	10.37
Linolenic	5.31
Arachidonic	7.24
Others	6.90

* As percentage of total methyl esters.

oil soapstock was obtained from Misr Company for Soap and Oils, Zagazig, Egypt. Citric acid was dissolved by a little of tap water and carefully mixed with the offered basal diet directly before feeding. Also, the APS was melted firstly by using a waterbath and mixed with the basal diet just before distribution to prevent the lipid peroxidation. Rabbits were housed in galvanized wire cages (60 x 55 x 40 cm) each 2 together up to their puberty, then kept individually afterwards. The cages were provided with feeders and automatic nipples. The experimental diets were offered daily to rabbits ad libitum. The rabbits were kept under the same environmental and managerial conditions. During the growth period of rabbits (5-13 weeks old), individual live body weight and feed consumption were recorded weekly. The economical efficiency of feeding rabbits during the growth period (5-13 weeks of age) was calculated by the following equation:

$Y = ((A-B)/B) \times 100$, where A is selling cost of the obtained gain and B is the feeding cost for this gain. At 13 weeks of age, a digestibility trial was conducted by using 3 males from each group, which were kept individually in metabolic cages. During the collection period (7 days) feed consumption, faeces and urine output were recorded quantitatively daily. Samples of daily faeces of each rabbit were taken and oven dried at 65 ^{o}C for 48 h, then ground and stored for the chemical analysis. Also, composite samples of daily urine, which containing H_2SO_4 (10%) were taken and stored in a refrigerator at 5 ^{o}C until analyzed for nitrogen. At the end of digestibility trial, the males were slaughtered and blood samples were taken into dry non-heparinized glass tubes. Blood samples were also taken from the three groups of rabbits (5 for each group) at 22 weeks of age by ear vein puncture to estimate the effect of continuous feeding on the changes of the levels of blood serum metabolites. Blood serum was separated by centrifugation of blood sample at 3000 r.p.m for 15 minutes, then serum was

stored frozen (-20 °C) in plastic vials until analysis. The levels of total cholesterol, total lipids, total protein, glutamate - oxaloacetate transaminase (GOT), glutamate - pyruvate transaminase (GPT), alkaline phosphatase (AlKP), creatinine, calcium (Ca) and inorganic phosphorus (P) were determined in the blood serum. Male rabbits were weighed just before slaughter as well as after complete bleeding. The head, skin, giblets (heart, liver and kidneys), abdominal fat and alimentary tract were weighed and related to the live body weight. Empty body weight and dressing percentages were also recorded.

At 22 weeks of age, 3 bucks from each dietary group were taken to evaluate the effect of dietary supplementation on their semen characteristics. Semen was collected by means of an artificial vagina. In each collection (n = 15) ejaculate volume, sperm concentration, the percentages of sperm motility, abnormal and dead spermatozoa were examined microscopically according to Smyth and Gordon (1967). Also, 5 females from each group were used to estimate the effect of feeding the experimental diets on their reproductive efficiency. At mating, each doe was transferred to the buck's pen (3 bucks/group) and returned to her cage after mating. All does were palpated 10 days post mating to determine pregnancy and to repeat mating in case of failure. Conception rate (%), gestation period (days) and litter size at birth, 21 and 35 days of age (weaning age) were recorded. Other productive traits of offsprings such as litter weight, bunny weight and mortality rate were also recorded.

The chemical routine analysis for basal diets, faeces and urine was done according to A.O.A.C (1980). Metabolizable energy (ME) of one kilogram feed dry matter (DM) was calculated according to the following equation described by Kalogen (1985):

ME (Kcal/kg feed DM) =

(0.588 + 0.164 X) x 239, where X is a dry matter digestion coefficient of the given diet. The fatty acids composition of APS was determined by gas liquid chromatography (Model: variant 3300; column OV. 101; temperatures of the column, injector and detector were 200, 280 and 240 °C, respectively). Fatty acids were identified by comparison of retention times with standards and expressed as percentages of fatty acid methyl ester distribution. The analysis of fatty acids was performed in the Laboratory of Department of Natural Products Chemistry, National Research Center, Dokki, Cairo, Egypt. All the biochemical constituents of blood serum

were determined calorimetrically by using commercial kits purchased from both of Egyptian-American Company for Laboratory Services and El-Nasr Pharmaceutical Chemicals Company, Cairo, Egypt.

Doe milk consumed (DMC) by pups from birth to 21 days of age was estimated according to the following equation:
DMC = LWG / 0.56, where LWG is a litter weight gain (kg) from birth to 21 days of age and 0.56 is a constant calculated by Cowie (1969).

Data of the present study were analyzed by ANOVA as a completely randomized design according to Snedecor and Cochran (1982). All the percentages data were transformed to their arc-sin $\sqrt{\%}$ values at analysis. Viability and conception rate were analyzed by using Chi-Square. Significant differences of means were tested by using Duncan's multiple range test (Duncan, 1955).

Results and discussion

Effects of citric acid and APS supplementation on:

1. Growth performance:

Data of growth performance of NZW rabbits during different ages as affected by feeding on basal diet supplemented with citric acid and acidulated palm oil soapstock are presented in Table 3.

Although, the differences in average daily gain, feed consumption and feed conversion efficiency were not significant among the treatment groups during the different weeks of age, rabbits fed either APS or citric acid supplemental diets had higher growth performance than those fed the basal diet. Partridge *et al,* (1986) indicated that rabbits given a basal diet supplemented with 2% soya acid oil (acidulated soybean oil soapstock) showed slight, non-significant improvements in daily live weight gain as compared to the control. Also, Zaghini *et al*, (1986) reported that addition of 1.5% of either citric or fumaric acid, replacing an equivalent amount of maize meal had no significant effects on daily body gain, feed intake and feed conversion ratio. The previous findings were in contrast with those of Castrovilli (1991) who found that feed conversion efficiency by rabbits was improved with addition of 0.15 or 0.3% mixture of organic acids including citric acid. Viability percentages were increased by 29.4 and 17.6%, while the economical efficiency was enhanced by 3 and 11% for rabbits fed citric acid and APS diets, respectively, relative to the control.

TABLE 3

GROWTH PERFORMANCE ($\bar{X}$±S.E) OF NZW RABBITS AS AFFECTED* BY FEEDING BASAL DIET SUPPLEMENTED WITH EITHER CITRIC ACID OR ACIDULATED PALM OIL SOAPSTOCK.

Items	Dietary supplementation		
	Control[1]	Citric acid[2]	APS[3]
	5 - 8 weeks of age		
No. of rabbits	17	17	17
Initial body weight at 5 weeks old (g)	692.94±42.84	683.23±38.01	681.47±38.73
Body weight at 8 weeks old (g)	1297.33±65.63	1278.85±52.77	1288.33±82.59
Total weight gain (g)	604.39±48.56	595.62±37.21	606.86±55.70
Daily weight gain (g)	28.78±2.31	28.36±1.77	28.90±2.65
Daily feed consumption (g)	96.14±1.00	94.19±0.74	96.24±6.03
Feed conversion ratio (g feed/g gain)	3.34	3.32	3.33
Viability (%)	88.24	100	88.24
Feed cost/kg gain (LE)	1.74	1.83	1.76
Economical efficiency (%)	240.9	227.9	240.9
	8 - 13 weeks of age		
Body weight at 13 weeks old (g)	2208.18±76.57	2262.81±126.27	2311.79±83.42
Total weight gain (g)	910.85±58.20	983.69±89.84	1023.46±50.30
Daily weight gain (g)	26.02±1.66	28.11±2.57	29.24±1.44
Daily feed consumption (g)	117.69±2.93	115.20±5.27	114.4±2.09
Feed conversion ratio (g feed/g gain)	4.52	4.10	3.91
Viability (%)	73.33	94.12	93.33
Feed cost/kg gain (LE)	2.35	2.26	2.07
Economical efficiency (%)	155.3	165.5	189.9
	5 - 13 weeks of age		
Total weight gain (g)	1515.24±68.01	1579.58±125.15	1630.32±61.18
Daily weight gain (g)	27.06±1.21	28.21±2.23	29.11±1.09
Daily feed consumption (g)	109.61±4.33	105.87±3.38	107.59±4.06
Feed conversion ratio (g feed/g gain)	4.05	3.75	3.70
Viability (%)	64.71	94.12	82.35
Feed cost/kg gain (LE)[4]	2.10	2.06	1.96
Economical efficiency (%)	185.7	191.3	206.1

*all the differences within the treatment groups were not significant.

[1]Basal diet (commercial pelleted ration)

[2]Basal diet + 0.5% citric acid.

[3]Basal diet + 1% acidulated palm oil soapstock (APS).

[4]Basal on that the price of one kilogram of basal, citric acid and APS diets was 0.52, 0.55 and 0.53 LE., respectively and the price of one kilogram of live body weight at selling was 6.00 LE.

It could be observed that, in spite of citric acid supplementation showed a little beneficial influence on daily body gain, feed conversion and in turn the economical efficiency, the viability percentage in rabbits fed citric acid diet was higher by 29.4% than in those fed the control diet. The higher survival rate of citric acid group may be attributed to that citric acid reduce the intestinal P^H, which became unsuitable for growth of the pathogenic bacteria that causes the diarrhoea and death for rabbits. In this connection, Pallauf *et al,* (1988) stated that supplementation of 1.5% citric acid to the basal ration decreased the diarrhoea and increased the growth of piglets.

2. The apparent digestibility, nutritive value of diets and nitrogen utilization:

Data in Table 4 show that addition of either citric acid or APS increased ($P < 0.05$) the apparent digestibility of CP and CF, while the digestibility of EE, OM and DM was not differed significantly within the treatment groups. The improvement in the digestibility of CP and CF by addition of citric acid or APS may be related to the lowering of intestinal and caecum P^H, which in turn increase the activity of microflora which digest such components (Scipioni *et al,* 1978 and Zaghini *et al,* 1986). In that regard, Pallauf *et al,* (1988) reported that the apparent digestibility of nutrients by piglets increased with addition of 1.5% citric acid to the basal ration.

Supplementation of citric acid or APS improved the nutritive value of the given diets expressed as ME, TDN or DCP. However, significant improvement was obtained when the feeding value expressed as DCP only. Although, rabbits with citric acid and APS supplementation retained more nitrogen ($P < 0.05$) than the control, the percentage of N-retained was not differ significantly among the treatment groups. Radecki *et al,* (1988) mentioned that N balance, percentage N-retained and apparent N digestibility were not affected by addition of 1.5% fumaric acid to the starter pig diet.

3. Blood serum metabolites:

Results of Table 5 indicate that addition of 1% APS increased significantly ($P < 0.05$ or 0.01) the levels of total cholesterol, total lipids and alkaline phosphatase. While, supplementation of 0.5% citric acid decreased the levels of total lipids ($P < 0.05$), total cholesterol ($P < 0.01$) and alkaline phosphatase ($P < 0.05$). The levels of serum calcium (Ca) and inorganic phosphorus (P) were

TABLE 4

APPARENT DIGESTIBILITY[1], NUTRITIVE VALUE AND NITROGEN UTILIZATION ($\bar{X}$±S.E) OF GROWING NZW RABBITS FED BASAL DIET SUPPLEMENTED WITH EITHER CITRIC ACID OR ACIDULATED PALM OIL SOAPSTOCK.

Items	Dietary supplementation			Statistical significance
	Control	Citric acid	APS	
Live body weights (kg):				
Initial	2813±197	2857±167	2980±231	NS
Final	2977±207	3047±162	3168±217	NS
DM intake (g/head/day)	156±12	165±10	184±4	NS
Apparent digestibility:				
DM	65.0±2.2	68.8±1.3	68.05±0.9	NS
OM	66.6±1.9	69.9±0.7	69.0±1.5	NS
CP	71.8±1.0^b	76.8±1.1^a	75.2±0.2^a	P<0.05
EE	71.0±1.7	75.8±3.2	78.69±2.2	NS
CF	28.2±2.3^b	39.2±2.0^a	36.06±1.5^a	P<0.05
NFE	75.6±2.4	76.0±0.9	76.74±1.7	NS
Nutritive value of feed as:				
[2]ME (kcal/kg DM)	2689±88	2839±51	2808±36	NS
TDN (%)	55.4±1.5	58.2±0.7	59.8±1.3	NS
DCP (%)	13.28±0.21^b	14.24±0.20^a	13.91±0.03^a	P<0.05
Nitrogen utilization:				
N-Intake (g/day)	5.18±0.28	5.48±0.31	6.10±0.13	NS
Faecal-N (g/day)	1.46±0.14	1.27±0.17	1.51±0.04	NS
Urinary-N (g/day)	2.80±0.28	3.14±0.35	3.56±0.07	NS
N-Retained (g/day)	0.92±0.03^b	1.07±0.02^a	1.03±0.01^a	P<0.05
(% of intake)	17.76±1.14	19.52±1.12	16.88±0.18	NS

Means in the same row with different litters differ significantly (P<0.05).

[1]Digestibility trial was conducted when rabbits aged 13 weeks.

[2]Metabolizable energy (ME) of one kilogram feed DM was calculated according to the equation described by Kalogen (1985).

TABLE 5

SOME OF BLOOD SERUM METABOLITES ($\bar{X}$±S.E)[1] OF NZW RABBITS FED BASAL DIET SUPPLEMENTED WITH EITHER CITRIC ACID OR ACIDULATED PALM OIL SOAPSTOCK.

Items	Dietary supplementation			Statistical significance
	Control	Citric acid	APS	
Total cholesterol (mg/dl):				
at 14 weeks of age	64.0±4.5^{b}	69.3±3.3^{b}	110.0±5.5^{a}	P<0.01
at 22 weeks of age	80.3±2.8^{b}	71.0±1.7^{c}	118.0±4.6^{a}	P<0.01
Total lipids (g/L):				
at 14 weeks of age	4.23±0.20^{b}	3.10±0.30^{c}	6.50±0.40^{a}	P<0.05
at 22 weeks of age	4.60±0.17^{b}	4.13±0.09^{c}	5.57±0.20^{a}	P<0.05
Total protein (g/dl):				
at 14 weeks of age	4.63±0.35	5.10±0.49	4.60±0.03	NS[2]
at 22 weeks of age	3.17±0.32	4.53±0.72	3.80±1.90	NS
SGOT (U/L):				
at 14 weeks of age	63.60±2.65	66.13±3.54	63.80±2.90	NS
at 22 weeks of age	64.70±5.73	69.80±4.22	60.40±5.88	NS
SGPT (U/L):				
at 14 weeks of age	27.84±1.60	28.07±1.18	30.20±0.30	NS
at 22 weeks of age	29.80±2.21	29.10±3.81	26.67±0.49	NS
Alkaline phos.[3] (U/dl):				
at 14 weeks of age	17.12±1.07^{a}	11.77±1.27^{b}	16.01±0.84^{a}	P<0.05
at 22 weeks of age	18.77±0.89^{a}	13.60±1.06^{b}	17.40±0.75^{a}	P<0.05
Creatinine (mg/dl):				
at 14 weeks of age	1.23±0.30	1.22±0.32	1.14±0.11	NS
at 22 weeks of age	1.15±0.32	1.19±0.17	1.23±0.15	NS
Calcium (mg/dl):				
at 14 weeks of age	10.07±0.24	10.1±0.17	10.4±0.11	NS
at 22 weeks of age	9.87±0.26^{b}	13.0±0.06^{a}	11.0±0.10^{c}	P<0.05
Phosphorus (mg/dl):				
at 14 weeks of age	4.00±0.06^{b}	4.50±0.16^{a}	4.0±0.06^{b}	P<0.05
at 22 weeks of age	3.33±0.16^{b}	4.07±0.09^{a}	3.93±0.12^{ac}	P<0.05

[1]Each mean represents 3 and 5 observations at 14 and 22 weeks of age, respectively.
[2]The differences were not significant (P<0.05).
[3]Alkaline phosphatase

increased ($P < 0.05$) by addition of either citric acid or APS. However, the levels of total protein, GOT, GPT and creatinine were not significantly differed within the treatment groups. Zaghini *et al,* (1986) found that total protein, urea and creatinine levels in the blood of rabbits were unaffected significantly by feeding diets containing 1.5% citric or fumaric acid replacing an equivalent amount of maize meal. In the other side, Grassmann and Klasna (1986) reported that supplementation of basal diet of rats by 3% citric acid significantly increased the activity of GOT and GPT enzymes. The contrast between these results and our data may be related to the differences in the level of citric acid used. The increase of Ca and P levels in blood serum produced by addition of either citric acid or APS may be attributed to the lowering of intestinal P^H by using these acids, which increases the absorption of such minerals from the gut into the blood stream. Hohler and Pallauf (1993) indicated that the availability of Ca and P, Mg and Fe in blood serum of pigs was improved by addition of 1.5% citric acid to a maize-soya diet.

4. Carcass traits:

The data in Table 6 indicate that carcass traits were not affected significantly by dietary treatments, with exception of that the percentage of abdominal fat, which tended to be higher ($P < 0.05$) in rabbits fed the acidulated palm oil soapstock (APS) diet. Partridge *et al,* (1986) demonstrated that although, the killing-out percentage of rabbits was unaffected significantly by feeding on diet supplemented with 2% acidulated soybean oil soapstock, the perirenal fat deposits were significantly heavier than the control.

5. Reproductive efficiency:

a. Semen characteristics:

Table 7 shows that the dietary supplementation of either 0.5% citric acid or 1% acidulated palm oil soapstock (APS) insignificantly improved, in general, the quality of bucks semen. The most obvious improvement was observed with APS supplementation.

b. Does and their offspring traits:

The results in Table 8 indicate that milk yield during the period from birth up to 21 days of age was increased ($P < 0.05$) by the acidulated palm oil soapstock (APS) supplementation. Conception rate, gestation period, litter size and litter weight were unaffected significantly by any of the dietary supplementation. The data presented in Table 8 show also that bunny weight at birth and 21 days of age was decreased

TABLE 6

CARCASS TRAITS ($\bar{X} \pm S.E$)[1] OF NZW RABBITS FED[2] A COMMERCIAL DIET SUPPLEMENTED WITH EITHER 0.5% CITRIC ACID OR 1% ACIDULATED PALM OIL SOAPSTOCK.

Items		Dietary supplementation			Statistical significance
		Control	Citric acid	APS	
Preslaughter weight	(g)	1983.3±101.5	2083.3±205.1	2050.0±76.5	NS
Giblets	(g)	103.3±4.4	95.0±2.9	91.7±11.7	NS
	(%)	5.2±0.3	4.7±0.5	4.5±0.6	NS
Abdominal fat	(g)	15.7±0.3	21.3±6.8	38.7±4.4	NS
	(%)	0.8 ± 0.1^{b}	1.0 ± 0.1^{bc}	1.9 ± 0.3^{a}	$P < 0.05$
Alimentary tract	(g)	400±20.2	428.3±21.7	340.0±26.5	NS
	(%)	20.3±1.4	20.8±1.1	16.6±1.1	NS
Empty body weight	(g)	1059±93.1	1096.3±140.0	1190±28.6	NS
	(%)	53.2±2.1	52.3±1.8	58.1±1.1	NS
Carcass weight	(g)	1162.3±95.2	1191.3±140.7	1282±38.0	NS
Dressing	(%)	58.4±2.0	56.9±1.3	62.6±1.5	NS

Means in the same row bearing different letters, differ significantly ($P < 0.05$).
[1]Each mean represents 3 observations.
[2]From 5 - 14 weeks of age.

TABLE 7

SEMEN CHARACTERISTICS ($\bar{X} \pm S.E$)[1] OF NZW BUCKS AS AFFECTED BY FEEDING A COMMERCIAL DIET SUPPLEMENTED WITH EITHER 0.5% CITRIC ACID OR 1% ACIDULATED PALM OIL SOAPSTOCK.

Semen characteristics[2]	Dietary supplementation		
	Control	Citric acid	APS
Ejaculates number (n)	15	15	15
Ejaculate volume (ml)	0.39±0.05	0.49±0.05	0.52±0.08
Sperm motility (%)	53.33±5.40	57.33±6.86	65.45±3.12
Dead spermatozoa (%)	26.87±3.24	28.47±4.16	24.27±2.02
Abnormal spermatozoa (%)	18.67±2.21	17.33±2.60	17.82±2.98
Sperm concentration (x 10^6)	186.1±3.68	193.7±5.03	188.60±4.07

[1]The differences within the treatment groups were not significant.
[2]Semen characteristics were initially determined when bucks aged 22 weeks.

TABLE 8

DOE AND OFFSPRING TRAITS ($\bar{X}$±S.E) AS AFFECTED BY DIETARY CITRIC ACID AND ACIDULATED PALM OIL SOAPSTOCK SUPPLEMENTATION

Items	Dietary supplementation			Statistical significance
	Control	Citric acid	APS	
No. of services	13	16	22	
Conception rate (%)	53.85	50.00	54.54	NS
Gestation period (days)	31.71±0.52	31.75±0.31	31.42±0.31	NS
Litter size at:				
Birth	5.71±0.75	6.75±0.16	6.50±0.58	NS
7 days	5.00±0.69	4.25±0.98	5.17±0.78	NS
21 days	3.86±0.86	3.50±0.82	4.67±0.82	NS
35 days	3.71±0.94	3.50±0.82	4.33±0.76	NS
Litter weight (g) at:				
Birth	345.7±60.14	265.00±12.03	343.75±35.08	NS
21 days	1093.57±209.07	1280.00±164.60	1694.09±157.71	NS
35 days	2371.67±431.19	2460.00±455.43	2804.55±231.63	NS
Milk yield (g) at:				
21 days of lactation	1335.47±252.78^{b}	1803.57±165.73^{b}	2389.61±147.45^{a}	P<0.05
No. of offsprings:	40	64	78	
Bunny weight (g) at:				
Birth	60.71±5.28^{a}	41.25±2.06^{b}	54.67±4.57^{a}	P<0.05
21 days	301.43±29.04^{ab}	270.00±9.66^{b}	367.10±27.85^{a}	P<0.05
35 days	577.04±48.99	566.67±45.36	659.27±47.19	NS
Daily weight gain (g) from birth to:				
21 days	11.46±1.51	10.89±0.45	14.88±1.31	NS
35 days	14.75±1.40	15.01±2.97	17.27±1.30	NS
Viability (%) from birth to:				
7 days	87.50^{a}	88.88^{a}	79.49^{b}	P<0.05
21 days	67.50	72.22	71.79	NS
35 days	65.00	68.52	66.67	NS

Means in the same row bearing different letters differ significantly (P<0.05)

($P < 0.05$) by supplemental citric acid. Viability percentages from birth to 7 days of age tended to be higher ($P < 0.01$) with the addition of citric acid or APS. The other offspring traits were not significantly differed between the treatment groups. Snitinski (1986) reported that, feeding of pregnant sows (during the last 3 weeks of parturition) on basal diet supplemented with either 2% sodium citrate or 6% animal fat, increased the birth weight of the offspring and their percentage survival to an early age, increased the fat and protein concentration of colostrum and milk. The author added that, in the newborn, the supplements increased the energy store as glycogen and lipids.

Conclusion

Our results suggest that the use of either 0.5% citric acid or 1% acidulated palm oil soapstock as feed additives could be a mean of reducing mortality, improving the efficiency of feed utilization and reproduction in commercial rabbit production.

References

A.O.A.C. (1980): Official methods of Analysis. Association of Official Analytical Chemists, 13th Edition, Washington, USA.

BURNELL, T.W.; CROMWELL, G.L. & STALY, T.S. (1988): Effects of dried whey and copper sulfate on the growth responses to organic aid in diets for weanling pigs. J. Anim. Sci., 66: 1100.

CLARKE, H.E.; COATS, M.F.; EVA, J.K.; FORD, D.J.; MILNER, C.K., O'DONOGHUE, P.N.; SCOTT, P.P. and WHRD, R.J. (1977). Dietary standards for Laboratory Animals: report of the Laboratory Animals Center Diets Advisory Committee. Laboratory Animals, 11: 1-28.

CASTROVILLI, C. (1991): Acidification of feeds for fattening rabbits. Rivista di Coniglicoltura, 38(8): 31-34.

COWIE, A.T. (1969): Variation in the yield and composition of milk during lactation in the rabbit and the galactopoietic effect of prolactin. J. Endocrinology, 44: 437-450.

DUNCAN, D.B. (1955): Multiple range and multiple F tests. Biometrics, 11: 1-42.

EDWARDS, H.M. (1969): Factors influencing the efficiency of energy utilization of growing chickens, with special reference to fat utilization. Feedstuffs, 41 (39): 14-15.

FALKOWSKI, J.F., & AHERNE, F.X. (1984): Fumaric and citric acid as feed additives in starter pig nutrition. J. Anim. Sci., 58: 935.

FINZI, A. and VERITA P. (1976): Appreciation of rabbit feed palatability. Conigigliocoltura, 13: 25-27.

GIESTING, D.W. & EASTER, R.A. (1985): Response of starter pigs to supplementation of corn soybean meal diets with organic acids. J. Anim. Sci., 60: 1288.

GRASSMANN, E. & KLASNA, T. (1986): Comparative studies on the effect of supplements of fumaric and citric acid on body composition and enzyme activities of rats, differently supplied with protein, Landwirtschaftliche Forschung, 39(4): 307-319.

HOHLER, D. & PALLAUF, J. (1993): Effect of citric acid added to maize - soya - diet with or without Zn - supplementation on the availability of minerals. J. of Animal Physiology and Animal Nutrition, 69(2/3): 133-142.

KALOGEN, U.A. (1985): Rabbits feeding (In Russian). 112 P., Press, Agropromozdat, Moscow, Russia.

KIRCHGESSNER, M. & ROTH, F.X. (1982): Fumaric acid as a feed additive in pig nutrition, Pig News Info., 3: 259.

LIPSTEIN, B. & BORNSTEIN, S. (1974): "Extra caloric" properties of acidulated soybean oil soapstock for broilers during hot weather. J. Poultry Sci., 54: 396-404.

PALLAUF, J.; GOTTERT, W. & KRAMER, K. (1988): Influence of citric acid on the digestibility of nutrients and N-balance in piglets. Deutsche Tierarztliche Wochenschrift, 95(4): 146-150.

PARTRIDGE, G.G.; FINDLAY, M. & FORDYCE, R.A. (1986): Fat supplementation of diets for growing rabbits. Animal Feed Science and Technology, 16(1/2): 109-117.

RADECKI, S.V.; JUHL, M.R.; & MILLER, E.R. (1988): Fumaric and citric acids as feed additives in starter pig diets: effect on performance and nutrient balance. J. Anim. Sci., 66: 2598-2605.

RISLEY, C.R. (1990): Effect of feeding fumaric or citric acid on weanling pig performance and selected intestinal digesta measurements at varying times postweaning. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg.

SCIPIONI, R; ZAGHINI, G. & BIAVATI, A. (1978): Acidified diets in early weaning piglets. Zootec. Nutr. Anim., 4: 201.

SMYTH, P. and GORDON, I. (1967): Seasonal and breed variations in the semen characteristics of rams in Ireland. Ir. Vet. J., 21: 222-233.

SNEDECOR, G.W. & COCHRAN, W.C. (1982): Statistical methods. 6th Edition, The Iowa State University, Press Ames. U.S.A.

SNITINSKI, V.V. (1986): Metabolic and productive effects of animal fat and sodium citrate added to the diet given to pregnant sows. Cited from Nutrition Abstracts and Reviews (Series B) 1989, 59(2): 104.

ZAGHINI, G; LAMBERTINI, L & BONIOLI, A. (1986): Further experiments on the role and efficiency of organic acids in rabbit feeds. Zootecnica e Nutrizione Animale, 12(5): 357-366.