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PRODUCTIVE PERFORMANCE, CARCASS TRAITS AND SOME PHYSIOLOGICAL CHANGES IN RABBITS FED ON ACACIA DESERT PLANTS

By

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CHAPTER 1

INTRODUCTION

Since, Avian influenza disease is widespread emergence in Egypt and worldwide. This disease has become a matter of significant reduction in rooster production and highly price of meat and fish. Urgent action is therefore required to solve the problems, including increasing rabbit's production. Rabbit meat is of high quality and safety. Rabbit is suitable to be raised for meat production due to its high feed conversion efficiency, high fecundity and short generation interval. Moreover, rabbits use protein more efficiently than broiler and up to 20% roughage can be included in their diet. In these circumstances, it is important to use non-traditional feeds in animal feeding have low coast and help to raise the product which decreases the marketing price of animal products. In Egypt, in general and the new reclaimed desert lands, in particular, there is a great shortage in animal feedstuffs particularly during summer season and autumn. Much of the rangelands in arid and semiarid regions are dominated by shrub vegetation that represents an important source of food for ruminants. With shortages of arable land, feed ingredients and water in many countries, rabbits can help in food production by conversion many agricultural byproducts into meat. Generally, there is no need to use prime forages for rabbit feeding, and there is no need to use grains that are fit for human consumption. The list of what ingredients can be incorporated into rabbit feed is enormous and growing continuously. There are large quantities of utilized inexpensive feed resources such as Acacia in the desert and newly reclaimed areas. This acacia is widely distributed in tropical and subtropical Africa from Egypt and Mauritania to South Africa. Some subspecies are widespread in Asia as far east as Burma. *Acacia saligna* is perennial legume shrubs that gives green forages around the year and grows in marshy areas near fresh and salt water on sandy soils. It is used for soil fixation, as a fuel, wood or fence plant and is available throughout the year. Acacia is also a fast growing species, which can maintain active growth during the dry season (Man *et al.*, 1995; Hua and Bee-Lian, 2000). The green biomass yields in three harvests up to 16 months after planting was 20.7 tones / ha (Man *et al.*, 1995). The content of CP in Acacia foliage is relatively high; around 170 g per kg DM, but the intake of Acacia by goats is low compared to other shrubs (Man *et al.*, 1995; Duyen *et al.*, 1996). Forbes *et al. (*1994) reported that acacia contain high concentrations of numerous amines and alkaloids. These compounds are characterized by the fact that they contain nitrogen and are to a greater or lesser extent toxic. It has been used for goat and sheep feeding in different research works. The information in the literature about including *Acacia saligna* in rabbit's nutrition is scant.

The susceptibility of rabbits to various infections diseases and high mortality of young rabbits after weaning, however, hinder the development of the rabbit industry. Weanling rabbits often suffer from diarrhoea, which is the major cause of their mortality. Coliform bacteria (mainly *Esherichia coli*) are normal inhabitants of the intestinal tract of many animal species. In the intestine of health rabbits their counts are low, 10^2 – 10^4 per g intestinal contents. In rabbits with enteritis, however, the concentration of *E. coli* exceeds 10^8 g (Cortez *et al.*, 1992). Digestive problems caused by enteropathogenic *E. coli* strains are often responsible for high morbidity and mortality of young rabbits after weaning, and consequently for important economic losses in rabbit farms (Licois, 2004). Rabbit breeders widely use antibiotics to control enteritis infections. The use of antibiotics, however, is viewed critically in recent times. Some were banned totally; some received no renewal of their license as a measure of preventive consumer protection. There is a pressing need for harmless antimicrobial substances suitable for rabbits nowadays. Organic acids have been used for decades as food and feed preservatives. Some of them (formic, fumaric, citric) positively influence the growth and feed conversion ratio of piglets (Partanen and Mroz, 1999). Several studies report the inhibitory effect of organic acids against *E. coli* –formic and propionic acid (Cherrington *et al.,* 1990), lactic acid (Dibner and Buttin, 2002) and medium-chain fatty acids (Marounek *et al.,* 2003); in the latter studies the authors showed the antimicrobial effect of organic acids toward *E. coli* was pH-dependent. Many researchers reported the effectiveness of formic acid as antimold agent like Tzatzarakis (2000).

The objective of the present work was to study the effect of feeding growing rabbits different levels of *Acacia saligns* leave meal as desert forages without or with supplementation of two types of organic acids, (acetic or propionic acids), on growth performance, carcass traits, digestibility coefficients of nutrients, hematological and blood biochemical characteristics. In addition, organic acids were evaluated as diet preservatives and to determine their effective concentrations as antifungal substances.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Chemical composition of acacia leave meal (ALM):

Variability in nutrients composition among the proximate chemical analysis of (ALM) was reported by Abd El- Galil and Khider (2000). Hassan and Abd El- Aziz (1979); Abou El-Naser *et al.* (1996) and El- Shaer (1984) found that the common forage species grown naturally in the desert varied widely in their chemical and mineral contents and palatability. Most of shrubs contained moderate crude protein and high of ash and fiber constituents but lower amount of soluble carbohydrates. The values of CP%, CF%, EE%, NFE%, and Ash% in (ALM) found by these researchers was nearly similar to those of Abdel Samee *et al.* (1992, 1994), El-Eraky and Mohamed (1996) and Abd El- Galil and Khider (2000) who reported 16.58, 16.48, 16.20 and 17.0% for crude protein, 17.82, 20.73, 21.30 and 20.90% crude fiber; 3.56, 5.36, 5.50 and 5.40% ether extract; 48.47, 44.27, 42.40 and 27.30% NFE; 7.51, 9.34, 9.70 and 9.30% Ash, respectively. They indicated that higher EE and CP contents of (ALM) permit its using as an energy source in rabbit feeds. They also suggested that the crude fiber content of (ALM) is equal to that found in *Luceren* hay which is usually used in rabbit feeding.

Akbar and Gupta (1985) considered leucaena leaf meal is a good source of protein. Veroce (1986) and Craig *et al.* (1991) found that phosphorus deficiencies in the calcium to phosphorus ratio in foliage, besides that potassium, sodium and sulphur were low.

Ghazalah *et al. (*1998) recorded the chemical composition of leucaena leaf meal and found that the DM, CP, EE, CF, NFE and Ash was 90.60, 27.63, 5.61, 16.64, 40.07 and 10.06 respectively.

Sotelo *et al.* (1999) Studies the chemical composition, digestibility and antinutritional factors content of two wild legumes: *Styphonolobium burseroides* and *Acacia bilimekii* collected in a semi-arid zone of Mexico. They reported that both legumes had high fiber content. The seeds of *Styphnolobium burseroides* had low protein content (14%), and the pod a high content of reducing sugars. However the seeds of *Acacia bilimekii* had a high protein concentration (35%). The seed proteins were low in sulphur amino acids and tryptophan in both legumes but were rich in lysine. Trypsin inhibitors and lectins were present in low concentrations; alkaloids and cyanogenic glucosides were not detected.

The chemical composition of ALM showed wide variation due to differences in varieties of date, environmental and climatic conditions and the processing method; crude protein i.e. 15.20%, Dry matter 27.10%, organic matter90.90%, NDF50.30%, ADF 27.70% and ADL 11.90% (Ben Salem *et al.,* 2000).

Dry matter content of berseem hay was higher than that of fresh *Atriplex halimus* and fresh *Acacia saligna* (89.42vs, 27.98 and 37.93, respectively), Fresh *Atriplex halimus* contained higher crude protein than berseem hay and fresh *Acacia saligna* which were comparable (18.17 vs. 13.15 and 13.76%, respectively).However, fresh *Atriplex halimus* contained less crude fiber and nitrogen free extract than berseem hay and fresh Acacia (18.22 vs. 32.2 and 25.5% and 39.28 vs. 41.43 and 49.2% respectively).On the other hand, fresh *Atriplex halimus* contained higher ash than berseem hay and fresh Acacia (21.87 vs. 10.56 and 8.83%, respectively) Ibrahim *et al. (*2000).

Bahatta *et al. (*2005) study the chemical composition of acacia nilotica and found that the DM, OM, CP, NDF, ADF, Cellulose and ADL were 486.3, 884.8, 139.6, 262.8, 126.7, 76.0 and 58.2 respectively.

In 2006, Rubanza *et al.*, reported that native pasture hay (basal diet) had a significantly the lowest (P < 0.05) CP of 25.5 g Kg-1 DM compared to sun- dried *Acacia nilotica*, *Acacia polyacanta* and *Leucaena Leucocephala* leaf meal (159, 195 and 187 g Kg -1DM, respectively).

Higher levels of CP in browse supplements compared to basal diets were consistent with reported higher CP levels CP of *Acacia nilotica* (140- 150 g Kg -1 DM) and *Acacia polyacantha* (180- 190 g Kg-1 DM) (Abdulrazak *et al.*, 2000; Rubanza *et al.*, 2003 and Rubanza *et al.*, 2006).

Cenci *et al* (2006) found that ALM contained considerable amounts of NFE and moderate levels of CP, CF and EE. Moreover, the organic matter (OM) content of Acacia mearnsii grass might give an idea about the nutrients utilization and energy content.

Abd El- Galil and Khider (2000) reported that the Mineral analysis showed higher concentration of K followed by P, Mg, Ca and Na. Among the microelements, Fe was in higher concentration (7.4 mg / 100 g dry weight) followed by Mn, Zn and Cu.

Abd El- Galil (2001) studied the chemical analysis of leucaena leaf meal and found that the values of DM, CP, EE, CF, NFE and Ash were 90.5, 24.46, 6.33, 14.94, 44.71 and 9.34, while that of calcium, sodium, phosphorus, NDF, ADF, and ADL were 2.41, 0.13, 0.18, 36.87, 21.51 and 8.22, respectively.

Additionally, Kamel *et al. (*2005) reported that ALM contained 16.98% crude protein, 2.5% ether extract, 16.8% crude fiber, 4.84% ash and 48.8% Nitrogen free extract (on dry matter basis).

Kekengi *et al*. (2001) and Rubanza *et al* (2005a) reported high levels of CP of *Leucena Leucocephala* leaf meal in the semi- arid areas of Tanzania.

2.2. Nutrient utilization of acacia leave meal (ALM):

Drying *Acacia cyanophylla* foliage under shade or in the sun reduced the condensed tannins (CT) content, but sun drying was more efficient than drying in the shade (Ben Salem *et al.*, 1999). The reason could be that drying probably resulted in a complex formation between tannins and protein and/or oxidation of tannins causing a decrease of extractable CT concentration in Acacia foliage (Goldstein and Swain, 1963).

Many legume trees and shrubs species have been reported as be useful for feeding livestock, (Topps, 1992). These trees and shrubs remain green even during droughts and maintain a relatively high crude protein content throughout the year. The contribution of trees and shrubs to livestock nutrition is important in marginal lands of semi arid and tropical regions, (Devendra, 1989). The foliage of these trees and shrubs may be used as a protein and energy supplement when animal are given low quality roughage during the dry season or when pasture availability is low (Bhattacharya,1989 and Reed *et al.*, 1990).

Abdel- Samee *et al. (*1992) reported that the digestibilities of most nutrients significantly decreased with increasing acacia leaves in the ration of the rabbits.

El-Eraky and Mohamed (1996) indicated that digestibility of crude protein and ether extract were higher in the rabbits fed 15% ALM. However, they decreased in the groups received 30% ALM as compared to control.

El-Gendy (1999) showed that dietary inclusion of acacia leave meal up to 30% in the diet instead of clover hay did not negatively affect nutrient digestibility and nitrogen utilization in growing NZW rabbits.

Abd El- Galil (2000) observed that there were no significant differences to be noticed in digestibility of EE and NEF among the different experimental diets containing 20, 40, 60 and 80% acacia leaves meal. Also DCP and TDN% did not significantly differ among the different experimental group by increasing substitution percentage of acacia leave meal up to 20-30% in the rabbit diets.

In the study of Ramchurn *et al. (*2000), NZW rabbits were fed *ad libitum* on complete rabbit pellets or in a combination of Star grass *ad libitum* along with 50 g/day of mash concentrate as supplement. Results showed that there were no differences ($P > 0.05$) in dry matter and organic matter digestibility. Digestibility of protein was higher for the Star grass diet than for the control ($P < 0.05$) but was lower ($P < 0.05$) for all cell wall components.

Robyn and Anthony (2002) found that the in vitro dry matter digestibility (IVD)) of acacia foliage has been determined for only a small percentage of the Australian species but available data indicated that it is relatively low ranging from 28.9% to 55.0%. This relatively low dry matter digestibility is probably associated with the high lignin content of the cell wall.

Using sheep, Reed *et al. (*1990) reported that animals fed forage from acacias had decreased fiber digestion as a result of the high level of condensed tannins in acacias.

Ibrahium *et al. (*2000) resulted that the apparent digestibility (%) of dry matter (DM), organic matter (OM) and nitrogen free extract (NFE) of the experimental diets fed to the growing lambs were significantly ($P < 0.05$) decreased as a result of changing type of roughage by replacing berseem hay (control diet) with *Atriplex halimus* plus *Acacia saligna* in experimental diets. But crude protein (CP) and crude fiber (CF) digestibilites are not affected.

2.3. Effect of Acacia leave meal (ALM) on Rabbit performance:

2.3.1. Live body weight and body weight gain (BWG):

In an early study, Odonker (1979) found that the average growth rates of rabbits over 8 weeks fed *ad libitum* on 100% complete rabbit pellets, or 80, 60, 40, 20 or 0% complete rabbit pellets plus *Leucaena Leucocephala* (Mauritian *Acacia*) were 29.1, 28.6, 27.1, 25.0, 17.2 and 9.5g/d respectively. They concluded that *Leuaena* may be provided up to 40% of the rations without unduly depress in live weight gain.

Abdel Samee *et al. (*1992) reported that willing green *Acacia* leaves freely *ad libitum* in growing diet can substitute up to 40% of the concentrate without adverse effects on growth. Also, El- Eraky and Mohamed (1996) found that body weight was significantly ($P < 0.05$) increases in rabbits fed on the diet contained 15% *Acacia* leaves as compared to control diet.

Ghazalah *et al. (*1998) cleared that leucaena leaf meal can be used at 15% in rabbit diets up to 9 weeks of age without significant effect on performance.

El- Gendy (1999) found that during 9- 13 weeks of age, live body weight, total body gain and daily body gain were affected insignificantly by the dietary treatment of *acacia* leaves meal (10, 20, 30%). Abd El- Galil and Khider (2000) resulted that using 20% *Acacia* leaves meal (ALM) caused significant increase in body weight and weight gain of growing rabbits, while 10, 30 or 40% of levels did not showed any significant changes compared to the control.

Abd El-Galil (2001) found the final live weight and weight gain values were significantly varied ($P \leq 0.01$) among the different experimental groups. Rabbits fed on *leucaena* leaf meal up to 20% recorded the lowest final live weight and weight gain, while, those fed on control diet recorded the highest one.

Kamel *et al. (*2005) studied the effect of replacement of *Acacia saligna* leave (ACL) by part of rabbit concentrate diet. Four diets were studied (0, 20, 40, 60% of acacia leaves). The results showed that body weight and body weight gain did not significantly differ by feeding 20 and 40% levels of acacia compared to control diet. But the high level of acacia caused a significant ($P \leq 0.05$) decrease in body weight and body weight gain.

2.3.2 Feed intake (FI):

Intake of *Acacia saligna* widely vary, ranging from 20.8 g/kg/day, Reed *et al. (*1990), 32.6 g/kg/day, Dumancic and Le Houerou (1981) and between 2.9 and 13.4 g/kg/ day, Degen (1997). These differences in intakes could be attributed to the variable tannin contents.

El-Eraky and Mohamed *(1996)* found that feed intake increase with the increasing level of acacia level meal in diet. However, El- Gendy (1999) showed that dry matter intake as g per Kg W was significantly ($P < 0.05$) higher in rabbit fed diet 20% acacia leaves meal than in those fed diet (control) and 30% acacia leaves meal.

The results of the study carried out by Abd El- Galil and Khider (2000) suggested that feed intake increased significantly ($P < 0.05$) with the increasing level of acacia leave meal. It is clear that partial substitution of control diets by 40% (ALM) increased feed intake by 27.25% more than that of the control treatment.

Abd El-Galil (2001) found that feed intake increased significantly ($P \leq 0.05$) with increase of leucaena leaf meal by 10.11% more than that of control groups. Also, Kamel *et al.* *(*2005) found that feed intake did not significantly differ by feeding 20 and 40% levels of *Acacia saligna* compared to control group. On the other hand, the high level of acacia (60%) caused a significant ($P < 0.05$) decrease in feed intake.

2.3.3. Feed conversion ratio (FCR) and feed efficiency:

Abd El-Samee *et al.* *(*1992) found that feed conversion ratio did not change by feeding 80 or 60% concentrate plus acacia leave meal as compared to rabbits fed the control diet. But the results obtained by El-Eraky and Mohamed (1996) indicated that feed conversion ratio was improved when rabbits fed diets containing different levels of acacia up to 30% in comparison with control rabbits.

Ghazalah *et al.* *(*1998) found that feed conversion ratio decreased with increasing the level of leuceana leaf meal in the diet when compared to those rabbits fed the control diet free from leuceana leaf meal.

On the other hand, the results presented by El- Gendy (1999) showed that the feed conversion ratio (Kg feed/ Kg gain) values were the best ($P \leq 0.05$) in the rabbits fed the diet containing 30% acacia or the control diet than in those rabbits fed 10 and 20% acacia leave meal.

Abd El- Galil (2000) suggested that rabbits received supplemented diets with 30 - 40% acacia leave meal were to some extent less in feed conversion ratio compared to the other groups which received 0, 60, and 80% of acacia in their diets. The same author (2001) also, showed that substitution of rabbit diet by 20% leuceana leaf meal significantly decreased feed conversion ratio by 19.11% than that of the control group due to increase in feed intake and the reduction of daily body weight gain.

In an experiment conducted by Kamel *et al.* *(*2005), they demonstrated that feed conversion ratio in NZW rabbits fed *Acacia saligna* leave meal up to 40% showed no adverse effects on feed conversion ratio compared to control group. On the other hand, high level (60%) of acacia caused a significant ($P \leq 0.05$) deterioration in feed conversion ratio as compared to the other experimental groups.

2.3.4. Mortality rates (MR):

In the study of Ramchurn *et al. (*2000), twelve, forty-five-days old, New Zealand White rabbits were allocated to two treatments and kept in separate cages. The first treatment (control) was fed *ad libitum* complete rabbit pellets and the second treatment (SG) was fed a combination of Star grass *ad libitum* along with 50 g/day of mash concentrate as supplement. The results find that there were no health problems during the experimental period.

Abd El- Galil (2001) showed that feeding different levels of *leucaena* leaf meal had a highly significant effect on mortality rate among the different treatment groups. It is worthy noting that mortality rate of the group fed control diet and those fed 5% *leucaena* leaf meal recorded the lowest value (5%), while the group fed diet containing 20% *leucaena* leaf meal recorded the highest value (15%).

2.4. Slaughter traits:

Abdel- Samee *et al. (*1992) reported that willing green Acacia leaves freely *ad libitum* in the growing diets up to 40% plus pelleted concentrates did not cause any changes in the dressing percentage, liver, testes and kidney relative weight.

El-Eraky and Mohamed (1996) found that there was no significant difference in slaughter yield of growing rabbits feed diets containing up to 30% acacia leaves in the diets in comparison with control rabbits.

Using *leuceana* leaf meal, Ghazalah *et al. (*1998) revealed no significant effects of *leuceana* leaf meal on carcass characteristics and chemical composition of NZW rabbits meat up to 20% of the diets as compared to the rabbits fed diet free of *leuceana* leaf meal.

El- Gendy (1999) showed that percentages of each of dressing, carcass. giblet and alimentary tract weights were insignificantly affected by feeding rabbits on a diet containing up to 30% acacia leaves meal. This level did not adversely affect dressing, carcass, giblets or alimentary tract percentage.

Abel- Galil and Khider (2000) found that feeding growing rabbits on diets containing up to 40% acacia leave meal (ALM) did not differ statistically in carcass traits among the different feeding groups. Carcass weight and kidney, liver, head, heart, spleen, lung and ceacum relative weight did not differ among the four (20, 40, 60 and 80%) acacia leave meal.

Abd El- Galil (2001) showed that, it is worthy noting that substituting control diet with *leuceana* leaf meal up to 20% did not significantly increase the cecum full of content weight percentage as compared to control. Also, Kamel *et al. (*2005) showed that the carcass weight and kidney, liver, head, heart, spleen, lung and ceacum relative weight did not differ among the four acacia leaves levels (20, 40, 60 and 80%) in comparison with control.

2.5. Blood characteristics:

2.5.1. Hematological parameters:

There were no histological changes and no significant changes in hematological parameters in male or female rats at the top dose tested with young Wistar rats that fed gum Arabic at dietary concentrations of 0% (two control groups), 1, 2, 4, 8 and 20% for 13 weeks (Anderson *et al.*, 1982).

Al- Redhraiman *et al. (*2003) reported that the decrease in Hb, RBCs and PCV of rabbits could indicate anemia evidenced by any significant increase in MCV and significant decrease in MCHC values.

Kamel *et al. (*2005) showed that there were no significant increase in Hb content and RBCs when fed 20% level of acacia in the diet and WBCs also increased when rabbit were fed on low and medium levels of acacia (20 and 40%) compared with control.

In a study carried out by Cenci *et al. (*2006), they indicated that the values of hemoglobin and hematocrit in the serum were within normal levels and no significant differences between the groups of animals fed acacia containing diet and those fed the control diet.

2.5.2. Blood biochemical parameters:

Wadood *et al. (*1989) administered powdered seeds of *Acacia arabica* and roots of *Caralluma edulis* in doses of 2, 3 and 4 gm/kg body-weight to normal and alloxan-diabetic rabbits. The blood glucose levels were estimated before and 2, 4, 6 and 8 hours after the administration of plant suspension. The powdered seeds of *Acacia arabica* exerted a significant (P less than 0.05) hypoglycemic effect in normal rabbits. The hypoglycemic effect was not significant (P greater than 0.01) in alloxan diabetic rabbits. From this study it may be concluded that the powdered seeds of *Acacia arabica* act by initiating the release of insulin from pancreatic beta cells of normal rabbits.

Abdel-Samee *et al. (*1992) found that the activities of AST and ALT did not change among control group (100% concentrate) group 2 (80% concentrate + 20% green acacia), group 3 (60% concentrate+ 40% green acacia) and group 4 (40% concentrate+ 60% green acacia).

El-Eraky and Mohamed (1996) found that no significant changes were found in total protein, albumin, globulin and urea between the treatments growing rabbits fed on 15 and 30% acacia leave meal. However, they reported that NZW rabbits fed acacia leaves up to 30% for 8 weeks showed no significant changes in total protein, albumin, globulin, total lipids, urea and creatinine, while serum GOT and GPT showed non significant change in groups fed 10% acacia leaves.

El Gendy (1999) showed that inclusion of acacia leave meal up to 30% in rabbit diets had no adverse effects on serum total protein, albumin, globulin, total lipids, GOT, GPT, Urea-N and creatinine of rabbits as compared to control rabbits.

Al-Mustafa and Dafallah (2000) investigated the potential toxicity of Acacia nilotica in rats maintained on 2 and 8% acacia diets for 2 and 4 weeks. Their results showed a significant reduction in body weight in all acacia-fed groups and a significant decrease in the levels of hemoglobin; serum total protein and total cholesterol in animals fed 8% acacia diet for up to 4 weeks were observed. These effects were, however, reversed one week after treatment termination.

Al-Redhaiman *et al. (*2003) who fed rats on 10% acacia abyssinica diet or those receiving the plant extracts, the occurrence of hepalonphrotoxicita is supported by the elevated AST,ALT activity and urea concentration and the decreased levels of total protein and albumin.

Kamel *et al. (*2005) suggested that a significant and gradual decrease in plasma total protein, albumin (A), globulin (G), A/G ratio and glucose were observed in rabbit given high level of acacia. Also they observed an increase in plasma urea of group fed on high level of acacia and the percentage of increase was 122.8% compared with the control. While they demonstrated significant and gradual increase in plasma total bilirubin, AST and ALT were observed in rabbits given high level (80%) of acacia.

In a study carried out by Cenci *et al. (*2006) stated that the values of total protein, urea, phosphorus and calcium concentrations in the serum were within normal range and no significant differences between the groups of animals fed acacia containing diet and those fed the control diet.

2.6. The beneficial effect of feed additives:

Minor quantities of specific components (natural or synthetic origin) inclusion in diets are a common practice in the poultry feed industry. These components which are called feed additives can be classified into two categories: The first are essential for the biological function of birds such as vitamins and trace elements. The second category includes additives which are not essential for this function but have demonstrated a positive effect upon birds including growth promoters, antimicrobial agent's technological additives, absorption enhancers, metabolic modifiers, probiotics and prophylactics (Namur *et al.*, 1988).

Since 1967, the use of antibiotics in farm animals as growth promoter has been questioned. More recently, in the late 80's and 90's strong regulatory actions have removed most of the antibiotic growth promoters from the European Union market, and the last one was removed in January 2006. In the same way Egypt Government removed all antibiotic growth promoters from the poultry production in 2006.

The adjustments following the withdrawal of these products in animal production have been difficult at times and many replacement solutions have been proposed, more or less successfully, by the feed additive industry. It is not easy to replace products that have proven to be generally efficacious for the last 50 years.

2.7. The use of organic acids:

Organic acids have been used for decades in feed preservation, protecting feed from microbial and fungal destruction or to increase the preservation effect of fermented feed, e.g. silages. In particular formic acid and propionic acid have been used extensively for this purpose.

Gulam *et al.* (1987) found an obvious anti-mould activity of acetic acids when used against different types of fungi which was indicated by the reduction of total fungal count.

Mike Rankin(2004) reported that the technologies used for preserving hay harvested above optimum moisture levels is to apply organic acids to the hay at harvest time. The use of organic acids has proven to be an effective strategy for preserving baled hay. Because of when hay is baled and put into storage at moderate moisture levels (18 - 30%), a favorable environment exists for the growth of undesirable bacteria, fungi, and yeast. Both moisture and temperature drive the population growth of these microorganisms. Fungi such as *Aspergillus* and *Fusarium* can produce a wide range of toxic metabolites and greatly reduce hay palatability.

In poultry production, organic acids have not gained as much attention as in pig production. One reason for this may be that the results regarding weight gain and feed conversion ratio following dietary addition of organic acids are not as convincing as the results from pig production (Langhout, 2000). However, a positive influence on either feed conversion ratio or growth performance has been reported for fumaric acid, propionic acid, sorbic acid and tartaric acid (Vogt *et al.*, 1981; Vogt *et al.*, 1982).

A very important objective of dietary acidification is the inhibition of intestinal bacteria competing with the host for available nutrients, and a reduction of possibly toxic bacterial metabolites, e.g. ammonia and amines, thus improving weight gain of the host animal. Furthermore, the growth inhibition of potential pathogen bacteria and zoonotic bacteria, e. g. *E. coli* and Salmonella, in the feed and in the gastrointestinal tract are of benefit with respect to animal health. In poultry production organic acids have mainly been used in order to sanities the feed considering problems with salmonella infections (Hinton and Linton, 1988; Iba and Berchieri, 1995; Berchieri and Barrow, 1996; Thompson and Hinton, 1997).

Organic acids (C_1-C_7) are widely distributed in nature as normal constituents of plants or animal tissues. They are also formed through microbial fermentation of carbohydrates mainly in large intestine (Partanen and Mroz, 1991). They are also found in their sodium, potassium or calcium form.

2.7.1. The mode of action of organic acids:

Different aspects of the working mechanism of organic acids with respect to their antibacterial activity are given in the review articles of Cherrington *et al.* (1991) and Russell (1992). The antibacterial activity of organic acids is related to the reduction of pH, as well as their ability to dissociate, which is determined by the pKa-value of the respective acid, and the pH of the surrounding milieu. The antibacterial activity increases with decreasing pH-value. Organic acids are lipid soluble in the un-dissociated form, in which they are able to enter the microbial cell. However, carrier-mediated transport mechanisms seem to be also involved in the membrane transport. Once in the cell, the acid releases the proton in the more alkaline environment, resulting in a decrease of intracellular pH. This influences microbial metabolism inhibiting the action of important microbial enzymes and forces the bacterial cell to use energy to release protons, leading to an intracellular accumulation of acid anions. This accumulation depends on the pH gradient across the membrane. The acid anion seems to be very important regarding the antibacterial effect of organic acids and their salts. Several investigations have shown a strong bactericidal effect of organic acid without significantly decreasing the pH-value in the gastrointestinal tract. Generally lactic acid bacteria are able to grow at relatively low pH, which means that they are more resistant to organic acids than other bacterial species, e. g. *E. coli*. An explanation for this may be that gram-positive bacteria have a high intracellular potassium concentration, which provides a counteraction for the acid anions (Russell and Diez-Gonzalez, 1998). Generally the antimicrobial effect of organic acids increases with increasing concentrations and increasing length of the carbon chain. However, gram-negative bacteria are able to uptake and metabolize long and medium-chained organic acids. Furthermore, vegetative cells are more sensitive to organic acids than the corresponding spore forms.

In 1999, Brul and Coote related the mode of action of organic acids on bacteria to:
1) Undissociated organic acids entering the bacterial cell.
2) Bacteria membrane disruption (leakage, transport mechanisms).
3) Inhibition of essential metabolic reactions (ex. of glucolysis).
4) Stress on intracellular pH homeostasis (normal bacteria pH is ± neutral).
5) Accumulation of toxic anions.
6) Energy stress response to restore homeostasis.
7) Chelating as permeabilizing agent of outer membrane and zinc binding.

The key basic principle on the mode of action of organic acids on bacteria is that non-dissociated (non-ionized) organic acids can penetrate the bacteria cell wall and disrupt the normal physiology of certain types of bacteria that we call "pH sensitive" meaning that they cannot tolerate a wise internal and external pH gradient. Among those bacteria we have *E. coli, Salmonella* spp., *C. perfringens, Listeria monocytogenes, Campylobacter* spp. Upon passive diffusion of organic acids into the bacteria, where the pH is near of above neutrality, the acids will dissociate and lower the bacteria internal pH, leading to situations that will impair or stop the growth of bacteria. On the other hand, the anionic part of the organic acids that cannot escape the bacteria in its dissociated form will accumulate within the bacteria and disrupt many metabolic functions and lead to osmotic pressure increase, incompatible with the survival of the bacteria.

Organic acids exert their antimicrobial action both in the feed and in the gastrointestinal tract of the animal. Following dietary intake organic acids are only recovered from the proximal part of the pig's gastrointestinal tract (stomach and small intestine). This is in agreement with observations that the strongest effect of organic acids with respect to digesta pH and antimicrobial activity are found in the stomach and the small intestine. In poultry, pathogen bacteria e. g. *Salmonella* enters the gastrointestinal tract via the crop. The environment of the crop with respect to microbial composition and pH seems to be very important in relation to the resistance to pathogens. High amounts of lactobacilli and low pH in the crop have shown to decrease the occurrence of Salmonella in the crop (Hinton *et al.*, 2000). Also the antibacterial effect of dietary organic acids in chickens is believed to take mainly place in the upper part of the digestive tract (crop and gizzard). Following addition of a combination of formic and propionic acid (Bio-Add) high concentrations of these acids could only be recovered from crop and gizzard (Thompson and Hinton, 1997). A study on the metabolism of dietary added propionic acid reveals that only little if any dietary propionic acid reaches the lower digestive tract and the caeca (Hume *et al.*, 1993).

2.8. Animal experiments with organic acids:

In order to screen various organic acids for their anti-bacterial effects in gastrointestinal contents and thereby find candidates to replace antibiotic growth promoters in feed for animals, a batch culture system has been established to simulate the major conditions in the stomach and proximal part of the small intestine (Knarreborg *et al.*, 2001, Naughton and Jensen, 2001). The applicability of the *in vitro* method has been tested in typical screening experiments where the concentration of various organic acids has been tested against the growth rate/survival of lactic acid bacteria as well as coliform bacteria and salmonella. The effect of potassium diformate, a salt of formic acid, on the population changes of coliform bacteria and lactic acid bacteria was studied in stomach content at pH 3, 4, and 5 and in content from the proximal part of the small intestine at pH 5, 6 and 7. Furthermore, the antimicrobial effects of six different organic acids (formic, propionic, butyric, lactic, benzoic, and fumaric acid were compared in stomach content at pH 4.5 and in small intestinal content at pH 5.5. Finally, a dose-response experiment involving stomach content at pH 4.5 with added benzoic acid was conducted. In contrast to lactic acid bacteria, coliform bacteria were unable to grow in stomach content at the pH values investigated. A pH-dependent inhibition of bacterial growth was demonstrated both in the content of the stomach and the small intestine. In particular, the growth rate of coliform bacteria was strongly influenced by pH, thus, showing generation times of 70 min and 25 min at pH 5 and 7, respectively. The high growth rate of coliform bacteria demonstrated in content from the small intestine at high pH emphasizes the important impact of the transit time on the colonization of coliform bacteria in the gastrointestinal tract. Addition of potassium diformate reduces the growth rate of coliform bacteria and lactic acid bacteria at all the pH values investigated. The comparative studies of the six organic acids showed that the inhibiting effect of the acids was more pronounced in stomach content than in content from the small intestine, properly due to the lower pH in the stomach content. The killing effect of the organic acids increased in the following way: propionic acid $<$ formic acid $<$ butyric acid $<$ lactic acid $<$ fumaric acid $<$ benzoic acid. Benzoic acid was superior to the other acids tested in exhibiting a bactericidal effect on coliform as well as lactic acid bacteria in both stomach and small intestinal content. As mentioned above, a recent study with piglets fed a diet supplemented with benzoic acid revealed a marked reduction in the density and activity of the gastrointestinal microbiota along with an improved growth performance of the piglets (Maribo *et al.*, 2000). In similar experiments carried out with *Salmonella typhimurium* in stomach content at pH 4, it was found that the killing effect of organic acids increased in the following way: acetic acid < formic acid < propionic acid < lactic acid < sorbic acid < benzoic acid.

Farran *et al* (2001) reported that TMEn and apparent amino acids availability of some feedstuffs increased as a result of soaking in 1% acetic acid. They concluded that soaking the seeds of some feedstuffs in acetic acid at room temperature and at 40° C improved their nutritional value.

Bolduan *et al.* (1988), Sweet *et al.* (1990) and Mathew *et al.* (1991) reported improved growth rates when weaning piglets diets were supplemented with propionic acid (from 0 .1 to 1%). In contrast, Giesting and Easter (1985) and Thacker *et al.* (1992) reported that the addition of 2 or 2.5% of propionate had no beneficial effect on the growth or feed conversion of weaning pigs; Giesting and Easter (1985) also found depressed feed intake possibly due to the pungent aroma of propionic acid.

The use of organic acid can reduce *E. coli* colonization in the gut of piglets (Bolduan *et al.*, 1988; Mathew *et al.*, 1991 ; Eckel *et al.*, 1992; Gedek *et al.*, 1992b, lsobe *et al.*, 1994) as well as the incidence of diarrhoea (Eidelsburger *et al.*, 1992b); other works have not pointed to any effects on enteric disorders or on a reduction in the number of intestinal coliform bacteria (Sutton *et al.*, 1991 ; Mathew *et al.* (1991).

Sutton *et al.* (1991) studied the effect of adding 0.25% Luprosil-NC or 0.3% sodium propionate on short chain fatty acids (SCFA) concentration and lactobacilli and *E. coli* counts in digesta from the stomach, duodenum, caecum and colon in 8 weeks-old piglets. Addition of the organic acid did not significantly affect any of the parameters measured. There was a tendency to lower acetic acid and total volatile fatty acids in the colon of animals fed with Luprosil-NC.

Mathew *et al.* (1991) added 0.25, 0.5 or 1% Luprosil-NC to a control diet, and measured pH, numbers of *E. coli* and lactobacilli in stomach, duodenum, caecum and colon in 8 and 12 weeks-old piglets. No effect of addition of the propionic acid-containing product was observed in 8 weeks-old piglets. Twelve weeks-old piglets fed Luprosil-NC showed higher lactobacilli counts in the duodenum than those fed the control diet. The number of lactobacilli in the stomach was only increased in pigs fed 0.25% Luprosil as compared to the control group. Moreover, the authors measured a lower density of *E. coli* in the proximal ileum of 4 to 6 weeks-old ileal cannulated wieners fed with 1% Luprosil-NC, whereas no effect of the product on pH or lactobacilli counts was detected.

As reported by Ravindran and Kornegay (1993), citrate supplementation to the weaning piglet diets modified the daily gain and feed conversion efficiency from 11.3 to 14.3% and from 6 to 11.1%, respectively, as compared to control. The best responses were usually obtained during the first 3 weeks of age probably because of insufficient gastric production of HCI and with level of acid supplementation higher 30 g / kg of feed. Generally, improvements in feed efficiency tended to be more consistent than body weight gain improvements.

Gabert (1994) fed diets containing 1.5 or 3% fumaric acid or 1.5% Na-fumarate to ileal canulated weaners. There was no effect of diet on the pH of the ileal digesta. However, there was a tendency to a higher concentration of total SCFA in the animals fed the experimental diets as compared to animals fed the control diet. Using the same product at a dose of 1.2%, Overland *et al.* (2000) observed a decreasing effect of the acid on the number of coliform bacteria in the duodenum, jejunum and rectum of growing finishing pigs. On the other hand, Formi (0.9 and 1.8%) lowered the pH of duodenal digest in piglets up to 65 hours post-feeding (Mroz *et al.*, 2001). Fevrier *et al.* (2001) fed piglets diets supplemented with 0.9 or 1.8% Formi and observed a reduction of pH, number of coliforms and streptococci in the stomach, and a reduction of coliforms in the colon. No effect on lactobacilli in any segment of the gastrointestinal tract was detected. The authors observed that Formi has been found to have growth promoting properties.

Experiments with pigs have shown that several organic acids, including citric acid, fumaric acid, formic acid, and propionic acid have a positive influence on growth performance (Partanen and Mroz, 1999). It has been reported that the nutritive effect of organic acids is most pronounced in weanling pigs (Gabert and Sauer, 1994; Roth and Kirchgessner, 1998), which often suffer from digestive disturbances resulting in diarrhea related to infections with *E. coli*. Problems at weaning are triggered by a number of factors. An insufficient production of hydrochloric acid and digestive enzymes, and the feeding of a pre-starter diet with high protein content and a high acid binding capacity (Eidelsburger, 1997) have been made responsible for problems at weaning. Dietary acidification increases gastric proteolysis and protein and amino acid digestibility. The acid anion has been shown to complex with Ca, P, Mg and Zn, which results in an improved digestibility of these minerals. Furthermore, organic acids serve as substrates in the intermediary metabolism (Kirchgessner and Roth, 1988).

Using rabbits, Scainello *et al* (1998) reported a linear reduction in daily feed intake and a quadratic effect on feed gain ratio with increasing acetic acid levels (0, 0.5, 1.0 or 2.0%) in growing New Zealand White rabbit's diet.

Caprylic acid (C8:0) is a compound present in the rabbit milk, active against a variety of microorganisms. Skrivanova and Marounek (2002) evaluated the effect of caprylic acid on growth and mortality of young rabbits. Caprylic acid was added to a granulated feed at 0, 2 and 5 g/kg. Two feeding trials on different farms were carried out using weaned Hyla 2000 and Hyplus rabbits, 5 weeks old at the start of the experiment. The results indicated that caprylic acid had no significant effect on total weight gains in either trial. No adverse effect of caprylic acid on feed intake was observed. The mortality of rabbits fed diets with caprylic acid at 0 and 5 g/kg was 16.7 and 0% ($P < 0.05$), and 9.3 and 2.0% in the 1st and the 2nd trial, respectively. It can be concluded that caprylic acid is capable to decrease mortality of young rabbits. Its use seems to be more effective on farms where rabbit mortality is high.

Abecia *et al.* (2005) reported that the inclusion of two doses of fumaric acid [5 and 10 g per kg; low fumaric acid and high fumaric acid] in a diet for growing rabbits was compared with a subtherapeutic dose of zinc bacitracin (25 ppm) and a control in terms of apparent nutrient digestibility and caecal environmental parameters. The results showed that there were no differences between the average fumaric diets and control and zinc bacitracin diets on total tract apparent digestibility of dry matter and organic matter, but a positive response to the dose of the acidifier was observed (P = 0.05 and 0.07). However, the digestibility of neutral detergent fiber was not affected by treatments ($P > 0.10$). There was a trend ($P = 0.09$) for a higher microbial nitrogen intake as caecotrophes in diets including fumaric acid. This effect increased when the fumaric acid dose was doubled. Although no differences among treatments were detected in total caecal bacterial counts, amylolytic bacterial concentration tended to be higher with fumaric diets than with zinc bacitracin diet ($P = 0.08$).

Radwan and Abdel-Khalek (2007) studied the response of summer stressed growing rabbits to some organic acids. Their results showed that acidification of diets with organic acids improved productive performance of growing rabbits.

Results concerning the inclusion of organic acids in broiler rations are very limited. The addition of 2% citric acid resulted in an increase of coliform bacteria in the small intestine (Vogt *et al.*, 1981).

The results presented by Falkowski and Aherne (1984) and Izat *et al.* (1990) showed that inclusion of organic acids into chicken diets altered the populations of intestinal microflora and reduced the total number of coliforms bacteria and microbial total count.

Using male broiler chicks fed to 21 days of age, Patten and Waldroup (1988) added fumaric acid at 0, .5, 1.0 and 1.5% and calcium format was added at 0, .72, 1.48, 2.20, and 2.89%. All combinations of fumaric acid and calcium format were evaluated in a 4 x 5 factorial arrangement of treatments. Their results indicated that addition of .5 or 1.0% fumaric acid significantly ($P \leq 0.05$) improved body weights of broilers but did not influence feed utilization.

In poultry formic acid alone or a combination of formic acid with propionic acid (Bio-Add™, 68% formic acid and 20% propionic acid) at concentrations of 0.6% were effective with respect to the prevention of infection with *Salmonella kedougou* (Hinton and Linton, 1988) and *Salmonella gallinarum* (Berchieri and Barrow, 1996).

Schulenberg *et al.* (1996) revealed that organic acids have antimicrobial, disinfecting and hygienic uses in animal feed industry. They found that Mycostat at 0.5 kg/t had the same activity as liquid propionic acid (98%) at 2 kg/ton. It was shown that a diet containing vinegar at a dietary concentration of 1.6 ml vinegar/100 g diet, for example, enhances the intestinal absorption of calcium (Kishi *et al.*, 1999).

Conkova and Para (1997) indicated that body weight gain of broiler chicks given a feed mixture containing organic acid (propionic acid at 0.5ml/kg was 5.9% greater than that of the control.

Bio-Add were reported to reduce the concentrations of lactic acid in the crop of laying hens, indicating a growth inhibition of lactic acid bacteria at this location. *In vitro* experiments with hens´ crop contents, where dietary addition of Bio-Add was simulated, showed a bactericidal effect for *Salmonella enteritidis* (Thompson and Hinton, 1997*).* In an experiment with broiler chickens infected with *Salmonella typhimurium*, the addition of 0.36% calcium formate and 0.25% formic acid significantly reduced levels of Salmonella on prechill carcasses. In caecal contents the number of Salmonella was reduced following addition of either 0.36% calcium formate or 0.5% formic acid (Izat *et al.*, 1990). However, Waldroup *et al.* (1995) found a reduction of ceacal pH in relation to an addition of a formic acid/propionic acid blend in concentrations of 1%. However, the authors found that the formic acid/propionic acid blend did not offer a reliable protection regarding the caecal colonisation with *Salmonella typhimurium* following oral challenge. The same authors also studied the use of citric acid at dietary concentrations up to 1% in relation to the caecal colonization with *Salmonella typhimurium* and carcass contamination following oral challenge. The number of birds colonized with *Salmonella typhimurium* was actually increased following supplementation with citric acid as compared to control, which indicates that citric acid may not be reliable with respect to the prevention of Salmonella colonization of the caeca. The same authors also, reported that increasing amounts of fumaric acid (0.5, 1,0 and 2.0%) did not offer protection from caecal *Salmonella* colonization or carcass contamination following oral challenge with *Salmonella typhimurium* in broiler chickens. In another experiment with broiler chickens, increasing amounts of dietary lactic acid (0.25, 0,5, 1,0 and 2.0%) did not offer protection from caecal Salmonella colonization or carcass contamination following oral challenge with *Salmonella typhimurium.*

Ozturk *et al. (*2006) reported that addition of humic acid in 30 ppm levels to drinking water of the broilers seems to improve feed efficiency as compared to control group, but live weight gain decreased at the level of 45 ppm humic acid preparation addition. Livability increased by adding humic acid.

Hassan *et al. (*2008) reported that reported that using 2, 4 and 6% acetic acid gave higher body weight and lower feed intake as compared with birds fed the control diet without supplementation.

CHAPTER 3

MATERIALS AND METHODS

The present study was carried out at Borg El-Arab Poultry Research Station belonging to Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture during the period from November 2006 to February 2007. The analytical part of this study was performed at the laboratories of Animal and Fish production Department, Faculty of Agriculture (Saba Basha), Alexandria University.

3.1. Acacia leave meal (ALM) evaluation:

Acacia leave meal were collected from a local variety (*Acacia saligna*) cultivated in Borg El- Arab research Station, North- Western desert of Egypt. After collection, the leaves were dried in the oven dried (60ºC) for 24 hours and then ground to be suitable diet formulation.

3.1.1. Proximate analysis:

Proximate analyses of ALM and the experimental diets were determined according to the methods of Association of Official Analytical Chemists (A. O. A. C., 1994).

Moisture content: by drying in an air oven at 105ºC for 6 hours.
Ash content: by dry-ashing in muffle furnace at 600 ºC for two hours.
Crude protein: by Micro-Kjieldahl method.
Crude fiber: by boiling with 1.25% H_2SO_4 (1.25%) followed by NaOH solution (1.25%) for each concentration according to the specified procedures.
Ether extract: By Soxhelt apparatus for 16 hours using diethyl ether as solvent.

3.2. Feeding experimental design:

A 3 x 5 factorial arrangement was conducted. Acacia leave meal (ALM) was included at levels of 16.5 and 33% to replace 50 and 100%, respectively, of the clover hay in control diet (free of ALM). Some modifications in the composition of the latter two diets were done to make the three experimental diets isonitrogenous and isoenergetic containing approximately 16% CP and 2500 Kcal/Kg DE (Table 1). Each one of these three experimental diets was supplemented or not with acetic or propionic acids at two levels of supplementation (0.025 and 0.05%). Pellets of the experimental diets were made as follow, pelleting was initiated by molasses addition as binding material and all diet ingredients were pressed at 70Cº, pellets were cooled, and supplemented with the diluted organic acids (acetic or propionic) by automatic atomizers.

Table 1: Composition and chemical analyses of the experimental diets (as fed).

Ingredients%	Acacia leave meal in the diet%		
	0	16.5	33
Clover hay	33.00	16.50	-----
Acacia leave meal (ALM)	----	16.50	33.00
Yellow corn	18.90	14.80	10.70
Wheat bran	11.00	9.75	8.50
Barley grain	17.30	17.15	17.00
Soybean meal (44%)	15.00	15.00	15.00
Wheat straw	-----	5.50	11.00
Molasses	3.00	3.00	3.00
Limestone	1.00	1.00	1.00
Salt	0.30	0.30	0.30
Dl- Methionine	0.10	0.10	0.10
L-Lysine	0.10	0.10	0.10
Vit, and min. mix.[1]	0.30	0.30	0.30
Total	100	100	100
Price (Egyptian LE / ton)**	1750	1500	1250
Chemical analysis			
Dry Matter	89.99	90.01	90.85
Organic Matter	82.36	82.31	82.82
Crude Protein	16.62	16.60	16.45
Ether Extract	3.27	3.30	3.51
Crude Fiber	13.45	13.61	13.70
Nitrogen Free Extract	48.52	49.25	49.07
Ash	7.58	7.70	8.02
DE (Kcal / Kg)*	2506	2501	2498

Each kilogram of Vit+Min mixture contained: vitamin A, 12000 IU; vitamin E, 20 IU; menadione , 1.3 mg; Vit. D_3, 2500 ICU; riboflavin, 5.5 mg; Ca pantothenate, 12 mg; nicotinic acid, 50 mg; choline chloride, 600 mg; vitamin B_{12}, 10 µg; vitamin B_6, 3 mg; thiamine, 3 mg; folic acid, 1.0 mg; d-biotin, 50 µg. Trace mineral (milligrams per kilogram of diet): Mn, 80; Zn, 60; Fe, 35; Cu, 8; Se, 0.60. [2]Calculated values (NRC, 1994).
* DE (Kcal / Kg) was calculated according to Cheeke (1987).
** Local price in Egypt in 2006- 2007.

3.3. Management and animal feeding:

A total number of 135 male growing (NZW) rabbits at 5 weeks of age and averaged 570 g body weight were used in this study. Animals were distributed into 15 experimental groups of 9 rabbits each and were fed randomly on the fifteen experimental diets. Each group has three replicates,(3 rabbits each). Rabbits were housed in galvanized batteries (60×40×24 cm) provided with feeders and automatic drinkers.

The experimental rabbits were kept under the same managerial and hygienic conditions. Rabbits were housed in well ventilated block building (three per cage in the fattening trials and individually during the digestibility trial). The batteries were arranged in rows in a windowed house naturally ventilated and the fresh air circulated in the house using exhaust fans. The rabbits were kept with a cycle of 16 h light and 8 h dark using artificial light sources. No heating was applied in the rearing pen. Fresh water was automatically available at all time by stainless steel nipples for each cage. The experimental diets were offered to rabbits *ad libitum* in pelleted form from 5 to 13 weeks of age. Pellets were offered twice daily at 8 am and 4 pm.

3.4. Digestion trials:

At 13 weeks of age, forty-five rabbits were randomly taken after the termination of fattening trial. Rabbits within each treatment were randomly housed individually in metabolic cages (three rabbits from each treatment) that allowed separation of feces and urine. A preliminary period of 7 days was followed by five days for measurements of actual consumed feed, feces and urine output collection. The animals were fed twice daily at 8 a.m. and 4 p.m. Water was available all time. Feces and urine were collected quantitatively once a day before the morning meal at 8 a.m. Samples of daily feces (20%) of each rabbit were stored at -10^0C. The seven days combined collection fecal samples were kept for routine analysis. Fecal samples were oven dried at 60^0C for 48 h (partial drying) then ground through a 1 mm screen on a wiley mill grinder. Samples were composite per treatment per animal for analysis. Digestibility was determined and expressed as a dry matter basis from feed and fecal sample content of dry matter.

Representative samples of feed offered and feces of each rabbit were chemically analyzed for determinations of (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash which were carried out according to **A.O.A.C. (1994)** methods. Nitrogen free extract (NFE) was determined by difference.

Apparent digestibility coefficient (ADC) was calculated as follows:

$$\text{ACD} = \frac{\text{total nutrient in take} - \text{total nutrient in feces}}{\text{total inutrient in take}} \text{ x } 100$$

Total digestible nutrient (TDN) was calculated according to the classic formula of **Cheeke *et al. (*1987)** as follows:

TDN%= DCP% +DCF% +DNFE% + (DEE% x 2.25)

Where:

DCP = digestible crude protein.

DCF= digestible crude fiber.

DNFE= digestible nitrogen free extract.

DEE= digestible ether extract.

Digestible energy (DE) of the experimental diets was calculated according to the equation described by Cheeke *et al. (*1987) as follows:

DE (Kcal) = 4.36 – 0.0491 x NDF%
NDF% = 28.924 + 0.657 x CF%

The metabolizable energy (ME kcal/kg feed DM) values of the offered diets were calculated according to the equation described by Forbs (1985) as follows:
ME (Kcal) = TDN x 41.85

3.5. Studied traits:

3.5.1. Average body weight:

Rabbits in the treatment groups were individually weighed biweekly in the morning before offering feed. Individual live weights of every treatment were totaled and divided by the number of rabbits to obtain the average live body weight.

3.5.2. Average weight gain:

The average live body weight gain was calculated by subtracting the average initial live weight of a certain period from the average final weight of the same period.

3.5.3. Feed consumption:

The feed consumption was calculated biweekly by subtracting the unconsumed feed from the total amount offered during this period and recorded as g/rabbit/period taken into account number of dead rabbits if any.

3.5.4. Feed conversion ratio (FCR):

FCR was estimated as units of kilograms of feed consumed to produce one kilogram body weight during a certain period.

3.5.3. Number of dead rabbits:

It was recorded in the day it occurred from the initial time of the experiment up to the termination of the experiment

3.7. Carcass traits:

After the termination of the experiment, three rabbits at 13 weeks of age from each experimental group were randomly chosen for slaughter test. Rabbits were kept off feed for 12 hours before slaughter, and then they were weighed individually as pre-slaughter weight. Rabbits were slaughtered by cutting the jugular veins. After complete bleeding, they were weighed, skinned and eviscerated. Carcass, liver, fur, kidney fat, kidneys and heart were immediately weighed. Dressed weight was calculated as a total weight of carcass plus head. All traits were calculated as percentage of the pre-slaughter weight. Hot carcass weight was obtained 15 to 30 minutes after slaughter after chilling of the carcass for 2 hours in a refrigerator at 5^oC the carcass was weighed to obtain cooled carcass weight.

3.8. Blood parameters:

3.8.1. Biochemical analysis:

During slaughtering of rabbits, individual blood samples were collected into beaker from each rabbit within each treatment and divided into two samples and were placed immediately on ice. Heparin was used as an anticoagulant. Plasma samples were obtained by centrifugation at 3,000 rpm for 20 min and were stored at –20^{o}C until being used for analysis.

Stored plasma samples were analyzed for total protein (TP), Albumin (A), urea-N, blood glucose level, that were determined in plasma calorimetrically using commercial kits (DIAMOND DIAGNOSTICS, Egypt) according to the procedure outlined by the manufacturer. Globulin concentration was calculated by subtracting the values of albumin from those of total proteins. Also. A/G ratio was calculated. Total bilirubin was measured using the methods of Walters and Gerade (1970), the activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were assayed by the method of reitman and Frankel (1957).

3.8.2. Blood hematology:

A part of blood samples which were collected during slaughtering of rabbits were used to determine the following hematology traits:

3.8.2.1. Red blood cells (RBCs)

RBCs were counted on Neubaueran line hemocytometer using light microscope at 40×10 magnification after diluting blood samples to 200 times with a diluting fluid (10% sodium sulphate, 2% sodium chloride and mercuric chloride 1% solution) before counting.

3.8.2.2. White blood cells (WBCs)

WBCs were counted on Neubaueran line hemocytometer using light microscope at 10×10 magnification after diluting blood samples to 20 times with a diluting fluid (1.5% glacial acetic acid solution and few crystals of gentian violet) before counting.

3.8.2.3. Hemoglobin (Hb):

Hb was determined by commercial kits (DIAMOND DIAGNOSTICS, Egypt).

3.8.2.4. Packed cell volume (PCV%):

Whole blood samples were used to determine (PCV%) by using Micro-AID® Heparised microhematocrit tubes and microhematocrit-centrifuge which centrifuged for 5 min at 4000 rpm.

3.8.2.5. Calculation of MCV, MCH and MCHC:

The following parameters were calculated:

Mean cell volume (**MCV**) = (PCV×10)/RBC× 100

Mean cell hemoglobin (**MCH**) = (Hb × 10)/RBC × 100

Mean cell hemoglobin concentration (**MCHC**) = (Hb× 100)/PCV (%)

3.9. Effectiveness of acetic and propionic acids as antifungal preservatives:

3.9.1. Preparation of different concentrations of examined organic acids:

Different concentrations of examined organic acid were prepared of acetic acid and propionic acid. The concentrations used were 100% and added at 0.025 0.05 for each.

3.9.2. Determination and adjustment of the moisture content of the feed before inoculation:

Moisture content of the feed sample was estimated according to (A.O.A.C 1998) then the moisture content was adjusted to be 18% according to the following equation:

$$S = \frac{\text{Required moisture content} - \text{Initial moisture content}}{100 - \text{Required moisture content}} \times 100$$

Where S = the value of water required for 100 gm of sample to reach the required level of moisture content.

3.9.3. Experimental design:

100 gm of each diet 18% moisture content was used for each of both acetic and propionic acids concentrations. This amount was placed in sterile Erlenmeyer flask. The prepared previously mentioned concentrations of organic acids included in this study were added to the diet with different inclusion rates (0.025 and 0.05% for both acetic and proionic acids). Three flasks were left without inoculation as control, one for each basal diet (0, 16.6% and 33% ALM). Ten grams were withdrawn from each flask just after inoculation with the acids(zero time), after 7 days, after 14 days and then after 21 days to estimate the changes in the fungal content.

3.9.4. The total fungal count:

The total fungal count was performed as follows: Ten grams of each sample were added to a 90 ml sterile saline solution in 500 ml Erlenmeyer flasks and homogenized thoroughly on an electric shaker at a constant speed. Tenfold serial dilutions were then prepared. One ml portion of three suitable dilutions of the resulting sample suspension were used to inoculate Petri dishes each containing 15 ml Sabaroud Dextrose Agar containing 0.5 mg Chloramphenicol/ml medium to inhibit bacterial growth. Plates were then incubated for 7 days at 28ºC and the grown fungal colonies were counted (Aziz *et al.*, 1998).

3.9.5. Criteria of acceptance:

The criteria of evaluation of antifungal activity are estimated according to British pharmacopoeia (2001) in terms of the log reduction in the number of viable microorganisms against the value obtained for the fungal count at zero time.

3.10. Statistical analysis:

Data of each growing and digestion experiment were analyzed using two-way ANOVA of GLM procedure of SAS® (SAS Institute, 1985). However, data for the total fungal count were analyzed using one way ANOVA of GLM procedure of SAS® (SAS Institute, 1985). Significant differences between means were detected using Duncan multiple range test (Duncan, 1955).

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Chemical Composition of acacia leave meal (ALM) and clover hay meal (CHM):

Acacia leave meal (ALM) and clover hay meals (CHM) that were used in this study were analyzed for their nutrients contents (Table 2). The mean values of chemical composition of ALM are as follows: crude protein 16.63%, ether extract 5.16%, ash 8.67%, nitrogen free-extract (NFE) 51.73% and crude fiber 17.81% of which 44.79% was NDF and 23.83% was ADF, indicating that ALM containing 20.96% hemicelluloses.

It is shown from the chemical analysis that the ALM has reasonable amount of protein, but it showed higher value of protein percentage and ether extract than that for CHM by 1.9 and 97.7%, respectively, however, it was lower in crude fiber by 4.2%. ALM nitrogen free extract (NFE) was about 110.0% fold of CHM content. The value recorded for protein in ALM was less by about 2.2% than the value recorded by Abd El-Galil and Khider (2000). In general, the composition of ALM presented herein was in agreement (more or less) with those reported by Abdel Samee *et al. (*1992) and El-Eraky and Mohamed (1996). However, the results of Abd El-Hafez *et al. (*2000) showed less amount of crude protein, ether extract and NFE. The vegetation period of plant and drying methods under shade or in the sun and other environmental factors involved a long together with handling and storage conditions may affect on chemical compositions.

Table 2. Chemical composition of ALM and clover CHM*.

Nutrients%	ALM %	CHM %
Organic matter	91.33	91.19
Crude protein	16.63	16.32
Ether extract	5.16	2.61
Crude fiber	17.81	18.60
Crude ash	8.67	8.81
Nitrogen free extract	51.73	53.66
DE Kcal / Kg**	2366	2340
Nutrient detergent fiber (NDF) **	44.79	41.10
Acid detergent fiber (ADF)	23.83	26.05

*On dry matter basis
**Calculated on the basis of Cheeke (1987) as follows,
NDF% = 28.92 + 0.657 x CF%
DE, Kcal/ g = 4.36 – 0.0491 x NDF%

4.2. Performance of growing New Zealand White rabbits as affected by different levels of ALM and organic acids supplementation and their interactions.

4.2.1. Performance of growing rabbits:

4.2.1.1. Live body weight:

The effect of feeding different levels of acacia leave meal (ALM), type of organic acids and their interactions on live body weight of New Zealand White (NZW) rabbits are presented in Table 3 and Figs. 1 and 2.

Initial body weight of NZW rabbits ranged from 522.9 to 542.2 g with no significant differences among treatments, which means a random distribution of the rabbits on the different treatments.

Irrespective of organic acid supplementation, the results showed that the incorporation of ALM in rabbit diets at the levels of 16.5 or 33% resulted in significant ($P \leq 0.0001$) differences in live body weight at 7, 9, 11 and 13 weeks of age. It was observed that feeding rabbits both diets containing 16.5 or 33% ALM resulted in reducing live body weight after two weeks from the beginning of experiment. The decrease in growth of rabbits reached to 4.8 and 7.7% at 7 weeks; 4.0 and 7.4% at 9 weeks; 5.0 and 2.0% at 13 weeks of age, respectively. However, at 11 weeks of age the group of rabbits fed 33% ALM in their diet had slight increase in live body weight as compared to control group and significantly surpassed the group fed 16.5% ALM by 5.1%. The decrease in live body weight may be attributed to either the significant decrease in feed intake and crude protein digestibility or the decrease in some blood metabolites such as, total protein, albumin and glucose when rabbits fed high level of ALM. These results were in accordance with those reported by Abd El-Galil *et al. (*2001) who found that rabbits fed on *leucaena* leaf meal up to 20% recorded the lowest final live weight, while those fed on control diet recorded the highest one. Also, El-Eraky and Mohamed (1996) found that the daily gain of rabbits decreased by the increasing of ALM in their diets. Using goats and sheep, Degen *et al. (*1997) reported that intake of *Acacia saligna* and *Acacia salicina* as sole fodder particular young trees were low, and both goats and sheep lost body mass and were in negative N- balance. Forbes *et al. (*1994) reported that acacia contain high concentrations of numerous amines and alkaloids. These compounds are characterized by the fact that they contain nitrogen and are to a greater or lesser extent toxic.

The improvement in body weight due to feeding rabbits diet containing 33% ALM at 11 weeks of age indicated that rabbit's tolerance to ALM was improved with increasing age of rabbits. These results are similar to those reported by Wyatt and Goodman (1993), Jeroch and Dänicke (1995), Radwan *et al.* (1997), Van Soest, (1997), Attia and Abd El-Rahman (2001) and El-Deek *et al.* (2003a). They attributed this to the maturity of the digestive tract (gut capacity, microflora, and enzymatic secretion) which could improve feed utilization over time. Also, Digestive disorders are frequently observed in rabbit breeding around weaning (21–42 days of age). These disorders are supposed to be due to an incomplete maturation of the digestive processes (either from caecal flora or from host) at the time of weaning (Gidenne 1997).

Table 3. Live body weights of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Body weight (g) wks			
	5	7	9	11	13
Main effect of (ALM) level:					
0.0	534.8	833.0^{a}	1203.5^{a}	1552.0^{a}	1908.9^{a}
16.5 %	535.8	793.2^{b}	1154.8^{b}	1481.7^{b}	1821.1^{c}
33.0 %	532.9	768.6^{c}	1113.9^{c}	1557.0^{a}	1871.5^{b}
SEM	2.940	3.81	5.625	5.752	6.415
P value	NS	0.0001	0.0001	0.0001	0.0001
Main effect of organic acid supplements					
Control	535.8	812.2^{a}	1168.0^{b}	1534.4^{b}	1830.3^{c}
Acetic acid, 0.025%	533.4	822.5^{a}	1233.7^{a}	1600.9^{a}	1925.7^{a}
0.05%	530.1	822.9^{a}	1139.8^{c}	1469.3^{c}	1795.7^{d}
Propionic acid, 0.025%	537.0	772.9^{b}	1110.5^{d}	1535.1^{b}	1888.4^{b}
0.05%	536.2	764.2^{b}	1140.9^{c}	1513.5^{b}	1899.2^{b}
SEM	3.801	4.926	7.258	7.421	8.277
P value	NS	0.0001	0.0001	0.0001	0.0001
Interaction effect					
Acacia Organic acids					
0 0.0	538.1	892.8^{a}	1288.0^{b}	1686^{b}	1994.6^{b}
Acetic acid, 0.025%	530.4	793.9^{de}	1153.7^{e}	1534.8^{d}	1915.7^{d}
0.05%	533.0	884.6^{a}	1162.4^{e}	1439.2^{f}	1732.4^{gh}
Propionic acid, 0.025%	532.1	769.9^{ef}	1164.3^{e}	1539.2^{cd}	1982.2^{b}
0.05%	540.4	823.8^{c}	1249.1^{c}	1560.6^{d}	1919.6^{cd}
16.5% 0.0	535.8	785.0^{e}	1103.0^{f}	1432.9^{f}	1758.6^{g}
Acetic acid, 0.025%	534.6	864.6^{b}	1331.6^{a}	1748.0^{a}	2047.8^{a}
0.05%	534.4	798.1^{de}	1088.7^{f}	1401.4^{g}	1738.4^{gh}
Propionic acid, 0.025%	542.2	760.9^{f}	1103.0^{f}	1374.4^{g}	1716.9^{h}
0.05%	531.7	759.1^{f}	1141.9^{f}	1446.3^{ef}	1836.9^{e}
33% 0.0	533.7	755.9^{f}	1105.8^{d}	1472.9^{e}	1729.8^{gh}
Acetic acid, 0.025%	535.1	807.3^{cd}	1213.5^{e}	1509.6^{d}	1799.6^{f}
0.05%	522.9	785.9^{e}	1168.2^{e}	1567.3^{c}	1916.1^{cd}
Propionic acid, 0.025%	536.5	787.8^{de}	1064.1^{g}	1691.6^{b}	1966.1^{bc}
0.05%	536.3	702.9^{g}	1018.1^{h}	1536.0^{d}	1946.4^{cd}
SEM	6.589	8.538	12.581	12.864	14.35
P value	NS	0.0001	0.0001	0.0001	0.0001

[a-h] Means within a column not sharing similar superscripts are significantly different ($P \leq 0.05$). NS ($P > 0.05$).

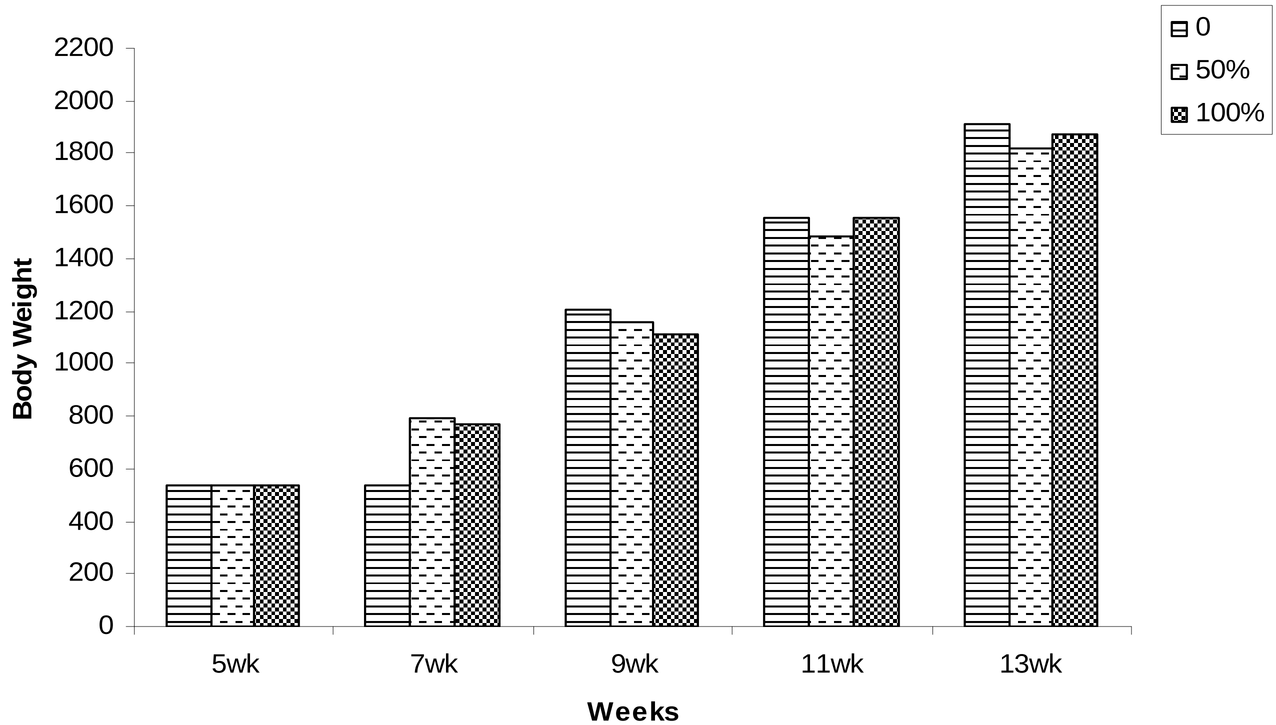

Fig 1. Live body weight of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*.0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hev

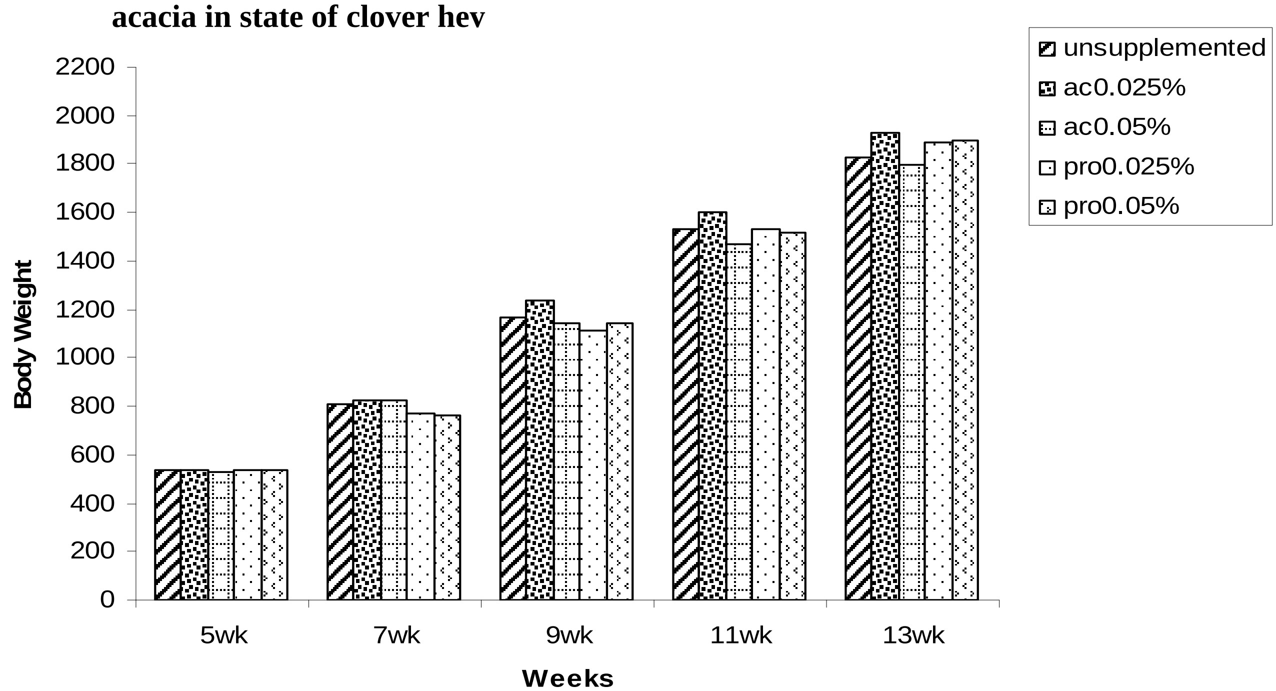

Fig 2. Live body weight of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids .ac= acetic acid%, pro=propionic acid%

When the effect of ALM was over looked, the results indicated that live body weight was affected significantly ($P \leq 0.0001$) by type of organic acids at all studied ages. After two weeks from the beginning of experiment, rabbits fed diets containing 0.025 and 0.05% acetic acid (AC) slightly recorded higher live body weight than those fed control diet, without significant differences between them. However, the groups of rabbits fed diet containing propionic acid recorded the lowest values of body weight as compared to the other experimental groups. Thereafter, the group of rabbits received 0.025% acetic acid in their diet recorded the best live body weight at 9, 11 and 13 weeks of age in comparison with the other experimental groups. This group had heavier live body weight than control ones at 9, 11 and 13 weeks of age by 5.6, 4.3 and 5.2%, respectively.

Addition of propionic acid at 0.025 and 0.05% level to the diets of NZW rabbits resulted in non significant effect at 11 weeks of age; however, these results reached significant at 13 weeks of age and surpassed the control one by 3.2 and 3.8%, respectively. The aforementioned groups were significantly less in live body weight as compared to the group received 0.025% acetic acid in their diet. The results demonstrated also that the group of rabbits fed 0.05% acetic acid in their diet recorded the lowest live body weight at 11 and 13 weeks of age in comparison with the other experimental groups. Many researchers (Falkowski and Aherne, 1984; Giesting and Easter, 1985 and Risley, 1990) observed an improvement in post-weaning growth 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 pH 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 the 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. Our results indicated also that the increase in live body weight due to including acetic acid or low level of propionic acid in the diet may be attributed to its strongest anti-mould activity as compared to rabbits fed control diet free from organic acid.

The results presented in Table 3 showed that, the interaction between ALM levels and organic acids were significant at 9, 11 and 13 weeks of age. NZW rabbits received 16.5% ALM with 0.025% acetic acid in their diet recorded the highest value of live body weight, however, the lowest value was observed in the group fed 16.5% ALM with 0.025% propionic acid at 11 and 13 weeks of age.

4.2.1.2 . Body weight gain:

Data of body weight gain of NZW rabbits during 5-7, 7-9, 9-11 and 11-13 weeks of age as well as during 5-9, 9-13 and 5-13 weeks of age as affected by different levels of ALM and type of organic acids and their interactions are shown in Tables 4 and 5 and Figs. 3, 4, 5 and 6.

Differences in body weight gain were significantly from 5th until the end of the study at 13th weeks of age due to different levels of ALM.

Table 4. Live body weights gain of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Body weight gain (g) wks			
		5-7	7-9	9-11	11-13
Main effect of (ALM)					
0.0		298.2[a]	370.5[a]	348.4[b]	356.9[a]
16.5%		256.9[b]	361.1[a]	326.9[c]	339.4[a]
33%		236.8[c]	345.3 [b]	443.1[a]	314.5[b]
SEM		3.204	5.288	3.992	6.293
P value		0.0001	0.006	0.0001	0.0001
Main effect of organic acid supplement					
Control	0	274.0[b]	355.8[c]	366.3[b]	295.9[d]
Acetic acid,	0.025%	290.5[a]	411.2[a]	367.2[b]	324.9[c]
	0.05%	292.7[a]	316.9[d]	329.6[c]	326.3[c]
Propionic acid,	0.025%	235.9[c]	337.6[c]	424.6[a]	353.3[b]
	0.05%	228.4[c]	376.7[b]	372.5[b]	385.7[a]
SEM		4.134	6.819	5.152	8.121
P value		0.0001	0.0001	0.0001	0.0001
Interaction effect					
Acacia	Organic acids				
0	0	354.7[a]	395.2[c]	398.0[cd]	308.6[de]
Acetic acid,	0.025%	263.4[d]	359.8[d]	381.1[d]	380.9[bc]
	0.05%	351.5[a]	277.9[f]	276.8[g]	293.2[de]
Propionic acid,	0.025%	237.8[ef]	394.4[c]	374.9[d]	443.0[a]
	0.05%	283.3[c]	425.3[b]	311.4[ef]	359.0[c]
16.5%	0	245.1[e]	318.0[e]	329.9[e]	325.8[d]
Acetic acid,	0.025%	330.0[b]	467.0[a]	416.7[c]	299.8[de]
	0.05%	263.7[d]	290.6[ef]	312.8[ef]	337.0[cd]
propionicacid,	0.025%	218.7[f]	342.1[de]	271.4[g]	342.4[cd]
	0.05%	227.3[f]	382.8[cd]	304.4[f]	390.6[bc]
33%	0	222.2[f]	349.9[d]	367.1[d]	256.9[f]
Acetic acid,	0.025%	276.6[cd]	406.3[bc]	296.1[fg]	290.0[e]
	0.05%	263.0[d]	382.3[cd]	399.1[cd]	348.8[cd]
Propionic acid,	0.025%	251.3[de]	276.2[f]	627.4[a]	274.6[ef]
	0.05%	167.7[g]	315.3[e]	517.9[b]	410.4[b]
SEM		7.166	11.819	8.929	14.076
P value		0.0001	0.0001	0.0001	0.0001

[a-g] Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

Table 5. Live body weights gain of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		5-9	9-13	5-13	dead animal number
		Body weight gain(g) wks			
Main effect of (ALM)					
0.0		668.7^{a}	705.4^{b}	1374.1a	2.0
16.5%		618.9^{b}	666.3^{c}	1285.2c	3.0
33%		582.1^{c}	757.7^{a}	1339.8b	2.0
SEM		5.482	6.110	6.540	
P value		0.0001	0.0001	0.0001	
Main effect of organic acid supplement					
Control	0	631.9b	662.3^{c}	1294.2c	2.0
Acetic acid,	0.025%	701.7a	692.0^{b}	1393.8a	1.0
	0.05%	609.7c	655.9^{c}	1265.6d	1.0
Propionic acid,	0.025%	573.5d	777.9^{a}	1351.4b	1.0
	0.05%	605.1c	758.3^{a}	1363.4b	2.0
SEM		6.940	7.883	8.440	
P value		0.0001	0.0001	0.0001	
Interaction effect					
Acacia	Organic acids				
0	0	749.9b	706.6^{d}	1456.4b	0.0
	Acetic acid 0.025%	623.2de	762.0^{c}	1385.2c	1.0
	0.05%	629.4de	570.0^{g}	1199.4fg	1.0
	Propionic acid 0.025%	632.2de	817.9^{b}	1450.1b	0.0
	0.05%	708.7c	670.4^{de}	1379.1c	0.0
16.5%	0	566.4f	655.3^{e}	1222.0f	1.0
	Acetic acid 0.025%	797.0a	716.2^{cd}	1513.2a	0.0
	0.05%	554.2fg	649.8^{e}	1204.0fg	0.0
	Propionic acid 0.025%	560.8f	613.9^{f}	1174.7g	1.0
	0.05%	610.1e	695.0^{d}	1305.1d	1.0
33%	0	572.1f	624.0^{ef}	1196.1fg	0.0
	Acetic acid 0.025%	682.9c	586.1^{fg}	1269.0e	1.0
	0.05%	645.3d	747.9^{c}	1393.2c	0.0
	Propionic acid 0.025%	527.6g	902.0^{a}	1429.6bc	0.0
	0.05%	483.0h	928.3^{a}	1411.3c	1.0
SEM		12.030	13.665	14.629	
P value		0.0001	0.0001	0.0001	

$^{a-h}$ Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

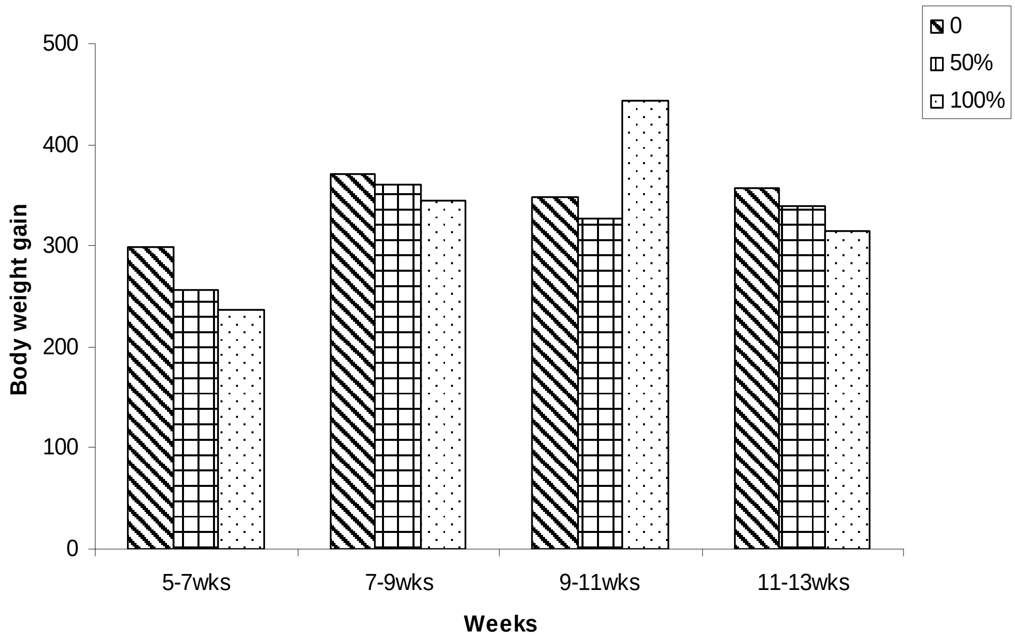

Fig 3. Live body weight gain of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*. .0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

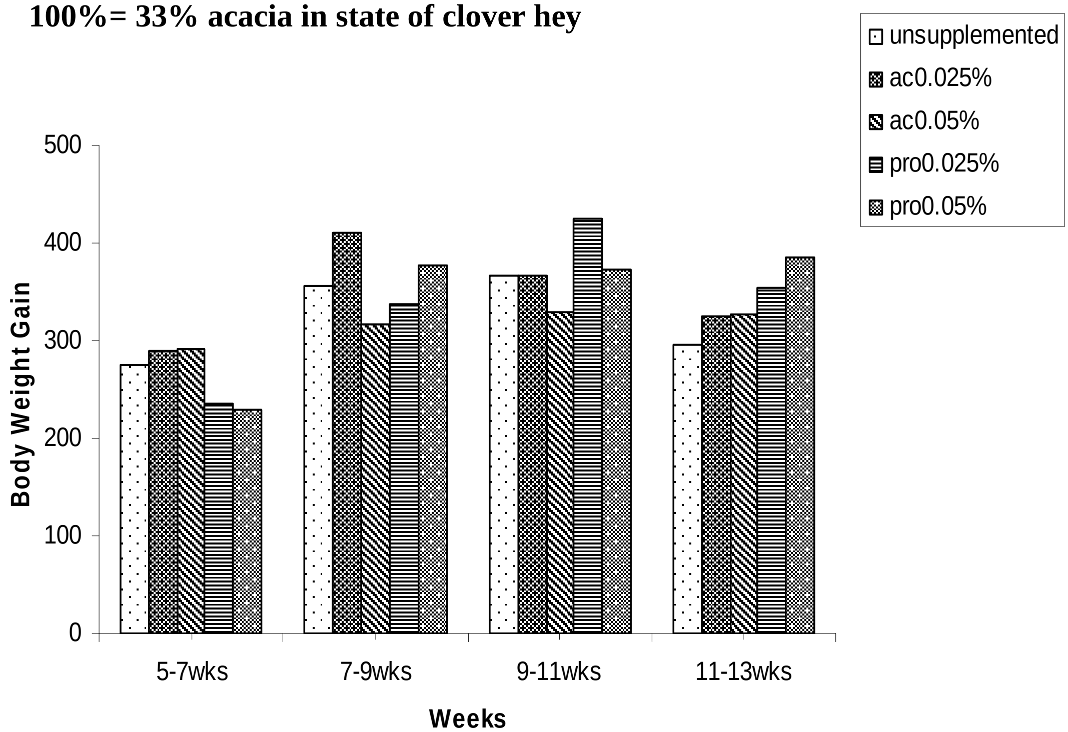

Fig 4. Live body weight gain of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids. .ac= acetic acid%, pro=propionic acid%

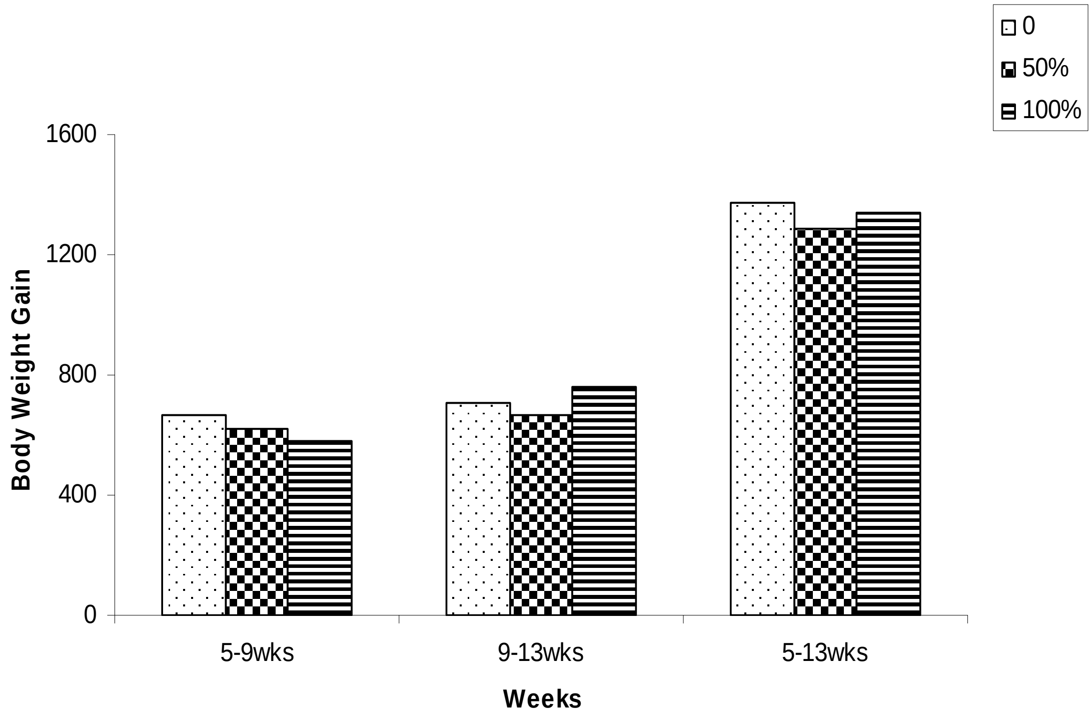

Fig 5. Live body weight gain of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*. .0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

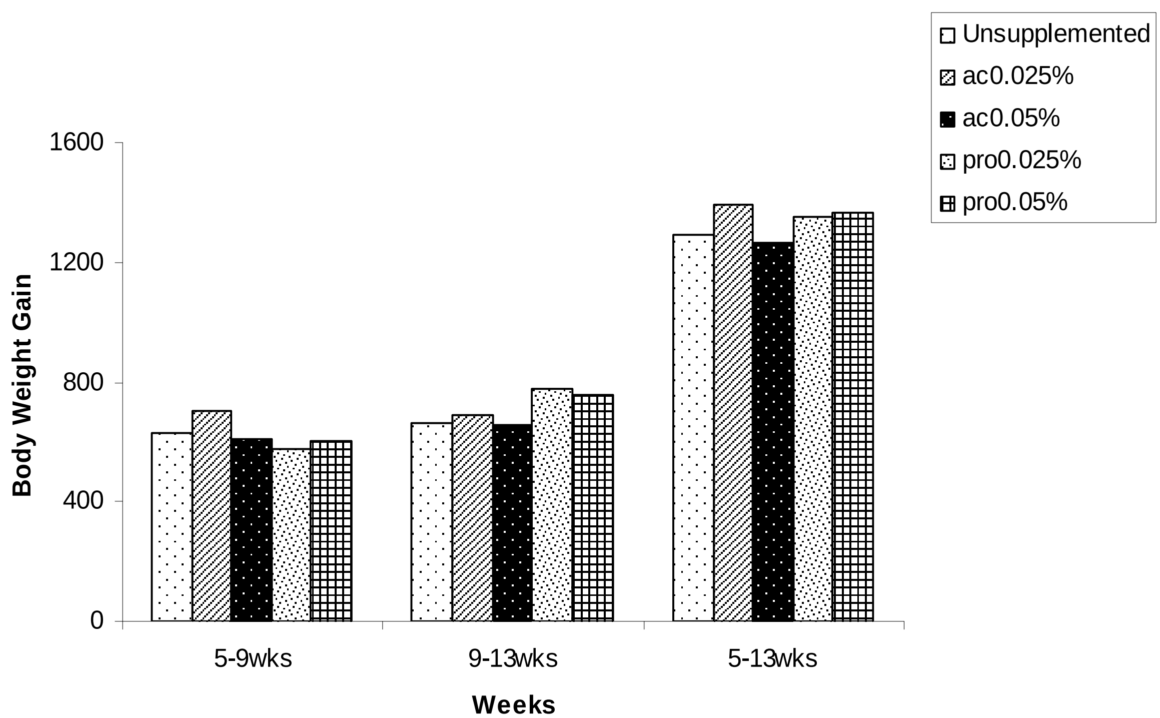

Fig 6. Live body weight gain of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids. .ac= acetic acid%, pro=propionic acid%

The groups of rabbits fed 16.5 and 33% ALM in their diets had significantly ($P \leq 0.0001$) the lowest values of weight gain during the first two weeks of study. However, there were insignificant differences between group of rabbits fed 16.5% ALM and those in control one during the period 7-9 and 11-13 weeks of age. It was noticed that the ALM incorporation in rabbit diets at 33% level had positive ($P \leq 0.0001$) effect on weight gain throughout the period 9-11 weeks of age.

When the data were pooled, body weight gain at 5-9 weeks and during the whole experimental period from 5-13 weeks of age, indicated that the diets containing ALM were negatively affected on this trait, however, during 9-13 weeks of age, the best ($P \leq 0.0001$) value of weight gain was obtained from rabbits fed 33% ALM in their diet.

It is of great importance to note that the results of the digestion trials were coincided generally with growth performance and feed conversion efficiency. In most periods rabbits fed control diet showed the highest body weight and recorded the highest body weight gain compared to the other experimental groups.

Irrespective of ALM levels, the results demonstrated that acetic acid addition to the diets at 0.025% level resulted in a highly significant increase in weight gain at 5-7 and 7-9 weeks of age. Also, the level of acetic acid at 0.05% exceeds the control group at 5-7 weeks of age. The positive effect of propionic acid was observed at 9-11 weeks of age for 0.025% level and at 11-13 weeks of age for 0.05% level.

During the experimental period 5-9 and 5-13 weeks of age, addition of acetic acid at 0.025% level had significant effect on weight gain. These rabbits recorded higher values of weight gain being 11.0 and 7.7% more, respectively, compared to the control. The obtained results showed that the superiority in weight gain during 9-13 weeks of age was observed in the group received 0.025 or 0.05% propionic acid in their diets compared to the other experimental groups. The weight gain of rabbits fed 0.025% propionic acid in their diet was more than control by 17.5%, however, the corresponding value for the group fed 0.05% propionic acid was increased by 14.5%. The results showed significant decrease in the groups fed 0.05% acetic acid, 0.025 and 0.05% propionic acid during the early period from 5-9 weeks of age. The group fed 0.05% acetic acid was continued to decrease during the periods 9-13 and during the whole experimental period. The early feed intake restriction by supplying 0.05% acetic acid may have determined the reduction in weight gain of this group observed by the end of the experimental period (Table 5).

In this respect, 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. Also, Scapinello *et al. (*2001) and Abecia *et al. (*2005) reported that productive performances of the inclusion of organic acids in rabbit nutrition are not clear. However, Improvements in daily gain have been reported by ZilLin *et al.* (1996) including 1.25 g fumaric acid per kg and by Castrovilli (2002) and Hullar *et al.* (1996) with different acidifiers included at 1.5 or 3.0 g per kg. On broiler chicks, Conkova and Para (1997) indicated that body weight gain of broiler chicks given a feed mixture containing organic acid (propionic acid at 0.5 ml/kg) was 5.9% greater than that of the control. Also, Garcia *et al,* (2000) detected that supplementation of broiler diets with organic acids (0.1%, in the initial phase, increased ($P \leq 0.05$) body weight gain.

The combination effect (ALM x type of organic acids) resulted in highly significant ($P \leq 0.0001$) effect during all periods of the study. The best group of rabbits in weight gain was those fed diet containing 16.5% ALM with 0.025% acetic acid during the periods 5-9 and 5-13 weeks of age. However, during the period 9-13 weeks of age the best results of weight gain were obtained in the groups fed 33% ALM with both levels of propionic acid (0.025 and 0.05%) with insignificant differences. The obtained results indicated the positive impact of organic acids on growth of rabbits. This may be due to the effectiveness of organic acids against as a broad spectrum of gram-positive and gram-negative bacteria, which could control proliferation of different types of bacteria and maintain healthy gut.

4.2.1.3. Viability rate:

Table 5 represent the results of the effect of feeding different levels of ALM, type of organic acids and their interactions on viability rate of New Zealand White (NZW) rabbits.

The results observed that most of rabbits mortality occurred during the first week of the experiment. It is clear that viability rate of groups of rabbits fed different levels of ALM was considerably the same in control group and the group fed 33% ALM-diet, however, it tended to decrease with 16.5% level of ALM in the diet). These results were in agreement (more or less) with those of Ramchurn *et al. (*2000). Abd El-Galil (2001) demonstrated that mortality rate was significantly increased when the rabbits fed diets containing ALM more than 20%.

Irrespective of ALM, the results indicated that most of rabbits groups fed diets supplemented with organic acids had the best viability rate as compared to control, except the group of rabbits received 0.05% propionic acid in their diet, it recorded the number of dead rabbits as in the control group fed diet without supplementation. The higher survival rates of acetic acids groups or those received 0.025% propionic acid may be attributed to that organic acids at these levels reduce the intestinal pH, 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 diarrhea and increased the growth of piglets. The action mechanisms of organic acids are mainly involved in balancing the microbial population in the small intestine and/or to stimulating the activity of digestive enzymes (Knarreborg *et al.*, 2002).

Similar to the present findings, Scapinello *et al. (*1999) and Skrivanova and Marounek (2002) demonstrated that caprilic acid decreased mortality in the post weaning period. The last authors stated that mortality of control rabbits and those fed caprylic acid at 5 g/kg was 16.7 and 0% ($P = 0.018$) in the first experiment. Caprylic acid at this concentration decreased mortality of rabbits also in the 2nd experiment (from 9.3 to 2.0%), but its effect was not statistically significant. (Dierick *et al.*, 2002) observed that the controlled release of medium-chain fatty acids (C6-C12) from coconut and *Cuphea* seeds oils resulted in significant suppression of the intestinal flora (total anaerobic count, lactobacilli, *E. coli*), improved mucosal health and growth performance of piglets.

Young animals have limited ability to produce hydrochloric acid in the stomach. At birth, hydrochloric acid production is negligible, but it increases with advancing age. The greater the production of acid in the stomach, the lower the gastric pH. In the stomach, pH can regulate the movement of viable bacteria and molds from the animal's environment to the small intestine and is involved in the activation of pepsin, a proteolytic enzyme. Pepsin is secreted as an inactive zymogen, pepsinogen, and its conversion to the active pepsin are catalyzed by the action of acid and any existing pepsin in the stomach. Additionally, the optimal pH for pepsin activity is 2.0. At higher pHs, activity is severely reduced. The initial proteolytic activity carried out by pepsin is necessary for the subsequent activity of trypsin in the small intestine. An additional important role for stomach acid is the protection of the lower part of the digestive tract from bacterial invasion (Easter, 1988). The low pH (2.0 or less) commonly found in normal growing and an adult animal has been shown to have a pronounced bacteriostatic effect. Thus, viable microorganisms entering the digestive system via the mouth are unable to pass through the stomach and successfully colonize in the small intestine. In suckling animals, lactose is converted to lactic acid by the *Lactobacillus* bacteria normally resident in the stomach. Moreover, milk is curdled in the stomach by the action of chymosin, which allows a longer stay and thus action of pepsin, even if pH is not as low as the optimal. When vegetable proteins instead of milk proteins are fed to those animals, curdling does not take place and a pH of 2 is not achieved because of the lack of hydrochloric acid. This type of proteins and, to a larger extent mineral mixtures, bind free hydrochloric acid, thus contributing even more to decrease available acid for protein digestion. In this case, undigested feed goes into the small intestine, where pathogenic bacteria can utilize them for their benefit. Also, when pH is above 4, most of these pathogenic bacteria can freely develop.

The susceptibility of rabbits to various infections diseases and high mortality of young rabbits after weaning, however, hinder the development of the rabbit industry. Weanling rabbits often suffer from diarrhoea, which is the major cause of their mortality. Canas-Rodriguez and Smith (1966) suggested that the rabbit milk fat contained antimicrobial compounds, identified as eight and ten carbon saturated fatty acids (caprylic and capric acid, respectively). Content of these acids in the rabbit milk is very high, they represent from one third to one half of the total fatty acids in the rabbit milk fat (Christ *et al.*, 1996; Lebas *et al.*, 1996). Both acids are practically absent from the feed, thus, rabbits synthesize them in the mammary gland. Bactericidal effect of fatty acids is well known (Nieman 1954; Galbraith *et al.* 1971; Galbraith and Miller 1973; Henderson 1973; Maczulak *et al.* 1981; Chalupa *et al.* 1984). Fatty acids penetrate bacterial membranes, interfere with the metabolism of energy within cells and disturb energy dependent processes (Galbraith and Miller 1973). Fatty acids bound in triglycerides did not influence *in vitro* rumen fermentation (Chalupa *et al.*, 1984). The hydrolysis of milk fat by lipase(s) is thus the prerequisite of their antimicrobial action. Antimicrobial activity of caprylic and capric acid confirmed Marounek *et al.* (2002).

4.2.1.4. Feed intake:

Data concerning the effect of different levels of ALM, types of organic acids and their interactions on feed intake during the different growing periods are shown in Tables 6 and 7 and Figs. 7, 8, 9 and 10.

It could be noticed that level of ALM affect significantly ($P \leq 0.0001$) feed intake from the first week of the experiment up to the 13th week of age. Negative ($P \leq 0.0001$) effect was observed during 5-7 weeks of age due to feeding rabbits diets containing 16.5 or 33% ALM. This effect gradually decreased ($P \leq$ 0.05 or 0.002) with advantage in age and rabbits seem to be tolerant to 16.5% ALM during 7-9 and 9-11 weeks of age, however, this tolerance did not continual during the period 11-13 weeks of age, since feed intake during this period was linearly ($P \leq 0.0001$) decreased with increasing level of ALM in the diet.

Pooled results indicated that ALM resulted in linear decrease in feed intake during the periods 9-13 and 5-13 weeks of age, except during 5-9 weeks, since the feed intake of rabbits was significantly the same in the groups fed control and those fed 16.5% ALM –diet. During the whole experimental period inclusion of 16.5 or 33% ALM in rabbit's diet had appetite depressing effect which reduces the growth performance of rabbits.

The decrease in feed intake amounted to 2.1 and 5.3% from control. The decrease in feed intake observed herein with increasing level of ALM in the diets may be attributed to the un-palatability of the diet as a result of increasing tannins content, Moujahed *et al. (*2005). The reduction in feed intake may be due to the lower intestinal motility which led to a higher retention time of the digest in the gut which reported by Garcia *et al. (*1999). Regulation of feed intake and dietary choices combine short-term control of feeding behavior related to the body's homeostatic and long-term control that depends on nutritional requirements and body reserves (Faverdin *et al.*, 1995). Feed quality and physical characteristics of forage, such as a dry matter (DM) content, fiber content, particle size, and resistance to fracture are known to affect ease of pretension and thus intake rate (Inoue *et al.*, 1994).

The report of Russel and Michael, (1992) demonstrated that the shrubs of Acacia contain some compounds that influence palatability and consequently nutritive value, which include tannins, phenolics, steroids, cyanogenic and alkaloids compounds. Makled *et al.* (2003) reported that bucks fed 0.25 and 0.50% tannic acid consumed less ($P \leq 0.01$) amount of feed than that consumed by control group (lower by 33.13 and 23.50%, respectively). Moreover, feed intake per buck was markedly decreased at the lower level of dietary tannic acid (0.25%) than at the higher level (0.50%).

The obtained results were in agreement with the results of Abdel-Samee *et al. (*1992) who reported that feed intake decreased with increasing the level of ALM in the diet, however, it was in disagreement with those of El-Eraky and Mohamed (1996) and Abd El-Galil (2001) who found that feed intake increased with increasing the level of ALM in the diet.

When the effect of ALM levels was over looked, the results indicated that during the experimental periods 7-9, 9-11, 9-13 and 5-13 weeks of age, the organic acids had significant

Table 6. Feed intake (gm) of growing NEZ rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Feed intake (g) wks		
	5-7	7-9	9-11	11-13
Main effect of (ALM)				
0.0	959.4^{a}	1248.1^{a}	1676.1^{b}	2597.1^{a}
16.5%	935.8^{b}	1262.9^{a}	1695.3^{a}	2451.8^{b}
33%	906.8^{c}	1227.4^{b}	1674.6^{b}	2331.3^{c}
SEM	6.001	6.965	6.145	1.949
P value	0.0001	0.002	0.05	0.0001
Main effect of organic acid supplement				
Control 0	964.6^{a}	1251.0^{b}	1669.7^{b}	2462.6a
Acetic acid, 0.025%	958.8^{a}	1295.6^{a}	1734.9^{a}	2463.4a
0.05%	886.7^{c}	1210.7^{c}	1661.4^{b}	2446.8b
Propionic acid, 0.025%	946.4^{a}	1256.6^{b}	1682.0^{b}	2468.3a
0.05%	916.9^{b}	1218.5^{c}	1662.9^{b}	2469.9a
SEM	7.744	8.987	7.93	2.515
P value	0.0001	0.0001	0.0001	0.0001
Interaction effect				
Acacia Organic acids				
0 0	983.6^{b}	1257.0^{c}	1686.3^{d}	2607.7^{a}
Acetic, 0.025%	1018.7^{a}	1356.7^{a}	1776.3^{a}	2598.0^{a}
0.05%	919.7^{f}	1188.0^{d}	1652.3^{f}	2572.0^{b}
Propionic acid, 0.025%	949.3^{de}	1255.0^{c}	1658.7^{ef}	2599.3^{a}
0.05%	925.6^{ef}	1183.7^{a}	1606.6^{g}	2608.7^{a}
16.5% 0	938.9^{e}	1247.4^{c}	1663.3^{ef}	2453.4^{d}
Acetic caid, 0.025%	954.7^{d}	1276.0^{b}	1733.3^{b}	2442.7^{d}
0.05%	914.7^{f}	1267.3^{bc}	1689.3^{d}	2441.3^{d}
Propionic acid 0.025%	920.3^{f}	1242.7^{c}	1671.7^{e}	2473.7^{c}
0.05%	950.7^{d}	1279.3^{b}	1715.3^{c}	2448.3^{d}
33% 0	968.3^{c}	1248.3^{c}	1658.7^{ef}	2325.3^{e}
Acetic acid 0.025%	896.1^{g}	1249.0^{c}	1690.0^{d}	2335.1^{e}
0.05%	827.7^{i}	1176.7^{d}	1642.7^{f}	2327.0^{e}
Propionicacid 0.025%	969.7^{c}	1272.0^{bc}	1715.7^{c}	2332.0^{e}
0.05%	868.9^{h}	1189.4^{d}	1667.0^{e}	2338.3^{e}
SEM	13.422	15.767	13.912	13.422
P value	0.0001	0.0001	0.0001	0.0001

$^{a-h}$ Means within a column not sharing similar superscripts are significantly different (P<0.05). NS (P>0.05).

Table 7. Feed intake (gm) of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments	Feed intake (g) wks 5-9	9-13	5-13
Main effect of (ALM)			
0.0	2207.5[a]	4273.2[a]	6480.7[a]
16.5%	2198.7[a]	4147.1[b]	6345.8[b]
33%	2134.3[b]	4005.9[c]	6140.2[c]
SEM	12.496	6.825	16.797
P value	0.0001	0.0001	0.0001
Main effect of organic acid supplement (OA)			
Unsupplement (control)	2215.6[ab]	4132.1[bc]	6347.7[b]
Acetic acid, 0.025%	2254.4[a]	4198.2[a]	6452.7[a]
0.05%	2097.3[c]	4108.2[c]	6205.6[d]
Propionic acid, 0.025%	2203.0[b]	4150.3[b]	6353.3[b]
0.05%	2135.4[c]	4132.8[bc]	6268.2[c]
SEM	16.124	8.807	21.675
P value	0.0001	0.0001	0.0001
Interaction effect			
Acacia / Organic acids			
0 / 0	2240.7[b]	4294.0[b]	6534.7[b]
Acetic acid, 0.025%	2375.3[a]	4374.3[a]	6749.7[a]
0.05%	2107.7[e]	4224.3[d]	6332.0[e]
Propionic acid, 0.025%	2204.3[c]	4258.0[c]	6462.3[c]
0.05%	2109.3[e]	4215.3[d]	6324.7[ef]
16.5% / 0	2186.3[cd]	4116.6[g]	6302.9[ef]
Acetic acid, 0.025%	2230.7[bc]	4176.0[e]	6406.7[d]
0.05%	2182.0[cd]	4130.7[fg]	6312.7[ef]
Propionic acid, 0.025%	2163.0[d]	4145.3[f]	6308.3[ef]
0.05%	2230.0[bc]	4163.7[e]	6393.7[d]
33% / 0	2216.7[bc]	3984.0[k]	6200.7[g]
Acetic acid,0.025%	2145.1[d]	4025.1[i]	6170.3[g]
0.05%	2002.3[g]	3969.7[k]	5972.0[i]
Propionic acid,0.025%	2241.7[b]	4047.7[h]	6289.3[f]
0.05%	2058.3[f]	4004.3[j]	6063.5[h]
SEM	28.286	15.45	38.02
P value	0.0001	0.0001	0.0001

[a-k] Means within a column not sharing similar superscripts are significantly different (P<0.05). NS (P>0.05).

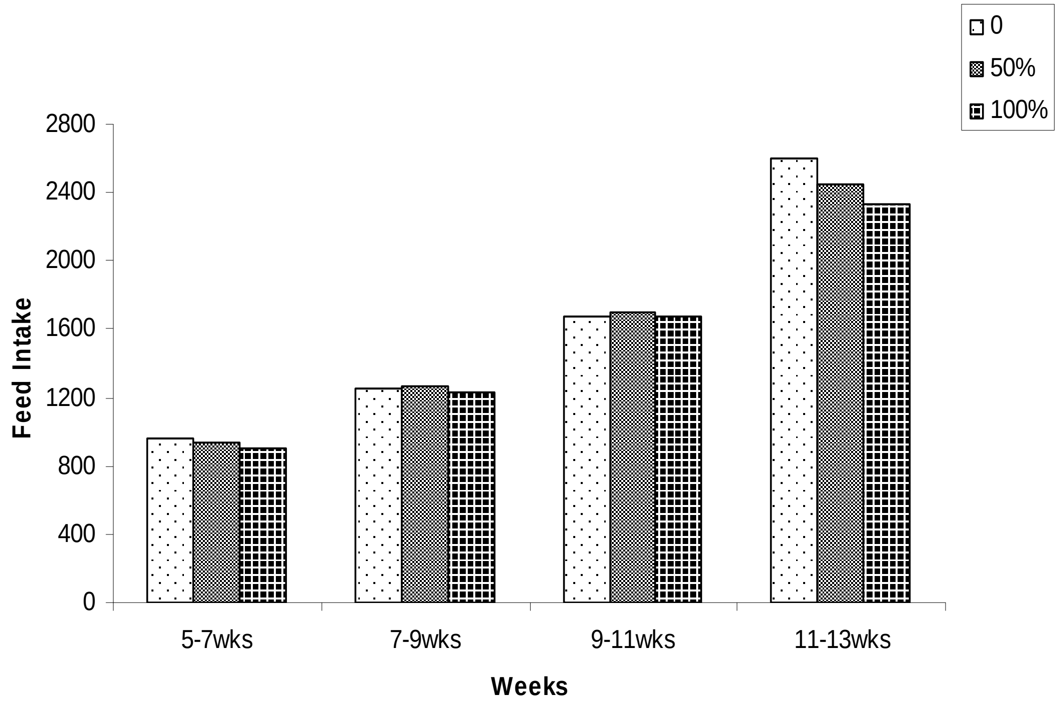

Fig 7. Feed intake of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*. .0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

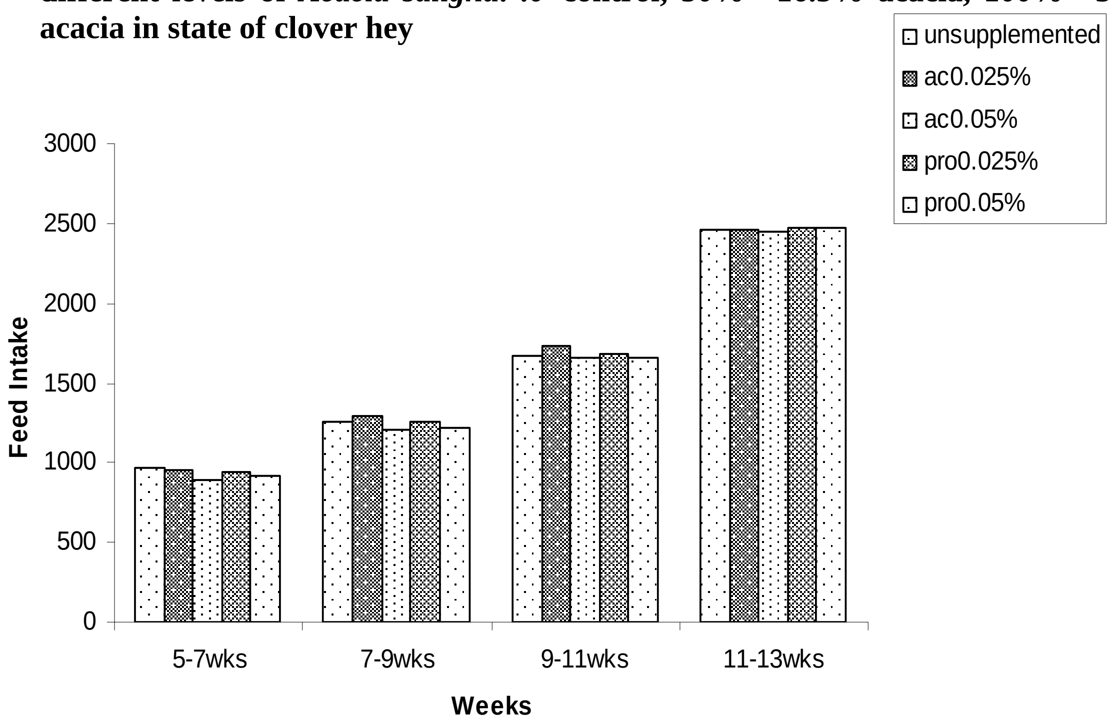

Fig 8. Feed intake of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids. .ac= acetic acid%, pro=propionic acid%.

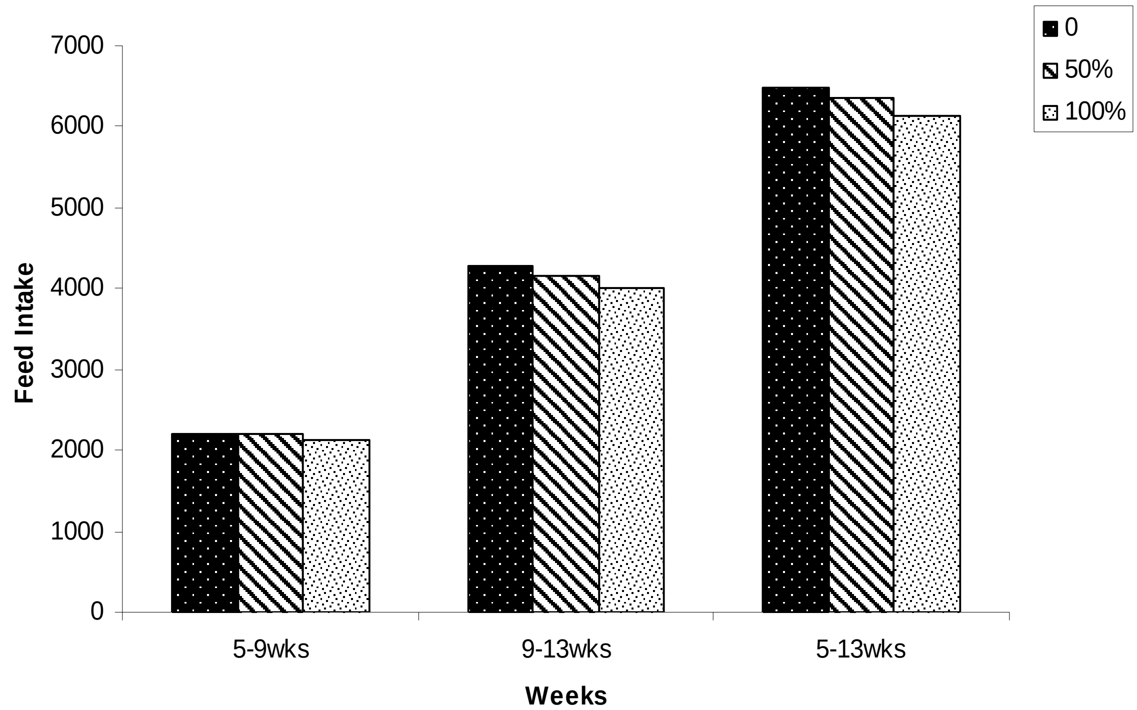

Fig 9. Feed intake of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*.0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

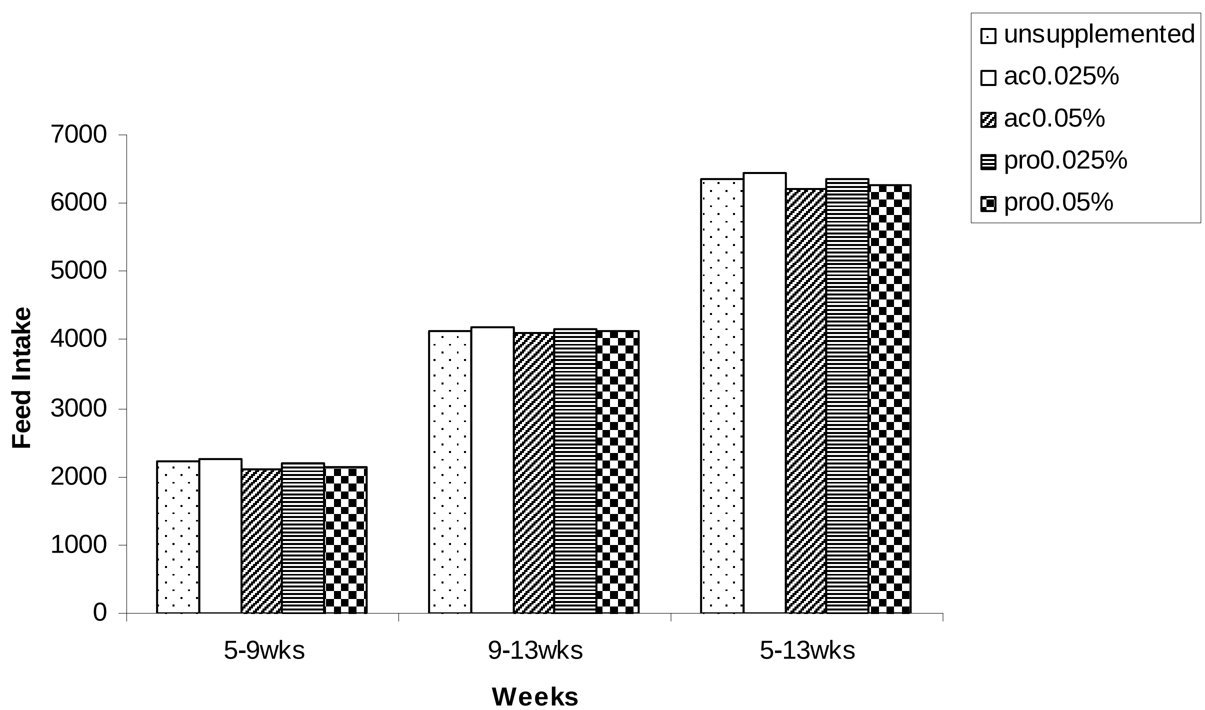

Fig 10. Feed intake of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids. .ac= acetic acid%, pro=propionic acid%

effect on feed intake. The rabbits fed 0.025% acetic acid in their diets recorded higher values of feed intake being 3.6, 3.9, 1.6 and 1.7% more compared to control. This increase was followed by a corresponding increase in live body weight, resulting in a positive effect on feed conversion ratio. Feed intake was deteriorated ($P \leq 0.0001$) in the groups of rabbits received 0.05% of both organic acids in their diets as compared to the control group during the periods 5-9 and 5-13 weeks of age. These results were in agreement with those of Do Vale *et al.* *(*2004) who found that the 0.25 and 0.5% inclusion levels of organic acids caused an increase in feed intake of about 117g and 53g per chicken, respectively, from one to 42 days of age, when compared with the treatment without addition of organic acids. The 1% inclusion level of the organic acids mixture resulted in a feed intake value similar to that observed for the zero level of addition; the 2% level of addition of the mixture decreased feed intake by nearly 240 g of ration in that period.

In this respect, 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 feed intake. Pinchasov and Jensen (1989) studied several organic acids, including formic and propionic, and showed that only propionic acid had a significant action in reducing feed intake. As a matter fact, Cave (1978) had already indicated that propionic acid plays a role in the satiation regulatory system, since the intraperitoneal injection of this organic acid into broiler chickens suspended intake for 0.5 to 1.5 hours. From one to 42 days of age, a difference ($P < 0.05$) was observed only regarding feed intake.

Data for the interaction between ALM levels by type of organic acids on feed intake of rabbits are presented in Tables 6 and 7. Addition of 0.025% acetic acid to the basal diet free from ALM resulted in higher increase in feed intake as compared to other experimental groups during all periods of the study, except for the period 11-13 weeks of age. The same conclusion was observed with rabbits fed basal diet with 0.05% of propionic acid at 7-9 weeks or 0.025 and 0.05% propionic acid at 11-13 weeks of age.

The results showed also that addition of 0.025% of% acetic acid or 0.05% of propionic to the diets containing 16.5% ALM resulted in increasing ($P \leq 0.0001$) feed intake by 1.6 or 1.4% compared to the rabbits fed the same diet without supplementation.

The obtained results demonstrated that addition of 0.025% propionic acid to the diet containing 33% ALM resulted in significant ($P \leq 0.0001$) increase in feed intake amounted to 1.4% from its control.

4.2.1.5. Feed conversion ratio:

Data reflecting the average feed conversion ratio of rabbits as affected by different levels of ALM, types of organic acids and their interactions during the different experimental periods of the study are shown in Tables 8 and 9 and Figs. 11, 12, 13 and 14.

The diet content of ALM had significant effect on feed conversion ratio during 5-7 and 9-11 weeks of age. However, insignificant differences were observed during 7-9 and 11-13 weeks of age. The results showed that feed conversion ratio gradually deteriorated with

Table 8. Feed conversion ratio of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments	Feed conversion (%) wks 5-7	7-9	9-11	11-13
Main effect of (ALM)				
0.0	3.308[c]	3.469[b]	4.913[b]	7.578
16.5%	3.746[b]	3.621[ab]	5.299[a]	7.390
33%	3.955[a]	3.671[a]	4.067[c]	7.777
SEM	0.048	0.065	0.055	0.177
P value	0.0001	0.09	0.0001	NS
Main effect of organic acid supplement				
Control 0	3.676[b]	3.587[b]	4.595[cd]	8.504[a]
Acetic acid, 0.025%	3.342[c]	3.229[c]	4.849[b]	7.875[ab]
0.05%	3.086[d]	3.942[a]	5.179[a]	7.681[b]
Propionic acid, 0.025%	4.026[a]	3.830[a]	4.448[d]	7.307[b]
0.05%	4.199[a]	3.317[c]	4.755[bc]	6.540[c]
SEM	0.062	0.084	0.071	0.229
P value	0.0001	0.0001	0.0001	0.0001
Interaction effect				
Acacia Organic acids				
0 0	2.789[fg]	3.199[d]	4.259[f]	8.574[b]
Acetic acid, 0.025%	3.872[c]	3.809[bc]	4.687[e]	6.937[f]
0.05%	2.616[g]	4.351[a]	5.981[ab]	9.060[ab]
Propionic acid 0.025%	3.992[c]	3.189[d]	4.433[ef]	5.876[h]
0.05%	3.273[de]	2.801[e]	5.206[cd]	7.442[de]
16.5% 0	3.891[c]	3.985[b]	5.046[d]	7.554[d]
Acetic acid 0.025%	2.899[f]	2.767[e]	4.168[f]	8.612[b]
0.05%	3.476[d]	4.363[a]	5.412[c]	7.244[e]
Propionic acid 0.025%	4.231[bc]	3.632[c]	6.164[a]	7.227[e]
0.05%	4.248[b]	3.396[cd]	5.676[bc]	6.332[g]
33% 0	4.371[b]	3.621[c]	4.531[ef]	9.278[a]
Acetic acid 0.025%	3.243[e]	3.098[de]	5.799[b]	8.100[c]
0.05%	3.166[e]	3.112[de]	4.143[f]	6.739[f]
Propionic acid 0.025%	3.866[c]	4.669[a]	2.746[h]	8.818[b]
0.05%	5.187[a]	3.809[bc]	3.213[g]	5.760[h]
SEM	0.107	0.145	0.122	0.397
P value	0.0001	0.0001	0.0001	0.0001

[a-h] Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

Table 9. Feed conversion ratio of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments	Feed conversion (%) wks		
	5-9	9-13	5-13
Main effect of (ALM)			
0.0	3.329^{c}	6.168^{a}	4.741^{b}
16.5%	3.624^{b}	6.258^{a}	4.981^{a}
33%	3.744^{a}	5.480^{b}	4.609^{c}
SEM	0.039	0.056	0.027
P value	0.0001	0.0001	0.0001
Main effect of organic acid supplement			
Control 0	3.579^{b}	6.257^{ab}	4.939^{a}
Acetic acid 0.025%	3.264^{c}	6.155^{b}	4.653^{bc}
0.05%	3.475^{b}	6.386^{a}	4.943^{a}
Propionic acid 0.025%	3.870^{a}	5.485^{c}	4.743^{b}
0.05%	3.615^{b}	5.590^{c}	4.606^{c}
SEM	0.050	0.072	0.034
P value	0.0001	0.0001	0.0001
Interaction effect			
Acacia Organic acids			
0 0	2.994^{ef}	6.083^{d}	4.488^{de}
Acetic acid, 0.025%	3.820^{b}	5.760^{e}	4.879^{c}
0.05%	3.362^{d}	7.472^{a}	5.291^{ab}
Propionic acid 0.025%	3.488^{cd}	5.209^{f}	4.458^{de}
0.05%	2.979^{ef}	6.313^{cd}	4.590^{d}
16.5% 0	3.880^{b}	6.281^{cd}	5.163^{b}
Acetic acid 0.025%	2.808^{f}	5.901^{de}	4.241^{f}
0.05%	3.940^{b}	6.359^{cd}	5.246^{ab}
Propionic acid 0.025%	3.860^{b}	6.753^{b}	5.371^{a}
0.05%	3.660^{c}	5.999^{de}	4.902^{c}
33% 0	3.897^{b}	6.408^{c}	5.191^{b}
Acetic acid 0.025%	3.152^{e}	6.885^{b}	4.865^{c}
0.05%	3.122^{e}	5.327^{f}	4.291^{ef}
Propionic acid 0.025%	4.262^{a}	4.492^{g}	4.401^{e}
0.05%	4.279^{a}	4.316^{g}	4.290^{ef}
SEM	0.087	0.125	0.059
P value	0.0001	0.0001	0.0001

[a-h] Means within a column not sharing similar superscripts are significantly different (P<0.05). NS (P>0.05).

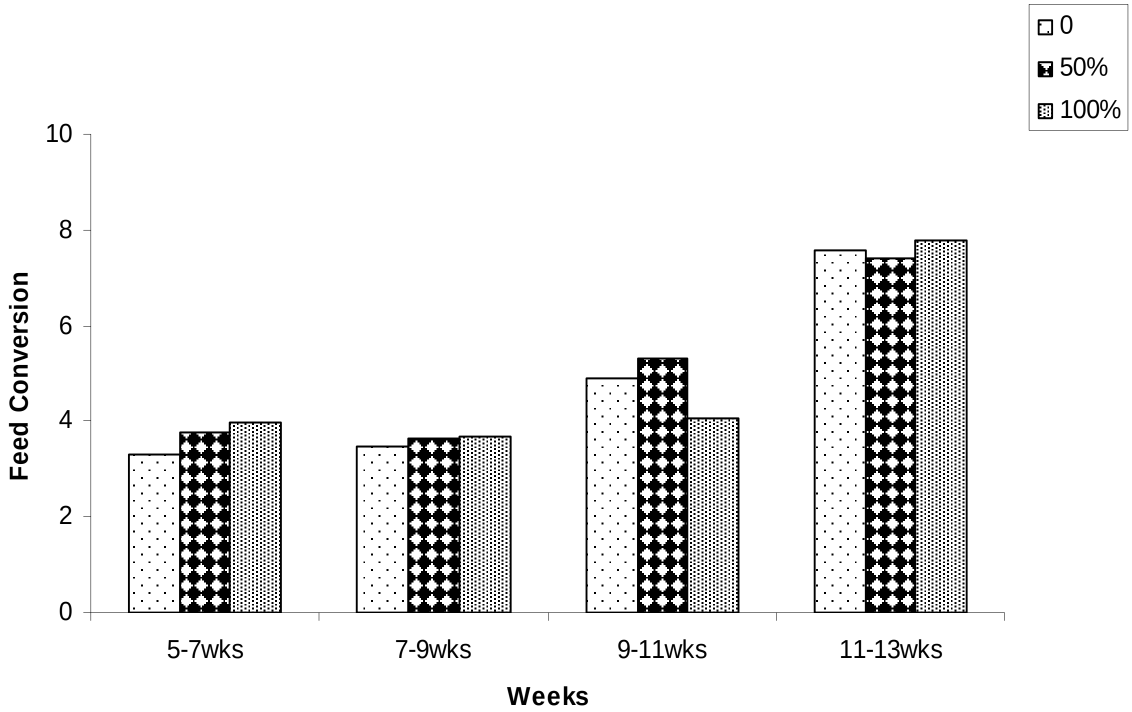

Fig 11. Feed conversion ratio of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*.0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

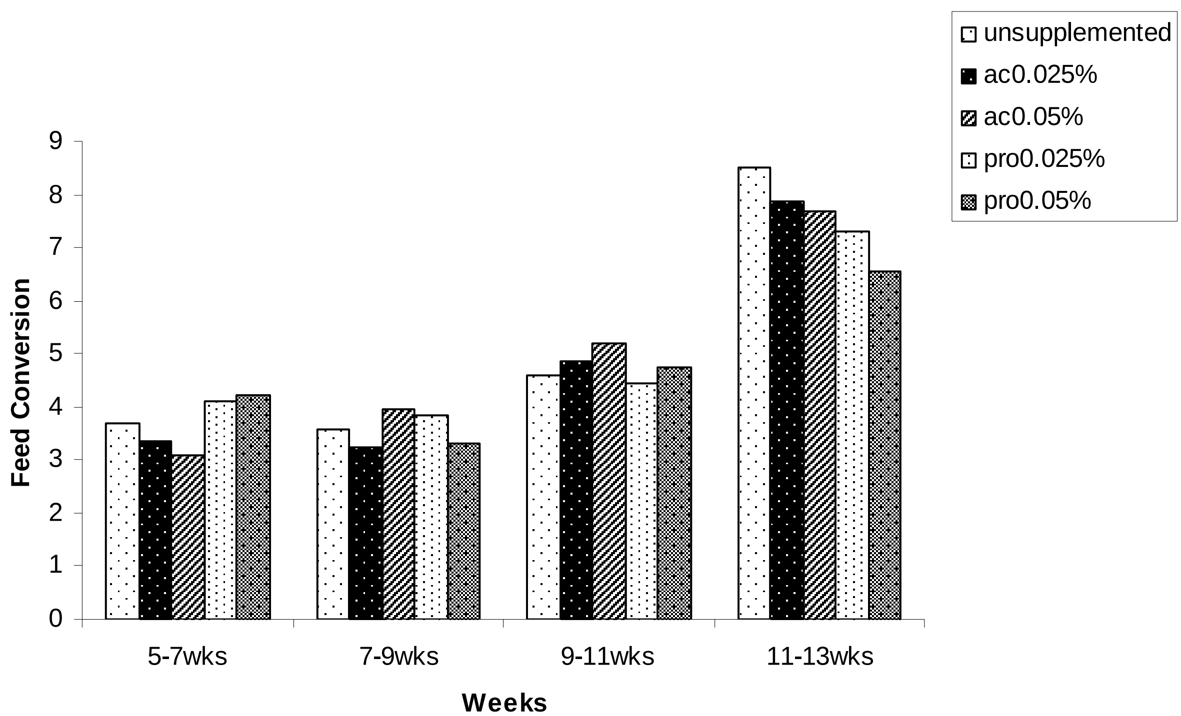

Fig 12. Feed conversion of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids. .ac= acetic acid%, pro=propionic acid%

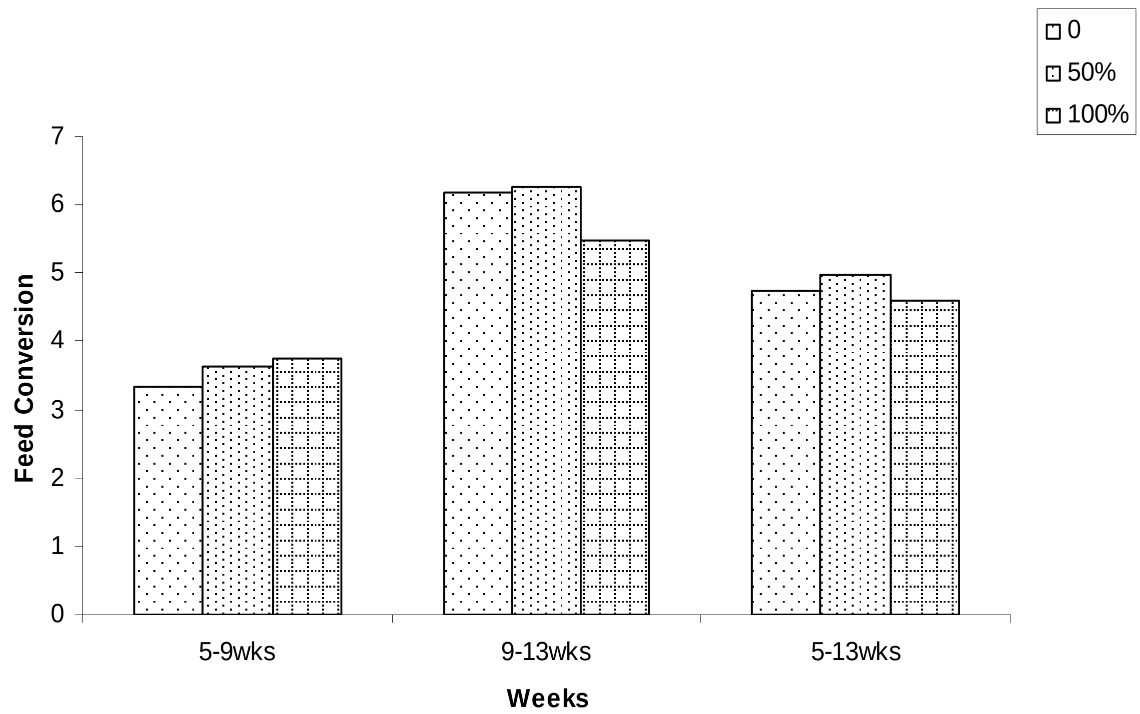

Fig 13. Feed conversion of growing NEZ rabbits as affected by feeding diets containing different levels of *Acacia saligna*. 0=control, 50%= 16.5% acacia, 100%= 33% acacia in state of clover hey

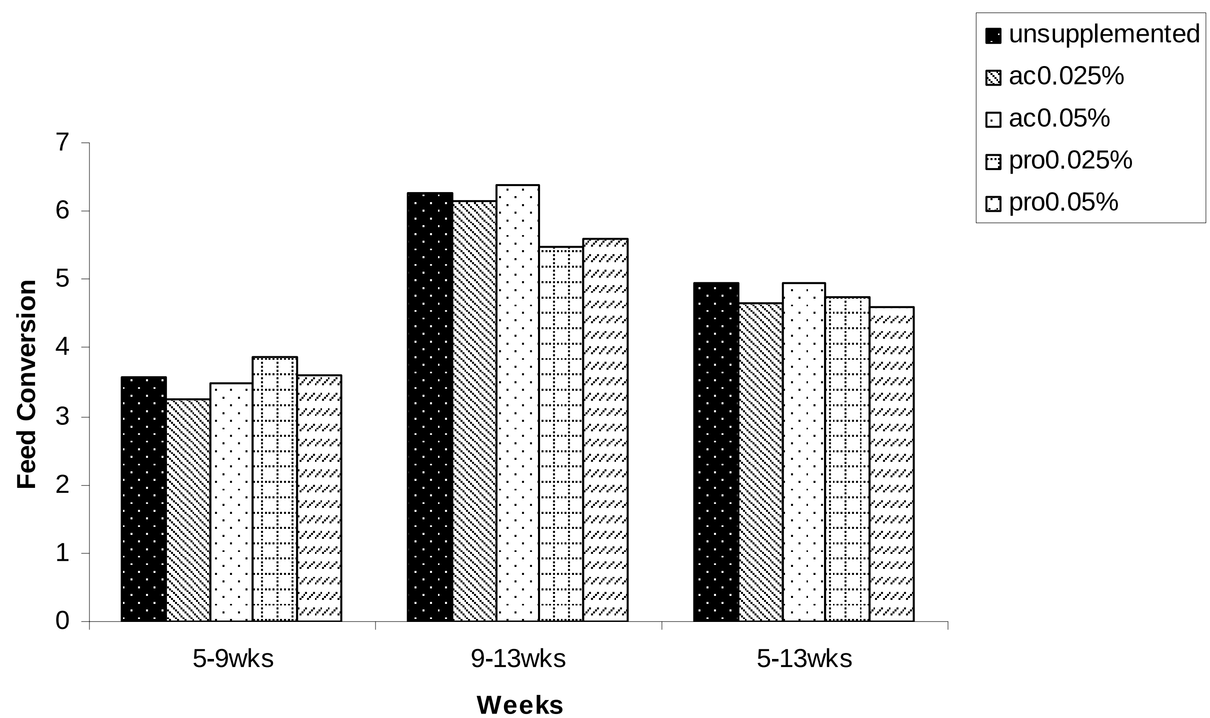

Fig 14. Feed conversion ratio of growing NEZ rabbits as affected by feeding diets containing different levels of Organic acids.ac= acetic acid%, pro=propionic acid%

increasing level of ALM in the diet; on the other hand, the obtained results during the period from 9-11 weeks of age indicated significant improvement in feed conversion ratio reached to 17.1% from control.

When the data are pooled, the results indicated that inclusion of ALM in the diets at both levels (16.6 or 33%) during the period 5-9 weeks resulted in significant ($P \leq 0.0001$) deterioration (8.7 or 12.3%) in feed conversion ratio than the control. On contrast, significant improvement in feed conversion ratio was detected when rabbits fed diet containing 33% ALM during 9-13 weeks of age and during the whole experimental period, where rabbits fed 33% ALM-diet had better values of feed conversion ratio than those fed control diet by 11.2 and 2.7%, respectively.

In this respect, Abd El-Galil (2001) stated that rabbits fed 10 or 20% ALM in their diets showed the same feed conversion ratio in comparison with control, however, rabbits received diets containing 30-40% ALM were to some extent poor in feed conversion ratio as compared to control or the other experimental groups.

Regardless to the effect of ALM, the present results indicated that, when applying acetic acid at 0.025 or 0.05%, feed conversion ratio improved at 5-7 weeks, however, it only improved at 7-9 weeks with 0.025% level, then it deteriorated during 9-11 weeks of age, however, it had insignificantly improved during the period 11-13 weeks o age.

A significant ($P \leq 0.0001$) improvement in feed conversion ratio was recorded during 11-13 weeks of age with supplementing 0.05% propionic acid in the diet as compared to control or the other experimental groups.

Pooled results showed that addition of 0.025% acetic acid to the diet showed positive effect on feed conversion ratio during 5-9 weeks of age. This treatment showed less value of feed conversion ratio by 8.3% than those of control. With advantage in age this significant effect disappears during 9-13 weeks of age. Propionic acid at levels 0.025 or 0.05% showed significant positive effect on feed conversion ratio during 9-13 weeks of age, where the feed conversion ratio values of the groups received 0.025 or 0.05% propionic acid were better than that of control group by about 12.3 or 10.7%, respectively.

Throughout the whole experimental period (5-13 weeks), the groups of rabbits fed 0.025% acetic acid or those fed 0.05% propionic acid recorded significant improvement in their values of feed conversion ratio in comparison to the control group by 5.9 or 6.7%, respectively. The obtained results were in accordance with the results 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, however, the previous findings were in contrast with those of Zaghini *et al.* (1986) who reported that addition of 1.5% of either citric or fumaric acid had no significant effects on feed conversion ratio.

The interaction effect between the studied traits was observed during all periods of the study. The best results of feed conversion ratio were observed by feeding 16.5% ALM-diet with 0.025% acetic acid during the period 5-9 weeks of age and during the whole experimental period. However, rabbits fed 33% ALM-diet with 0.025 or 0.05% Prop showed the best values of feed conversion ratio at 9-13 weeks.

4.2.2. Apparent digestibility coefficients of nutrients:

Data for the digestibility coefficients of various nutrients as affected by the dietary different levels of acacia and supplemented with organic acids at 13 weeks of age are shown in Table 10.

The incorporation of ALM in rabbit diets resulted in non significant differences on the digestibility coefficients of dry matter (DM), organic matter (OM), crude fiber (CF) and nitrogen Free extract (NFE). However the differences were significant for the digestibility coefficients of crude protein (CP) and ether extracts (EE). Feeding 16.5% ALM-diet resulted in non significant effect on digestibility of CP, however it increased digestibility coefficient of EE. On the other hand, feeding 33% ALM-diet had negative effects on the digestibility coefficient of CP. The probable interpretation for the decreasing of digestion coefficients of some nutrients is due to the presence of tannins and phenolic amines in ALM. These substances, however, form insoluble complexes with proteins and carbohydrates lowering the nutritive value of the product (Ferket and Middelton, 1999; Reddy, 1999). In this respect, Akbar and Gupta (1985) added that tannin formulate a protein-tannin complexes in the gut which results in limiting dietary protein availability. Also, Picard *et al. (*1987) presented very low amino acids digestibility values for leucaena (*Mauritian Acacia*) leaf meal.

The results of the present study were in agreement with those of Abdel-Samee *et al. (*1994) that showed that digestibility of various nutrients in the ration containing high ALM level were significantly lower than in the control. Also, Abdel-Samee *et al. (*1992) found similar trend for acacia leaves when fed to growing NZW rabbits. El-Eraky and Mohamed (1996) found insignificant differences in DM, OM, CF and NFE among rations containing different levels of acacia leaves (0, 15 and 30%). With Barki sheep El-Lakany *et al. (*1991) indicated that replacing 50% of the daily dry matter alfalfa intake with Acacia foliage reduced digestible crude protein.

Irrespective of ALM levels, the results showed that apparent digestibility coefficients of different nutrients were not affected by different organic acids. However, the data in Table 10 showed that addition of 0.025 and 0.05% acetic acid insignificantly increased the apparent digestibility of crude protein by 0.8 and 1.5%, crude fiber by 1.8 and 3.9%, nitrogen free extract by 0.6 and 1.7% and organic matter by 1 and 2.2%, respectively, in comparison with control. While the digestibility of ether extracts and dry matter was not differed significantly within the treatment groups. The improvement in the digestibility of crude protein, crude fiber, nitrogen free extract and organic matter by addition of acetic acid may be related to the lowering of intestinal and caecum pH, which in turn increase the activity of microflora which digest such components (Scipioni *et al*, 1978 and Zaghini *et al*, 1986).

Table (10). Digestibility coefficient (%) of experimental diets containing different levels of acacia and supplemented with organic acids.

Treatments	DM	OM	CP	EE	CF	NFE
Main effect of (AL)						
0.0	85.32	57.95	67.30[a]	75.22[b]	38.51	61.94
16.5%	85.04	57.73	66.71[ab]	79.60[a]	41.06	61.56
33%	85.63	56.11	65.19[b]	74.89[b]	38.52	60.39
SEM	0.206	0.633	0.499	0.343	0.891	0.573
P value	NS	NS	0.03	0.0001	NS	NS
Main effect of organic acid supplement						
Control 0	85.07	57.13	66.26	76.75	39.30	61.27
Acetic acid 0.025%	85.34	57.70	66.76	76.71	39.99	61.66
0.05%	85.17	58.37	67.26	76.90	40.83	62.31
Propionic acid0.025%	85.29	56.54	65.86	76.31	38.28	60.62
0.05%	85.77	56.58	65.84	76.19	38.43	60.63
SEM	0.266	0.819	0.643	0.442	1.149	0.739
P value	NS	NS	NS	NS	NS	NS
Interaction effect						
Acacia Organic acids						
0 0	86.00	57.46	66.94	75.13	37.72	61.49
Acetic acid, 0.025%	85.46	58.26	67.56	75.39	39.03	62.20
0.05%	84.52	58.15	67.41	74.87	38.71	62.20
Propionic acid 0.025%	84.77	57.69	67.14	75.27	38.08	61.67
0.05%	85.86	58.19	67.45	75.46	39.02	62.14
16.5% 0	84.24	57.56	66.47	80.13	41.32	61.51
Acetic acid 0.025%	85.02	58.87	67.63	80.03	42.53	62.56
0.05%	84.98	60.59	68.94	80.77	44.87	64.16
Propionic acid 0.025%	85.39	55.64	65.11	78.55	38.05	59.61
0.05%	85.58	56.01	65.39	78.54	38.54	59.96
33% 0	84.99	56.36	65.39	75.02	38.85	60.82
Acetic acid 0.025%	85.54	55.98	65.09	74.71	38.40	60.24
0.05%	86.01	56.38	65.44	75.05	38.91	60.56
Propionic acid0.025%	85.74	56.29	65.33	75.10	38.71	60.58
0.05%	85.89	55.53	64.69	74.56	37.74	59.78
SEM	0.461	1.416	1.116	0.766	1.994	1.281
P value	NS	NS	NS	NS	NS	NS

[a-b] Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).
DM=dry matter, OM organic matter, CP=crude protein, EE=ether extract, CF=crude fiber, NFE nitrogen free extract

The data presented in Table 10 demonstrated that significant effect of the interactions between the studied traits was not observed, however, the data showed that OM, CP, EE, CF, and NFE were improved by 5.4, 3.0, 7.5, 19.0 and 4.3% when the rabbits fed 16.5% ALM-diet with 0.05% acetic acid supplementation. Also, addition of both organic acids to the basal diet resulted in numerical improve in digestibility coefficients of OM, CP and CF. El-Kerdawy (1996) observed that 0.5% fumaric acid did not affect total tract apparent digestibility of dry matter or organic matter of growing rabbits, although digestibility of crude protein and crude fiber significantly increased.

4.2.3. Nutritive values:

The results of DCP, TDN and ME (Kcal / Kg diet) values as affected by different levels of ALM, types of organic acids and their interactions at 13 weeks of age are shown in Table 11.

The results showed that DCP, TDN and ME were not significantly affected by ALM levels, type of organic acids and their interactions, but the data showed numerical improvement in TDN and ME due to feeding 16.5% ALM-diets with 0.025 or 0.05% acetic acid supplementations. The improvement reached to 1.3 and 1.3% for diet containing 0.025% acetic acid; however it was 4.1 and 4.1% for diet containing 0.05% acetic acid, respectively. Significant deterioration was observed in DCP value due to feeding rabbits 33% ALM-diet. The reduction in DCP value may be due to containing high concentrations of numerous amines and alkaloids. Forbs *et al.* (1994) reported that acacia contains high concentrations of numerous amines and alkaloids. These compounds are characterized by the fact that they contain nitrogen and are to a greater or lesser extent toxic.

4.2.4. Carcass characteristics:

Data concerning the effect of different levels of ALM, types of organic acids and their interactions on carcass characteristics of NZW rabbits at 13 weeks of age are shown in Tables 12, 13 and 14.

The preslaughter weight, slaughter weight, hot carcass, cold carcass and fur percentage of rabbits fed ALM-diets was significantly affected by different treatments. The data indicated that the rabbits fed control diet had significantly ($P \leq 0.01$) the heaviest preslaughter weight compared to the groups fed ALM containing-diets. The depression of preslaugter weight in rabbits fed ALM-diets is mainly due to the decrease in daily weight gain obtained by those rabbits.

The group of rabbits fed 16.5% ALM containing-diets exhibited similar significant effect on hot carcass and cold carcass as compared to control. However, the group fed 33% ALM-diet demonstrated significant ($P \leq 0.01$) decrease in hot and cold carcass as compared to the other experimental groups. Fur percent significantly ($P \leq 0.01$) increased with increasing level of ALM in the diet.

Table 11. Nutritive value of different experimental diets containing different levels of acacia and supplemented with organic acids.

Treatments	DCP	TDN	ME
Main effect of (ALM)			
0.0	11.18[a]	52.43	2194.54
16.5%	11.07[ab]	52.63	2202.67
33%	10.72 [b]	51.05	2136.57
SEM	2.96	0.516	21.55
P value	0.02	NS	NS
Main effect of organic acid supplement (OA)			
Control 0	10.97	52.03	2177.71
Acetic acid 0.025%	11.05	52.35	2191.07
0.05%	11.13	52.91	2214.37
Propionic acid 0.025%	10.90	51.46	2153.60
0.05%	10.89	51.44	2152.88
SEM	3.85	0.665	27.839
P value	NS	NS	NS
Interaction effect			
Acacia Organic acids			
0 0	11.12	52.01	2176.80
Acetic acid, 0.025%	11.2[2]	52.69	2205.00
0.05%	11.20	52.59	2201.06
Propionic acid 0.025%	11.15	52.22	2185.30
0.05%	11.21	52.68	2204.53
16.5% 0	11.03	52.75	2207.50
Acetic acid 0.025%	11.22	53.44	2236.67
0.05%	11.44	54.92	2298.57
propionic acid 0.025%	10.80	50.91	2130.77
0.05%	10.85	51.13	2139.83
33% 0	10.75	51.34	2148.83
Acetic acid 0.025%	10.70	50.93	2131.53
0.05%	10.76	51.22	2143.47
Propionic acid 0.025%	10.74	51.25	2144.73
0.05%	10.64	50.52	2114.27
SEM	6.77	1.153	48.276
P value	NS	NS	NS

Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).
ME was calculated according to Forbs (1985).
ME = TDN × 41.85

Table 12. Carcass characteristics of growing NEZ rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments	Live Weight (g)	Slaughter Weight (%)	Fur (%)	Hot Carcass (%)	cold Carcass (%)
Main effect of (ALM)					
0.0	1880.6^{a}	96.655^{b}	13.182^{b}	56.673^{a}	53.531a
16.5%	1820.1^{c}	96.885^{a}	13.186^{ab}	58.777^{a}	56.008a
33%	1852.9^{b}	96.622^{b}	13.190^{a}	56.063^{b}	53.462b
SEM	9.566	9.45	1.78	5.761	5.457
P value	0.0005	0.001	0.01	0.001	0.003
Main effect of organic acid supplement					
Control 0	1810.6^{b}	96.940^{a}	13.134^{b}	57.158^{b}	54.286^{b}
Acetic acid 0.025%	1896.0^{a}	96.292^{b}	13.381^{a}	57.247^{b}	53.972^{ab}
0.05%	1801.2^{b}	97.019^{a}	13.158^{b}	57.873^{a}	55.502^{a}
Propionic acid0.025%	1875.3^{a}	96.817^{b}	13.182^{ab}	57.345^{a}	53.879^{c}
0.05%	1872.9^{a}	96.556^{b}	13.076^{c}	56.202^{b}	54.012^{ab}
SEM	12.341	12.19	2.29	7.432	7.04
P value	0.0001	0.0001	0.0001	0.0001	0.005
Interaction effect					
Acacia Organic acids					
0 0	1916.0^{d}	96.713^{ef}	13.326^{d}	56.242^{f}	52.630^{h}
Acetic acid, 0.025%	1869.0^{e}	96.106^{h}	13.153^{e}	55.062^{i}	52.766^{h}
0.05%	1773.3^{h}	97.023^{b}	12.972^{g}	58.010^{c}	56.048^{c}
Propionic acid 0.025%	1970.0^{b}	96.790^{e}	13.096^{ef}	57.513^{d}	53.492^{fg}
0.05%	1874.7^{e}	96.665^{f}	13.371^{c}	56.574^{e}	52.878^{h}
16.5% 0	1777.7^{h}	96.953^{d}	13.097^{ef}	59.082^{b}	56.404^{b}
Acetic acid 0.025%	2014.0^{a}	96.668^{ef}	13.423^{b}	59.935^{a}	56.495^{a}
0.05%	1765.3^{hi}	96.590^{g}	13.388^{bc}	58.897^{b}	56.421^{ab}
Propionic acid 0.025%	1713.0^{j}	96.649^{g}	13.076^{ef}	58.827^{b}	55.090^{f}
0.05%	1839.3^{f}	97.033^{b}	12.867^{h}	56.766^{de}	55.287^{d}
33% 0	1738.0^{i}	97.181^{a}	12.965^{gh}	56.197^{f}	53.941^{f}
Acetic acid 0.025%	1805.0^{g}	96.066^{h}	13.573^{a}	56.510^{e}	52.404^{i}
0.05%	1874.0^{e}	96.898^{de}	13.056^{f}	56.494^{ef}	53.858^{f}
Propionic acid 0.025%	1943.0^{c}	96.983^{c}	13.364^{c}	55.862^{g}	53.201^{g}
0.05%	1904.7^{d}	95.993^{i}	12.985^{g}	55.290^{h}	53.888^{f}
SEM	21.77	21.52	4.04	13.11	12.42
P value	0.0001	0.0001	0.0001	0.0001	0.0001

$^{a-h}$ Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

Table 13. Edible organs of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Kidney (%)	kidney fat (%)	Heart (%)	Liver(%)
Main effect of (ALM)					
0.0		0.776a	0.461^{a}	0.313^{a}	3.510^{b}
16.5%		0.760a	0.415^{c}	0.296^{b}	3.794^{a}
33%		0.721b	0.437^{b}	0.323^{a}	3.446^{c}
SEM		0.08	0.06	0.04	0.57
P value		0.0001	0.0001	0.0001	0.0001
Main effect of organic acid supplement					
Control	0	0.752^{c}	0.457^{a}	0.293^{c}	3.589^{b}
Acetic acid	0.025%	0.750^{cd}	0.455^{b}	0.314^{b}	3.615^{b}
	0.05%	0.778^{bc}	0.407^{d}	0.317^{b}	3.514^{b}
Propionic acid	0.025%	0.782^{a}	0.411^{c}	0.303^{c}	3.778^{a}
	0.05%	0.741^{d}	0.460^{a}	0.325^{a}	3.434^{c}
SEM		0.1	0.07	0.06	0.73
P value		0.0001	0.0001	0.0001	0.0001
Interaction effect					
Acacia	Organic acids				
0	0	0.793^{d}	0.509^{a}	0.302^{e}	3.697^{ef}
Acetic acid,	0.025%	0.757^{e}	0.492^{b}	0.346^{b}	3.340^{g}
	0.05%	0.790^{d}	0.405^{j}	0.319^{c}	3.516^{f}
Propionic acid	0.025%	0.781^{de}	0.431^{d}	0.302^{e}	3.697^{ef}
	0.05%	0.734^{h}	0.467^{c}	0.313^{d}	3.300^{h}
16.5%	0	0.812^{b}	0.447^{c}	0.288^{f}	3.916^{a}
Acetic acid	0.025%	0.765^{f}	0.449^{c}	0.303^{e}	3.744^{de}
	0.05%	0.803^{c}	0.402^{g}	0.289^{f}	3.853^{b}
propionic acid	0.025%	0.815^{a}	0.372^{h}	0.289^{f}	3.811^{c}
	0.05%	0.728^{i}	0.400^{g}	0.308^{d}	3.715^{e}
33%	0	0.634^{j}	0.411^{f}	0.287^{f}	3.168^{j}
Acetic acid	0.025%	0.732^{h}	0.423^{de}	0.293^{f}	3.749^{d}
	0.05%	0.738^{h}	0.414^{e}	0.359^{a}	3.189^{i}
Propionic acid	0.025%	0.743^{g}	0.425^{de}	0.275^{g}	3.832^{bc}
	0.05%	0.804^{c}	0.510^{a}	0.306^{d}	3.747^{d}
SEM		0.18	0.13	0.1	1.29
P value		0.0001	0.0001	0.0001	0.0001

[a-h] Means within a column not sharing similar superscripts are significantly different (P<0.05). NS (P>0.05).

Table 14. Inedible organs of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Cecum (%)	Stomach (%)	Intestine (%)	Lungs (%)
Main effect of (ALM)					
0.0		5.986^{b}	5.083	12.021^{a}	0.640^{a}
16.5%		5.818^{c}	5.229	11.109^{c}	0.617^{b}
33%		6.172^{a}	5.362	11.573^{b}	0.613^{b}
SEM		0.57	2.36	2.98	0.07
P value		0.001	NS	0.0001	0.0001
Main effect of organic acid supplement					
Control	0	5.959^{d}	5.482	10.578^{c}	0.616^{b}
Acetic acid	0.025%	5.976^{c}	4.984	11.807^{ab}	0.628^{a}
	0.05%	6.037^{b}	5.309	11.680^{b}	0.625^{b}
Propionic acid	0.025%	6.301^{a}	5.128	11.958^{a}	0.623^{b}
	0.05%	5.685^{cd}	5.229	11.809^{ab}	0.625^{b}
SEM		0.74	3.04	3.84	0.09
P value		0.0001	NS	0.0001	0.0001
Interaction effect					
Acacia	Organic acids				
0	0	5.461^{h}	5.163^{g}	11.890^{d}	0.641^{b}
Acetic acid,	0.025%	6.386^{c}	4.732^{i}	12.805^{a}	0.603^{g}
	0.05%	6.178^{d}	5.541^{c}	11.257^{h}	0.645^{b}
Propionic acid	0.025%	6.529^{a}	5.209^{f}	12.482^{c}	0.648^{b}
	0.05%	5.364^{j}	4.783^{h}	11.625^{e}	0.662^{a}
16.5%	0	5.953^{hf}	5.744^{b}	9.670^{k}	0.619^{e}
Acetic acid	0.025%	6.081^{e}	5.325^{e}	11.454^{f}	0.648^{b}
	0.05%	5.753^{g}	5.415^{d}	11.143^{i}	0.607^{fg}
propionic acid	0.025%	5.811^{f}	4.691^{i}	11.899^{d}	0.609^{f}
	0.05%	5.463^{h}	4.949^{gh}	11.356^{fg}	0.598^{h}
33%	0	6.513^{a}	5.565^{c}	10.065^{j}	0.586^{i}
Acetic acid	0.025%	5.427^{i}	4.863^{h}	11.169^{i}	0.631^{c}
	0.05%	6.179^{d}	4.993^{gh}	12.593^{b}	0.624^{d}
Propionic acid	0.025%	6.496^{b}	5.430^{cd}	11.480^{f}	0.610^{f}
	0.05%	6.213^{d}	5.944^{a}	12.433^{c}	0.615^{e}
SEM		1.31	5.36	6.78	0.17
P value		0.0001	0.002	0.0001	0.0001

$^{a-k}$ Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

The relative weights of kidneys significantly ($P \leq 0.01$) decreased when rabbits were fed 33% ALM-diet as compared to the group fed 16.5% ALM-diet or control. Rabbits fed 16.5% ALM-diet were significantly the same as those fed the control diet. Kidney fat was significantly decreased with inclusion of ALM in the diet. Significant ($P \leq 0.01$) differences were observed for heart, liver, cecum and intestine percentages, however, these differences had no trend, this might be due to the low number of the samples used in this study. Stomach percent was not affected by different levels of ALM.

In this respect, El-Gendy (1999) suggested that percentages of each for dressing, carcass, giblets and alimentary tract weights were insignificantly affected by feeding rabbits on a diet containing up to 30% ALM. In addition, Abdel-Samee *et al. (*1992) reported similar results on dressing weight and giblet weight percentages with rabbit fed 100, 80. 60 and 40% concentrate plus acacia leaves.

When the effect of ALM levels was over looked, the results indicated that, when applying acetic acid at 0.025, propionic acid at 0.025 or 0.05%, preslaughter weight improved ($P \leq 0.01$) by 4.7, 3.6 and 3.4% in comparison with control. Also, inclusion of 0.05% acetic acid or 0.025% propionic acid in the diets resulted in significant ($P \leq 0.01$) increase in hot carcass percentage, however, only 0.05% acetic acid increased ($P \leq 0.01$) cold carcass percentage in comparison with control. Fur percent recorded the highest value in the group received diet containing 0.025% acetic acid, however the lowest group in this trait was observed in rabbits fed 0.05% propionic acid containing diet.

Concerning liver and kidney weight percentages, the results demonstrated that the group fed 0.025% propionic acid recorded the highest values, however, the group fed 0.05% propionic acid recorded the lowest values. The lowest value of kidney fat percent was observed in all groups fed organic acids in their diets in comparison with the control one.

Cecum and intestine percentage recorded the highest values in the group received 0.025% propionic acid in their diet.

Significant ($P \leq 0.01$) effect due to the interactions between levels of ALM and organic acids was detected in all carcass studied traits. For preslaughter weight, hot and cold carcass, the best results were obtained when rabbits fed 16.5% ALM-diet with supplementation of 0.025% acetic acid. The highest kidney weight percentage and the lowest kidney fat were recorded in the group fed 16.5% ALM with 0.025 propionic acid.

4.2.5. Hematological parameters of the blood:

Some hematological parameters of blood have been used as indicators of the nutritional and physiological status of growing NZW rabbits at 13 weeks of age. The results of the estimated hematological blood parameters are presented in Table 15.

Red blood cells (RBCs) count, hemoglobin (HB), packed cell volume% (PCV) and white blood cells (WBCs) as affected by different treatments are presented in Table 15 and Figs. 15 and 16.

Table 15. Hematological parameter of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		HB(g/dl)	RBC	PCV %	WBC
		Hematological parameter			
Main effect of (ALM)					
	0.0	13.40[a]	5.78[a]	44.08[a]	9.48[b]
	16.5%	13.16[b]	5.73[b]	42.08[b]	9.69[a]
	33%	12.05[c]	5.10[c]	41.74[c]	8.11[c]
	SEM	0.016	0.009	0.051	0.031
	P value	0.0001	0.0001	0.0001	0.0001
Main effect of organic acid supplement					
Control	0	12.85[b]	5.62[a]	42.50	9.07[b]
Acetic acid	0.025%	12.85[b]	5.61[a]	42.65	9.09[ab]
	0.05%	12.87[ab]	5.60[ab]	42.70	9.14[a]
Propionic acid	0.025%	12.91[a]	5.56[b]	42.62	9.06[b]
	0.05%	12.87[ab]	5.28[c]	42.70	9.10[ab]
	SEM	0.013	0.013	0.066	0.013
	P value	0.0001	0.0001	NS	0.0001
Interaction effect					
Acacia	Organic acids				
0	0	13.32	5.81[c]	44.03	9.56
Acetic acid,	0.025%	13.41	5.77[d]	44.12	9.48
	0.05%	13.43	5.80[c]	44.10	9.43
Propionic acid	0.025%	13.41	5.74[e]	44.09	9.43
	0.05%	13.41	5.80[c]	44.05	9.50
16.5%	0	13.17	5.92[a]	42.03	9.54
Acetic acid	0.025%	13.15	5.89[b]	42.02	9.72
	0.05%	13.15	5.90[ab]	42.07	9.77
Propionic acid	0.025%	13.18	5.88[b]	42.21	9.68
	0.05%	13.14	5.03[h]	42.10	9.74
33%	0	12.04	5.15[f]	41.44	8.12
Acetic acid	0.025%	11.99	5.16[f]	41.82	8.08
	0.05%	13.32	5.08[g]	44.03	9.56
Propionic acid	0.025%	13.41	5.07[g]	44.12	9.48
	0.05%	13.43	5.03[h]	44.10	9.43
	SEM	0.028	0.022	0.115	0.069
	P value	NS	0.0001	NS	NS

[a-h] Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

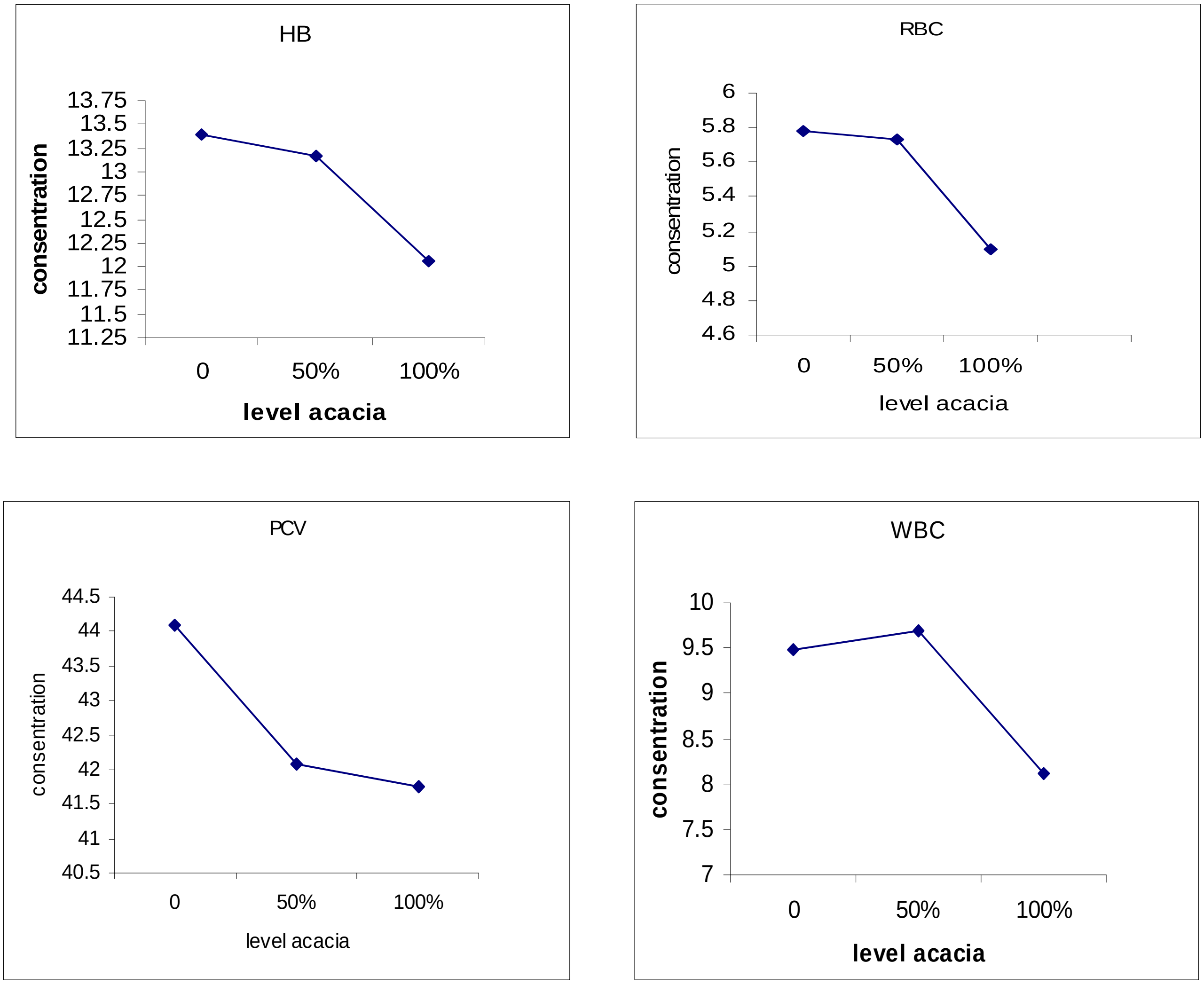

Fig. 15. Mean value of HB, RBC, PCV and WBC at different levels of acacia leaves meal

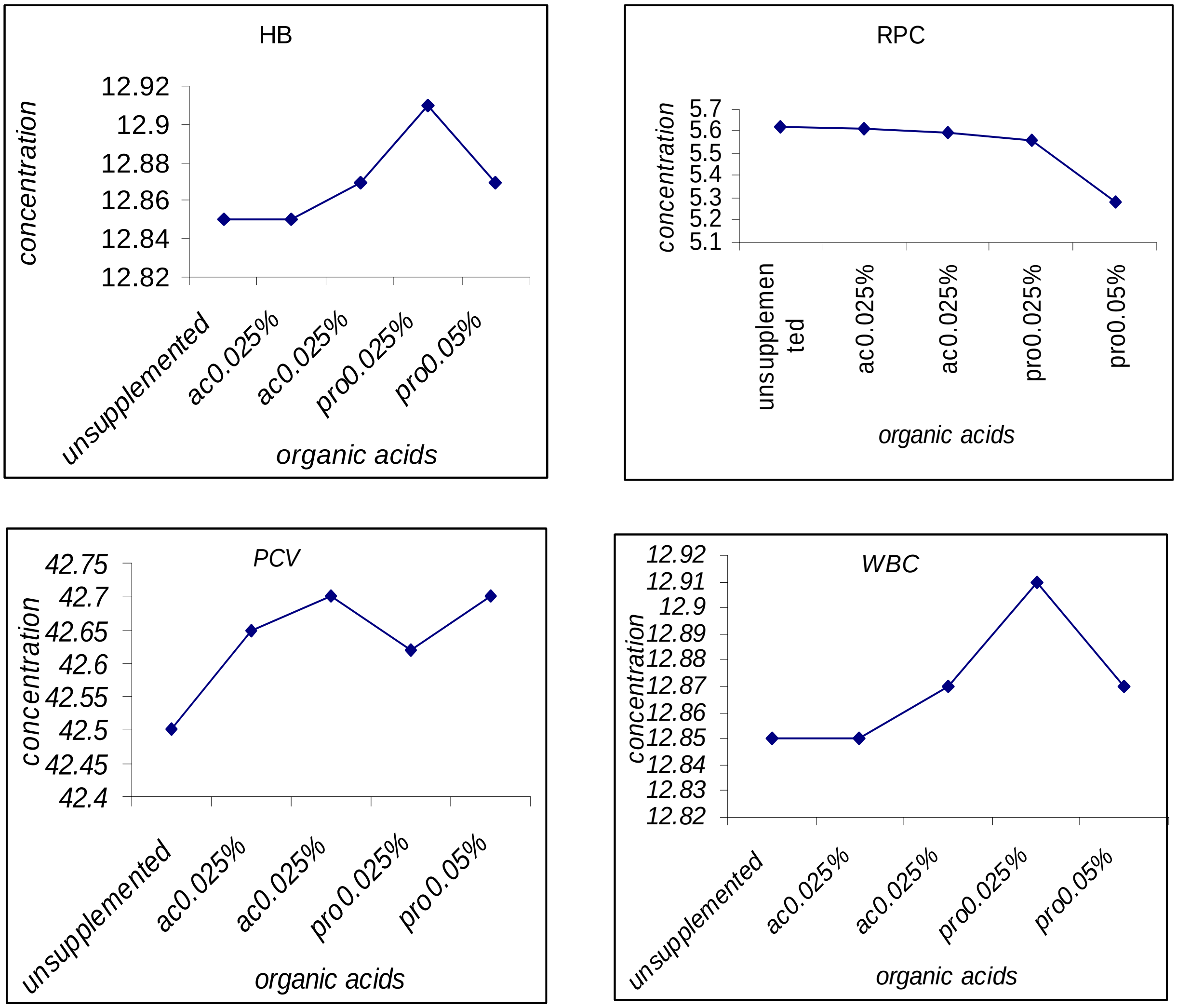

Fig. 16. Mean value of HB, RBC, PCV and RBC at different levels of organic acids

However, mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) are presented in Table 16 and Figs. 17 and 18

Red blood cells, hemoglobin (HB) and packed cell volume (PCV) were significantly ($P \leq 0.0001$) decreased with increasing level of ALM in the diet. However, white blood cells were significantly ($P \leq 0.0001$) increased in the group fed 16.5% ALM and decreased in the group fed 33% ALM in comparison with control (Table 15 and Fig. 14).

Results presented in Table 16 and Fig. 16 showed significant $P \leq 0.0001$) impact of 33% ALM-diets on mean corpuscular hemoglobin (MCH) and mean corpuscular volume (MCV). They increased to surpass the control one by 2.1 and 7.4%, respectively. However, at this level mean corpuscular hemoglobin concentration (MCHC) was significantly decreased. The decrease es in HB, RBCs and PCV of rabbits could indicate anemia as evidenced by any significant increase in MCV and significant decrease in MCHC values (Al-Redhaiman *et al.*, 2003).

In this respect, Kamel and Mervat (2000) showed that the high levels of *Acacia saligna* 60% gave a decrease in Hb, RBCs and PCV. Knowles *et al.*, 2000; Egli and Blum, 1998; Zanker *et al.*, 2001a; Mohri *et al.* (2006), suggested that, because the erythrocyte number remained stable, whereas hemoglobin concentration and PCV decreased, there was development toward microcytes and hypochromic anemia. Mohri *et al.* (2006) showed that regard to a declining trend in PCV and hemoglobin concentration while RBC showed an increasing trend, may implicate a state of microcytic change probably due to iron deficiency. The availability of sulphur and iron also becomes limiting to animals consuming tannin-rich foliage Robyn and Anthony. (2002).

The positive correlations between PCV, RBC, and HB with performance evinced in this study agreed with the previous results on rabbits and broiler chickens (Onifade and Tewe, 1993; Onifade, 1997; Onifade and Abu, 1998).

Irrespective of ALM levels, the results showed that addition of propionic acid to the diets had negative effect on RBCs count in comparison with control; however it had positive effect on HB concentration. Also, insignificant effect was detected on PCV and WBCs. Acetic acid had insignificant effect on HB, RBCs, PCV and WBCs, except the level of 0.05% acetic acid it increased ($P \leq 0.0001$) concentrations of WBCs in comparison with control.

The obtained results (Table 16) indicated that 0.025 and 0.05% propionic acid supplementations to the diet resulted in significant ($P \leq 0.0001$) increase in MCH and MCV in comparison with control. Also, 0.05% acetic acid increased the MCV value, however, MCHC insignificantly affected by organic acid supplementations.

In general, the organic acids showed insignificant deterioration effect on blood hematological parameters.

Table 16. Hematological parameter of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		MCH	MCV	MCHC
		Hematological parameter		
Main effect of (ALM)				
0.0		23.17^{b}	76.25^{b}	30.39^{b}
16.5%		23.08^{b}	73.82^{c}	31.27^{a}
33%		23.65^{a}	81.90^{a}	28.87^{c}
SEM		0.055	0.180	0.046
P value		0.0001	0.0001	0.0001
Main effect of organic acid supplement				
Control	0	22.87^{c}	75.79^{c}	30.22
Acetic acid	0.025%	22.94^{c}	76.29^{bc}	30.12
	0.05%	23.03^{c}	76.60^{b}	30.13
Propionic acid	0.025%	23.24^{b}	76.87^{b}	30.28
	0.05%	24.43^{a}	81.07^{a}	30.14
SEM		0.071	0.243	0.06
P value		0.0001	0.0001	NS
Interaction effect				
Acacia	Organic acids			
0	0	22.95^{f}	75.83^{e}	30.26^{c}
Acetic acid,	0.025%	23.29^{de}	76.52^{de}	30.39^{bc}
	0.05%	23.15^{e}	76.04^{e}	30.45^{b}
Propionic acid	0.025%	23.38^{de}	76.85^{d}	30.43^{b}
	0.05%	23.14^{e}	75.99^{e}	30.44^{b}
16.5%	0	22.25^{g}	70.99^{g}	31.34^{a}
Acetic acid	0.025%	22.32^{g}	71.30^{fg}	31.31^{a}
	0.05%	22.27^{g}	71.27^{fg}	31.25^{a}
propionic acid	0.025%	22.42^{g}	71.78^{f}	31.22^{a}
	0.05%	26.14^{a}	83.76^{a}	31.21^{a}
33%	0	23.41^{d}	80.53^{c}	29.06^{d}
Acetic acid	0.025%	23.24^{e}	81.05^{c}	28.67^{e}
	0.05%	22.95^{c}	82.50^{b}	30.26^{e}
Propionic acid	0.025%	23.29^{b}	81.96^{b}	30.39^{d}
	0.05%	23.15^{b}	83.45^{a}	30.45^{e}
SEM		0.123	0.421	0.104
P value		0.0001	0.0001	0.0001

[a-h] Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

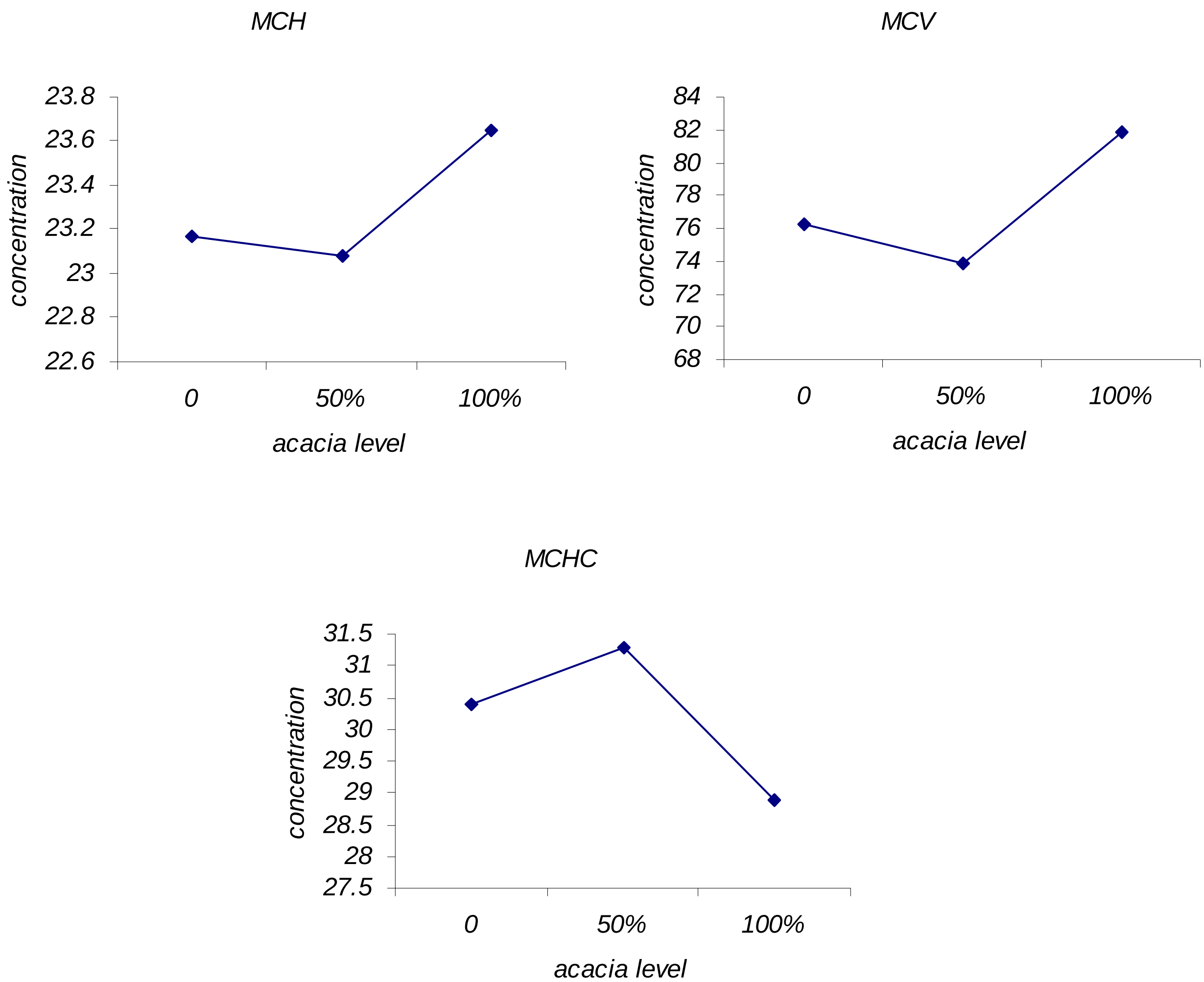

Fig. 17. Means value of MCH, MCV and MCHC at different level of acacia leaves meal

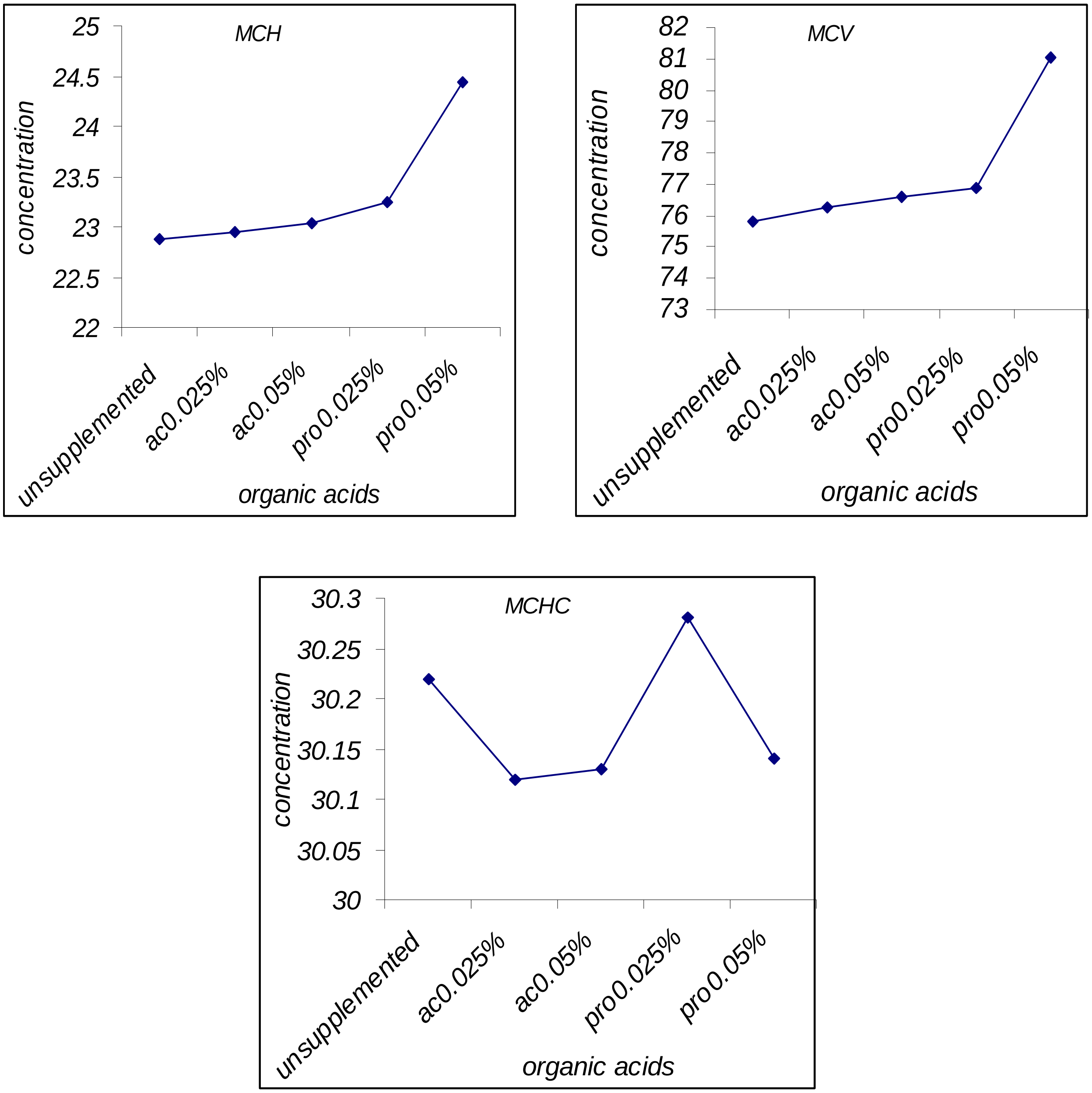

Fig. 18. Means value of MCH, MCV and MCHC at different value of organic acids

Acacia leave meal levels and organic acids supplementation interaction had no any significant effect on HB, PCV and WBCs. However, RBCs significantly affected by the interaction and the group fed 16.5% ALM-diet recorded the highest value among all the experimental groups (Table 15). Also, significant effect due to the interaction was observed on MCH and MCV, since feeding 16.5% ALM-diet with 0.05% propionic acid as compared to the other experimental groups showed the highest values. As a general trend, feeding 16.5% ALM-diets to the growing NZW rabbits with or without organic acids supplementation resulted in increasing MCHC.

4.2.6. Effect of experimental treatments on biochemical traits at 13 weeks of age:

Blood biochemical parameters of NZW rabbits at 13 weeks, which were measured in the present study, were selected to reflect the metabolic status of rabbits and to monitor their health sub-clinically.

4.2.6.1. Liver Function Determination:

4.2.6.1.1. Plasma asparatate aminotransferase (AST), alanine aminotransferase (ALT) and Thiobarbituric acid reacting substances (TBARS) concentrations:

The function of plasma transaminases (AST and ALT) enzymes in the living cells is to transfer the amino group from amino acid to synthesize another one and play an important role in gluconeogenesis (Harper *et al.,* 1977). Rosen *et al.* (1958) found that the increase in transaminases activity is related to amino acid imbalance which indicates protein catabolism. In addition, Kuttler and Marble (1958) and Cornelius (1960) reported that the serum transaminases activity is considered as an index for the diagnosis of tissue necrosis, hepatic injury and muscular degeneration.

Plasma asparatate aminotransferase (AST) concentration (Table 17) was insignificantly affected by inclusion ALM in the diet up to 16.5%, however, it increased ($P \leq 0.0001$) by 10.0% in the plasma of rabbits fed 33% ALM-diet as compared to control. Significant ($P \leq 0.0001$) linear effects on alanine aminotransferase (ALT) were detected in the groups of rabbits fed 16.5 or 33% ALM in their diets. The elevation of AST and ALT in the plasma of rabbits could indicate on the liver dysfunction and necrosis. Since these enzymes are considered to be very sensitive indicator of liver cell damage and dysfunction (De Ritis, 1958 and Sherlock, 1975).

In this respect, Abou- Zeid *et al. (*2001) found that activities of (ALT) and (AST) were increased with increasing (Azolla hay) levels in the diets. This suggests that a low background rate of both enzymes was released into the serum from the liver. The implication is a normal functioning of the hepatic tissues (Walmsley and White, 1994 and Rosenthal, 1997). On the contrary, the significantly higher ($P \leq 0.05$) AST in rabbits fed the 16.6% ALM-diet suggests considerable leakage of the hepatic enzymes into the blood arising from a certain degree of damage of the hepatocyte and/or other tissues (Walmsley and White, 1994; Rosenthal, 1997). However, such a definitive conclusion was difficult in the present study because there was a lack of morbidity and mortality associated with the marked increase in AST and ALT. Other non-hepatic conditions, macro- and micro-nutrient deficiencies, might have caused the observed elevated activities (Walmsley and White, 1994; Adisa and Odutuga, 1998). Asanuma *et al.* (1997) have indicated that in the absence of organ-specific disease, a high serum concentration of the aminotransferases may be a resultant of formation of aminotransferase ± immunoglobulin complex.

Irrespective of ALM levels, the results in Table 17 and Figs. 19 and 20 demonstrated that AST was significantly ($P \leq 0.05$) increased in the group of rabbits fed diets supplemented with 0.05% acetic acid in comparison with control, however, ALT concentration was significantly ($P \leq 0.01$) decreased when NZW rabbits fed diet containing 0.025% acetic acid. It can be observed that the mean values of the AST concentration obtained in the current study fell within the normal physiological range. 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.

4.2.6.1.2. Plasma total protein, albumin and globulin concentrations:

The values of total protein, albumin, globulin and albumin/globulin ratio are shown in Table 18 and Figs. 21 and 22.

The results showed that the inclusion of ALM in NZW rabbit diets at the studied levels; irrespective of organic acids supplementation affect plasma total protein, albumin, globulin concentrations and the albumin/globulin ratio. Total protein was significantly decreased by feeding 16.5 or 33% ALM-diets, however, albumin concentration was significantly ($P \leq 0.0001$) decreased when NZW rabbits fed 33% ALM in their diet as compared to the control. Feeding rabbits diet containing 16.5% ALM had also significant ($P \leq 0.0001$) decrease in globulin concentration. The decrease in globulin concentration in this group might be explaining the increasing number of dead animal in this group (Table 3). Kholif *et al.* (1996) reported that the normal globulin value indicates good immunity status of the animal.

In this concern, El-Eraky and Mohamed (1996) and El-Gendy (1999) found that NZW rabbits fed acacia leaves up to 30% for 8 weeks showed non significant changes in total lipids and total protein. On the other hand, Abdel-Samee *et al. (*1992) found that up to 40% acacia leaves can be included in the diets of growing rabbits without negative effects on the physiological functions.

When the effect of ALM levels was overlooked, the results showed that organic acids supplementation had significant effect on serum total protein, globulin concentrations and albumin / globulin ratio. Only propionic acid at level 0.025% showed significant ($P \leq 0.01$) decrease in total protein and globulin concentrations and significant ($P \leq 0.05$) increase in albumin / globulin ratio in comparison with the control group fed diet without supplementing organic acids. Albumin concentration was not affected by organic acid supplementations. 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.

Table 17. Blood Biochemicals of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		Glo(g/dl)	Uream (g/dl)	TB(g/dl)	AST(µ/L)	ALT(µ/L)
Main effect of (ALM)						
0.0		107.95^{a}	43.541^{b}	0.262^{b}	64.764^{b}	36.366^{c}
16.5%		107.61^{a}	41.695^{b}	0.263^{b}	64.636^{b}	36.686^{b}
33%		92.09^{b}	50.490^{a}	0.287^{a}	71.242^{a}	43.148^{a}
SEM		0.218	1.565	0.001	0.106	0.041
P value		0.0001	0.01	0.0001	0.0001	0.0001
Main effect of organic acid supplement						
Control	0	102.35	46.300	0.268	66.588^{b}	38.832^{ab}
Acetic acid	0.025%	102.58	46.174	0.271	66.813^{ab}	38.514^{c}
	0.05%	102.80	46.279	0.273	67.171^{a}	38.688^{b}
Propionic acid	0.025%	102.56	46.080	0.270	66.842^{ab}	38.858^{a}
	0.05%	102.47	46.378	0.270	66.990^{ab}	38.775^{ab}
SEM		0.281	0.018	0.001	0.136	0.053
P value		NS	NS	NS	0.05	0.0004
Interaction effect						
Acacia	Organic acids					
0	0	107.35^{bc}	43.74	0.262	64.720^{f}	36.547^{e}
Acetic acid,	0.025%	107.44^{bc}	43.65	0.262	64.303^{g}	36.207^{g}
	0.05%	109.50^{a}	43.88	0.265	65.220^{e}	36.273^{g}
Propionic acid	0.025%	107.83^{b}	43.21	0.262	64.953^{ef}	36.397^{fg}
	0.05%	107.44^{bc}	43.22	0.262	64.626^{f}	36.407^{f}
16.5%	0	107.70^{bc}	44.39	0.261	64.613^{fg}	36.887^{d}
Acetic acid	0.025%	107.05^{c}	44.50	0.264	64..077^{g}	36.077^{h}
	0.05%	107.62^{bc}	44.23	0.266	65.057^{e}	36.757^{c}
propionic acid	0.025%	107.96^{b}	44.35	0.263	64.820^{f}	36.857^{d}
	0.05%	107.72^{b}	31.01	0.263	64.617^{fg}	36.857^{d}
33%	0	91.81^{ef}	50.77	0.283	70.433^{d}	43.063^{b}
Acetic acid	0.025%	93.26^{d}	50.38	0.289	72.060^{a}	43.260^{a}
	0.05%	91.26^{e}	50.72	0.290	71.237^{c}	43.037^{b}
Propionic acid	0.025%	91.89^{ef}	50.68	0.288	70.753^{d}	43.320^{a}
	0.05%	92.27^{e}	49.90	0.286	71.727^{b}	43.063^{b}
SEM		0.487	3.5	0.002	0.236	0.041
P value		0.01	NS	NS	0.0005	0.0002

[a-h] Means within a column not sharing similar superscripts are significantly different (P<0.05). NS (P>0.05).
T.P= Total protein, Glo= glucose

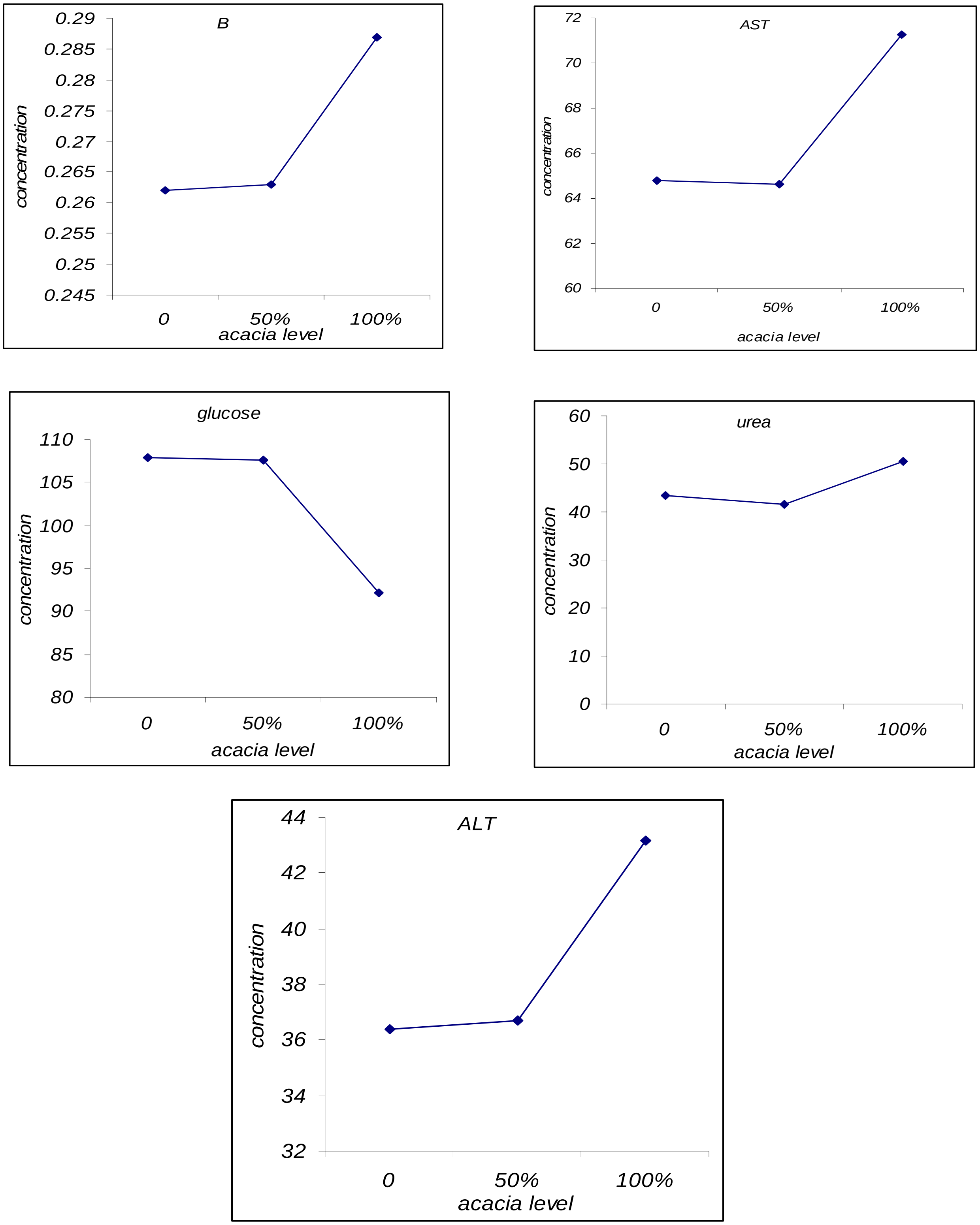

Fig. 19. Means value of Glucose, Urea, TBARS, AST and ALT at different level of acacia level

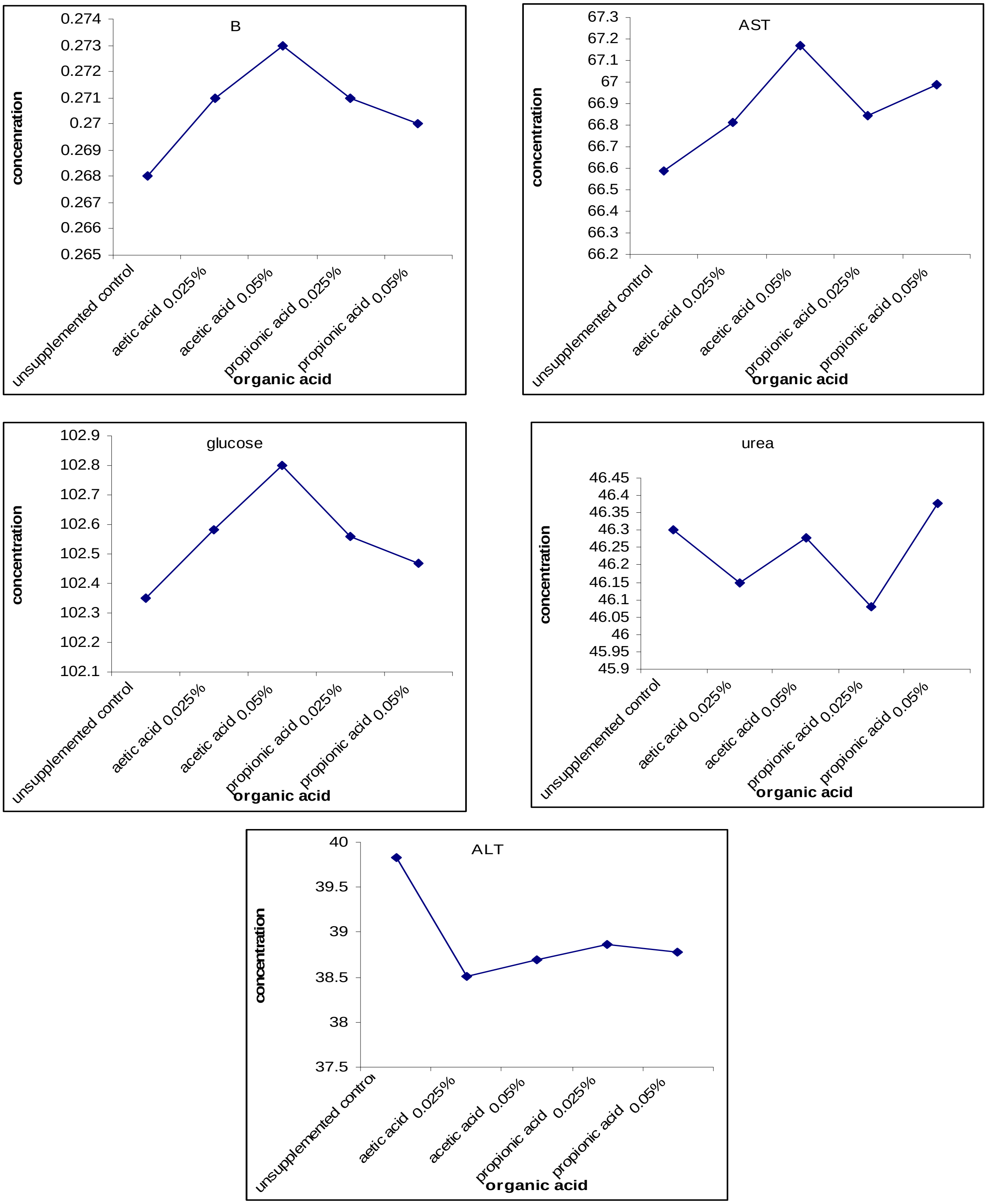

Fig. 20. Means value of Glucose, Urea, TBARS, AST and ALT at different level of organic acids

Table 18. Blood Biochemicals of growing NZW rabbits as affected by feeding diets containing different levels of acacia and supplemented with organic acids.

Treatments		TP(g/dl)	Albumin (g/dl)	Globulin(g/dl)	A/G ratio
Main effect of (ALM)					
0.0		6.800^{a}	3.782^{a}	3.015^{a}	1.260^{b}
16.5%		6.720^{b}	3.830^{a}	2.891^{b}	1.327^{a}
33%		6.070^{c}	3.140^{b}	2.928^{ab}	1.072^{c}
SEM		0.019	0.029	0.031	0.021
P value		0.0001	0.0001	0.02	0.0001
Main effect of organic acid supplement					
Control	0	6.547^{a}	3.562	2.986^{a}	1.195^{b}
Acetic acid	0.025%	6.555^{a}	3.590	2.966^{a}	1.213^{b}
	0.05%	6.580^{a}	3.588	2.991^{a}	1.201^{b}
Propionic acid	0.025%	6.404^{b}	3.615	2.789^{b}	1.301^{a}
	0.05%	6.548^{a}	3.554	2.993^{a}	1.190^{b}
SEM		0.025	0.037	0.040	0.027
P value		0.0002	NS	0.004	0.03
Interaction effect					
Acacia	Organic acids				
0	0	6.870^{a}	3.743	3.127	1.200
Acetic acid,	0.025%	6.853^{ab}	3.900	2.953	1.323
	0.05%	6.807^{b}	3.807	3.000	1.277
Propionic acid	0.025%	6.673^{c}	3.787	2.887	1.317
	0.05%	6.780^{b}	3.673	3.107	1.187
16.5%	0	6.770^{b}	3.900	2.870	1.360
Acetic acid	0.025%	6.700^{c}	3.753	2.947	1.273
	0.05%	6.823^{ab}	3.750	3.073	1.220
propionic acid	0.025%	6.500^{d}	3.866	2.633	1.467
	0.05%	6.797^{b}	3.863	2.933	1.317
33%	0	6.003^{f}	3.043	2.960	1.026
Acetic acid	0.025%	6.113^{e}	3.117	2.997	1.043
	0.05%	6.110^{e}	3.210	2.900	1.107
Propionic acid	0.025%	6.040^{ef}	3.193	2.846	1.120
	0.05%	6.067^{f}	3.127	2.940	1.067
SEM		0.043	0.064	0.069	0.047
P value		0.01	NS	NS	NS

$^{a-h}$ Means within a column not sharing similar superscripts are significantly different ($P<0.05$). NS ($P>0.05$).

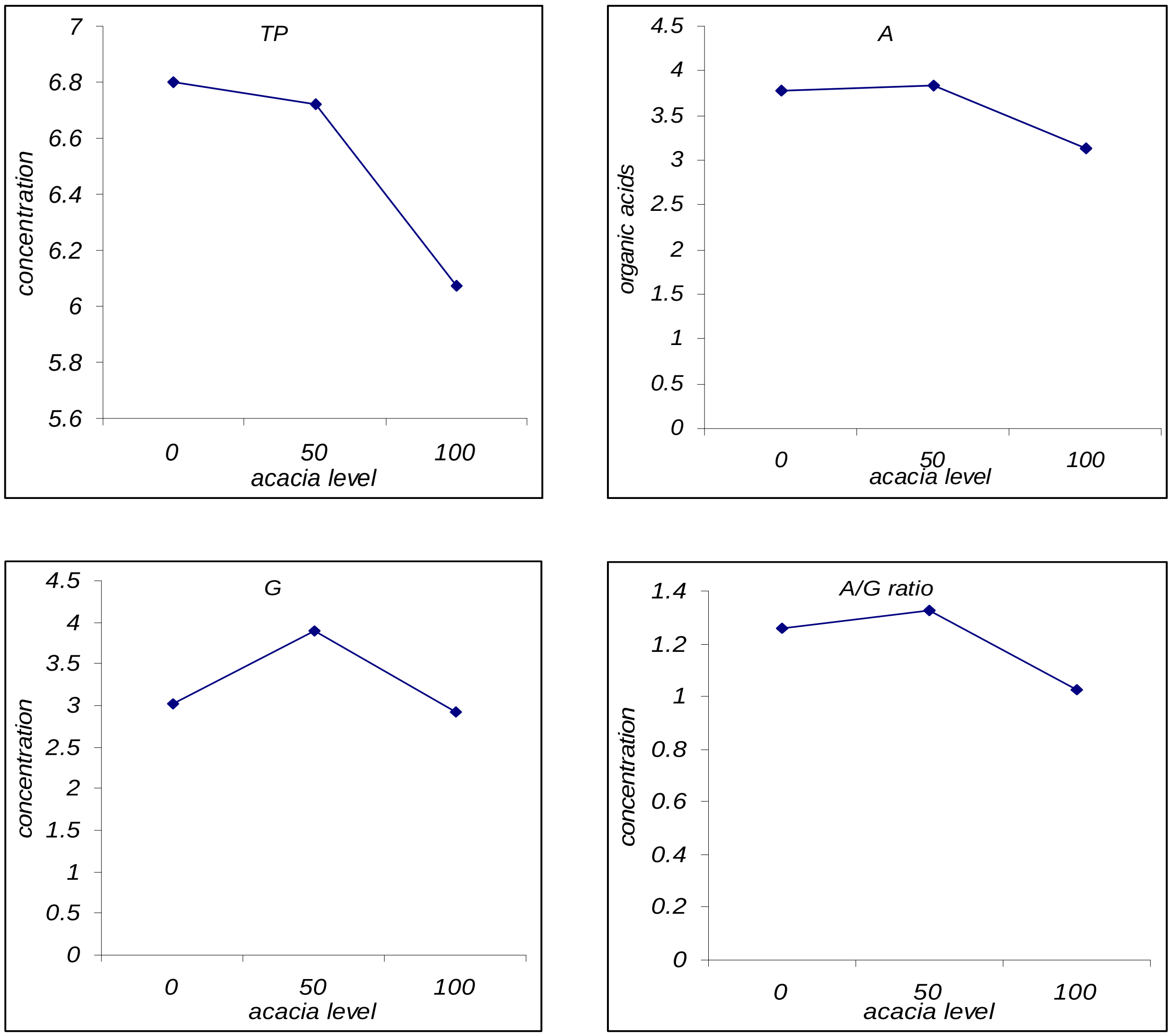

Fig. 21. Means value of TP, A, G and A/G ratio at different level of acacia leaves meal

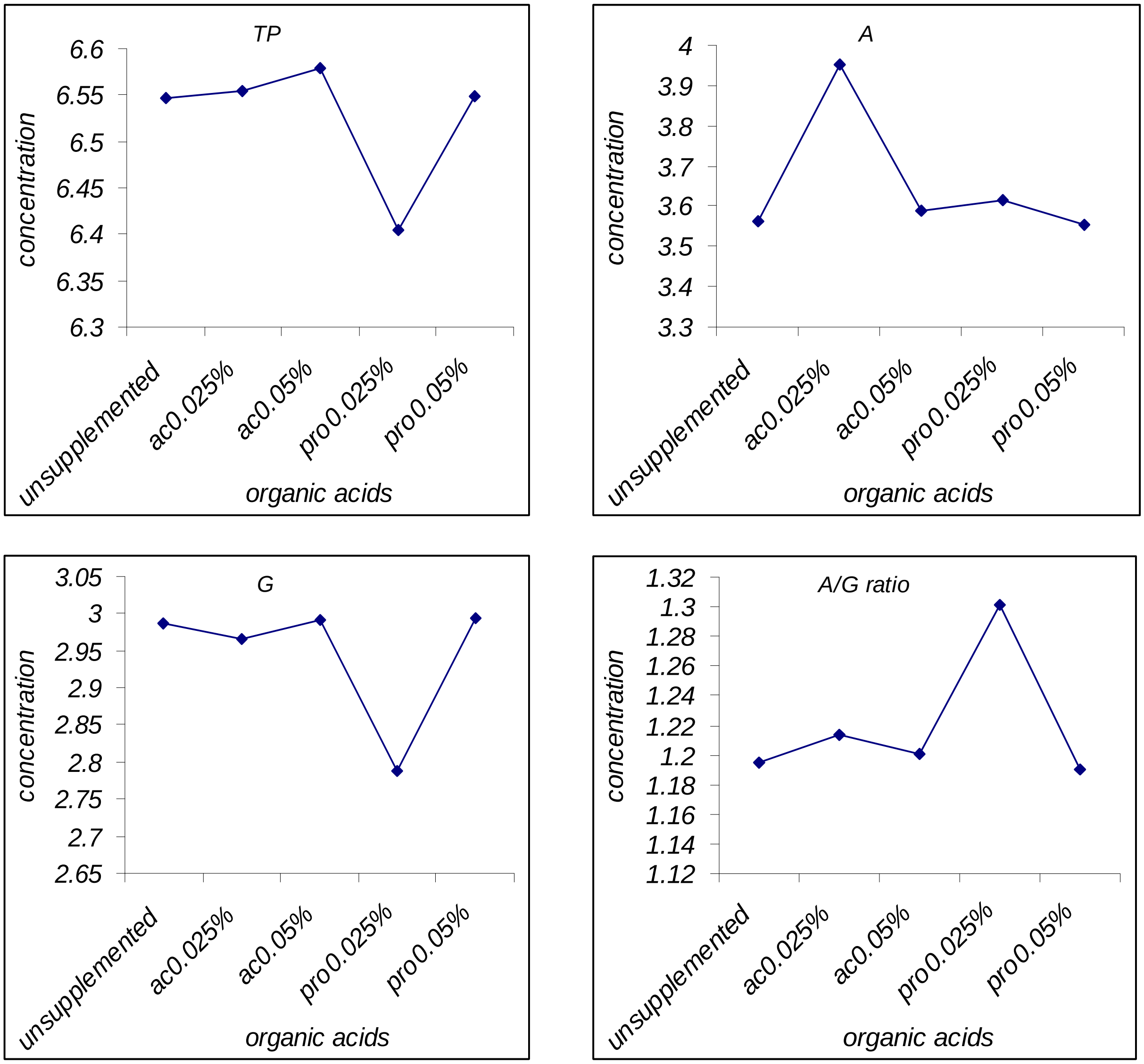

Fig 22. Means value of TP, A, G and A/G at different level of organic acids.

The interaction between ALM levels and organic acids supplementation was recorded on plasma total protein only, however, it not affected on plasma albumin, globulin and the ratio between them.

4.2.6.1.3. <u>Plasma glucose concentration</u>:

Results presented in Table 17 showed that plasma glucose recorded the same concentrations in the group fed control diet or those fed diet containing 16.5% ALM, however, it significantly ($P \leq 0.0001$) decreased in the group fed 33% ALM in their diet. Wadood *et al.* *(*1989) indicated that the powdered seeds of *Acacia arabica* act by initiating the release of insulin from pancreatic beta cells of normal rabbits.

Irrespective of ALM levels, the results showed that plasma glucose concentrations were insignificantly affected by organic acid supplementations.

The significant effect due to the interaction between ALM levels and organic acids was found. The highest glucose concentration was observed in the group fed control diet with 0.05% acetic acid in comparison with control, while the lowest values were observed in the groups fed 33% ALM-diet without or supplemented with different organic acids.

4.2.6.1.4. <u>Plasma urea-N concentration</u>:

Data on plasma urea-N concentration for the different treated groups are presented in Table 17 and Figs. 19 and 20. The urea-N concentration was gradually increased with increasing level of ALM in the diet and it reached significant when rabbits fed the diet containing 33% ALM. In this respect, El-Eraky and Mohamed (1996) and El-Gendy (1999) found that NZW rabbits fed acacia leaves up to 30% for 8 weeks showed non significant changes in urea-N.

Irrespective of ALM levels, the results showed that organic acid supplementation had no effect on urea-N concentration.

Interaction between ALM levels and organic acid supplementation did not show any significant effect on plasma urea-N concentration.

4.2.6.2. Plasma lipid peroxidation:

Formation of plasma thiobarbituric acid-reactive substances (TBARS) was insignificantly affected by inclusion ALM in the diet up to 16.5% (Table 17). However, it significantly ($P \leq 0.0001$) increased by 9.5% in the plasma of rabbits fed 33% ALM-diet, respectively, as compared to control. The increase in the formation of TBARS in plasma of rabbits could indicate lipid peroxidation in the plasma. These results were disagreed with the results of Yousef (2005). He stated that the formation of thiobarbituric acid-reactive substances was significantly ($P \leq 0.05$) decreased by Acacia supplementation. Saleem *et al.* *(*20010 reported that the extracts of *Acacia nilotica* were stronger antioxidants than alpha-tocopherol. The preferable effect of this material was demonstrated by Dafallah and Al-Mustafa (1996) who found that the aqueous extracts of *Acacia nilotica* contain phytoconstituents such as flavonoids, polysaccharides and organic acids that may be mainly responsible for their pharmacological activities. Fran *et al. (*2000) reported that flavonoides (isoflavones) reduce the formation of radicals and reactive oxygen by decomposition of hydrogen peroxide without generating radicals, by quenchingactive singled oxygen, and by trapping radicals before they reach a cellular target. The disagreement between the study of Yousef (2005) and the present study might be attributed to either the difference in source of Acacia, the specific phenolic amines present, the differences in the response of different species or age of the animals.

When the effect of ALM levels was over looked, the obtained results demonstrated that TBARS concentrations were insignificantly affected by type of organic acids. Also the interactions between the studied traits were not found.

In general, further experimentation is needed to specify its health- promoting effect in rabbits in more details.

4.3. Organic acids preservatives effects:

This study has shown the interaction between fungal colonization and organic acids as diet preservatives.

Table 19 shows the fungal behavior in the diets treated with different types and concentrations of organic acids. It is clear that all the inclusion rates of the different organic acids had anti-mould effect. While acetic acid has stronger anti-mould activity than propionic acid after 7, 14 and 21 days of storage the diet. Acetic acid caused more fixation of the total fungal count when added at 0.025 or 0.05% level as compared to propionic acid. The results showed also that propionic acid at 0.025% level caused enhancement of the fungal growth at 14 and 21 days as compared to the high level (0.05%). However, both levels of propionic acid showed positive effect on fixation of the total fungal count. These results showed the beneficial effects of acetic and propionic acids, when used against different types of fungi which were indicated by the reduction of total fungal count. This result is supported by the finding of Marine *et al. (*2002) and El-Moghazy *et al. (*2003). El-Moghazy *et al. (*2003) reported that acetic acid, formic acid and propionic acid caused fixation of the total fungal count when added at lower concentrations and inclusion rates than the inhibitory doses, while citric acid, fumaric acid and lactic acid caused enhancement of the fungal growth when used at lower levels. It is clear from Table 19 that, the total count of fungi increased with increasing number of days of storage the diets in the control group.

The higher growth performance of rabbits fed acetic acid supplemented group could be attributed to its strongest anti-mould activity as compared to rabbits fed propionic acid or both organic acids in comparison with control.

In conclusion, results indicated that ALM could be fed at 16.5% level with 0.025% acetic acid in their diet to obtain the highest value of live body weight, viability rate, enhancing feed intake, and improved feed conversion ratio without any detrimental effects on blood parameters. Also the level of 0.025% acetic acid had stronger anti-mould activity after 7, 14 and 21 days of storage the diet.

Table 19. Effect of addition acetic acid or propionic acid on total count of fungi in feed.

Treatments		Time of count fungi			
		0	7 Day	14 Day	21Day
Acacia treatment					
0	0	Log 10^5	Log 10^6	Log 10^8	Log 10^{10}
Acetic acid,	0.025%	Log 10^5	Log 10^5	Log 10^5	Log 10^5
	0.05%	Log 10^5	Log 10^5	Log 10^5	Log 10^4
Propionic acid	0.025%	Log 10^5	Log 10^6	Log 10^6	Log 10^6
	0.05%	Log 10^5	Log 10^6	Log 10^5	Log 10^6
16.5%	0	Log 10^4	Log 10^7	Log 10^8	Log 10^{10}
Acetic acid	0.025%	Log 10^5	Log 10^5	Log 10^5	Log 10^4
	0.05%	Log 10^5	Log 10^5	Log 10^5	Log 10^4
propionic acid	0.025%	Log 10^5	Log 10^6	Log 10^7	Log 10^7
	0.05%	Log 10^5	Log 10^6	Log 10^8	Log 10^7
33%	0	Log 10^5	Log 10^7	Log 10^9	Log 10^{10}
Acetic acid	0.025%	Log 10^5	Log 10^5	Log 10^5	Log 10^4
	0.05%	Log 10^5	Log 10^5	Log 10^5	Log 10^4
Propionic acid	0.025%	Log 10^5	Log 10^6	Log 10^7	Log 10^6
	0.05%	Log 10^5	Log 10^6	Log 10^6	Log 10^5

In conclusion, our results suggest that ALM could be fed at 16.5% level in the rabbit diets with 0.025% acetic acid supplementation to obtain the highest value of live body weight, reducing mortality, enhancing feed intake, and improving feed conversion ratio without any detrimental effects on blood parameters. The level of 0.025% acetic acid had stronger anti-mould activity after 7, 14 and 21 days of storage the diet.

Further experimentation is needed to specify their health- promoting effects on rabbits in more details.

CHAPTER 5

SUMMARY

This study was carried out at Borg El-Arab Poultry Research Station belonging to Animal Production Research Institute, Agriculture Research Center, and Ministry of Agriculture during the period from November 2006 to February 2007. The analytical part of this study was performed at the laboratories of Animal and Fish production Department, Faculty of Agriculture (Saba Basha), Alexandria University. The aim of this work was to investigate the influence of feeding different levels of acacia leave meal (ALM) without or with supplementation of different types of organic acids on growth performance, nutrients digestibility, carcass characteristics and some blood constituents of growing New Zealand White (NZW) rabbits.

A total number of 135 male New Zealand White (NZW) growing rabbits at 5 weeks of age and averaged 570 g body weight were used in this study. Animals were distributed into 15 experimental groups (9 rabbits for each). Each group has three replicates, 3 rabbits per replicate. A 3 x 5 factorial arrangement was conducted. Acacia leave meal (ALM) was included at levels of 16.5 and 33% to replace 50 and 100%, respectively, of the clover hay in control diet (free of ALM). Each one of these three experimental diets was supplemented with or without acetic or propionic acids at two levels of supplementation (0.025 and 0.05%).

The obtained results could be summarized as follows:

1- The mean values of chemical composition of ALM are as follows: crude protein 16.63%, ether extract 5.16%, ash 8.67%, nitrogen free-extract 51.73% and crude fiber 17.81% of which 44.79% was NDF and 23.83% was ADF, indicating that ALM containing 20.96% hemicelluloses.
2- Feeding rabbits both diets containing 16.5 or 33% ALM resulted in reducing live body weight from the beginning of experiment up to 13 weeks of age. Rabbits received 0.025% acetic acid in their diet recorded the best live body weight at 9, 11 and 13 weeks of age in comparison with the other experimental groups. NZW rabbits received 16.5% ALM with 0.025% acetic acid in their diet recorded the highest value of live body weight.
3- Viability rate was not affected by ALM levels, however it improved by including acetic acid (0.025 or 0.05%) or 0.025% propionic acid in the diets.
4- Including ALM in the diets resulted in linear decrease in feed intake during the periods 9-13 and 5-13 weeks of age. On the other side, organic acids at 0.025% level had significant effect on increasing feed intake during the experimental periods 7-9, 9-11, 9-13 and 5-13 weeks of age, however, the high levels of both organic acids used in this study had negative effect on feed intake. Addition of 0.025% acetic acid to the basal diet free from ALM resulted in higher increase in feed intake.
5- Inclusion of ALM in the diets at both levels (16.6 or 33%) during the period 5-9 weeks resulted in significant ($P \leq 0.0001$) deterioration in feed conversion ratio than the control. On contrast, significant improvement in feed conversion ratio was detected when rabbits fed diet containing 33% ALM during 9-13 weeks of age and during the whole

experimental period, where rabbits fed 33% ALM-diet had better values of feed conversion ratio than those fed control diet by 11.2 and 2.7%, respectively. Level of 0.025% acetic acid improved feed conversion ratio during 5-9 weeks of age, however, both levels of propionic acid improved it during 9-13 weeks of age. Throughout the whole experimental period (5-13) weeks, the groups of rabbits fed 0.025%% acetic acid or those fed 0.05% propionic acid recorded significant improvement in their values of feed conversion ratio in comparison to the control group by 5.9 or 6.7%, respectively. The best results of feed conversion ratio were observed by feeding 16.5% ALM-diet with 0.025% acetic acid during the period 5-9 weeks of age and during the whole experimental period as compared to the other experimental

6- Feeding 16.5% ALM-diet resulted in non significant effect on digestibility of CP, however it increased digestibility coefficient of EE. On the other hand, feeding 33% ALM-diet had negative effects on the digestibility coefficient of CP. Organic acids had insignificant effect on apparent digestibility coefficients of different nutrients.

7- The different nutritive values of the experimental diets were not affected by different treatments.

8- The group of rabbits fed 16.5% ALM containing-diets exhibited similar significant effect on hot carcass and cold carcass as compared to control. However, the group fed 33% ALM-diet decreased these traits. Inclusion of 0.05% acetic acid or 0.025% propionic acid in the diets resulted in significant ($P \leq 0.01$) increase in hot carcass percentage, however, only 0.05% acetic acid increased ($P \leq 0.01$) cold carcass percentage in comparison with control. Rabbits fed 16.5% ALM-diet with supplementation of 0.025% acetic acid showed the best results for hot and cold carcass percentage in comparison with other experimental groups.

9- Red blood cells, hemoglobin (HB) and packed cell volume (PCV) were significantly decreased with increasing level of ALM in the diet. Addition of propionic acid to the diets had negative effect on RBCs count in comparison with control; however it had positive effect on HB concentration. Acetic acid had insignificant effect on HB, RBCs, PCV and WBCs, except the level of 0.05% acetic acid it increased concentrations of WBCs in comparison with control.

10- Plasma asparatate aminotransferase (AST) concentration was insignificantly affected by inclusion ALM in the diet up to 16.5%, however, it increased in the plasma of rabbits fed 33% ALM-diet, but alanine aminotransferase (ALT) increased in rabbits fed ALM containing diets. Also, AST was significantly increased in the group of rabbits fed diets supplemented with 0.05% acetic acid in comparison with control, however, ALT concentration was significantly decreased when NZW rabbits fed diet containing 0.025% acetic acid.

11- Total protein was significantly decreased by feeding 16.5 or 33% ALM-diets; however, albumin concentration was significantly decreased when NZW rabbits fed 33% ALM in their diet as compared to the control. Feeding rabbits diet containing 16.5% ALM had also significant decrease in globulin concentration. Only propionic acid at level 0.025% showed significant ($P \leq 0.01$) decrease in total protein and globulin concentrations and significant ($P \leq 0.05$) increase in albumin / globulin ratio in comparison with the control group.

12- Plasma glucose was significantly decreased in the group fed 33% ALM in their diet; however, it was not affected by organic acid supplementations.
13- Plasma urea-N concentration was gradually increased with increasing level of ALM in the diet and it reached significant when rabbits fed the diet containing 33% ALM; however, organic acid supplementation had no effect on this trait.
14- Formation of plasma thiobarbituric acid-reactive substances (TBARS) was significantly increased by 9.5% in the plasma of rabbits fed 33% ALM-diet as compared to control, however, it insignificantly affected by organic acids.
15- The inclusion rates of the different organic acids had anti-mould effect, while acetic acid has stronger anti-mould activity than propionic acid after 7, 14 and 21 days of storage the diet.

CONCLUSION

In conclusion our results suggest that ALM could be fed at 16.5% level in the rabbit diets with 0.025% acetic acid supplementation to obtain the highest value of live body weight, reducing mortality, enhancing feed intake, and improving feed conversion ratio without any detrimental effects on blood parameters. Also the level of 0.025% acetic acid had stronger anti-mould activity after 7, 14 and 21 days of storage the diet. Further experimentation is needed to specify their health- promoting effects on rabbits in more details.

CHAPTER 6

REFERENCES

Abd El-Galil, K., Khidr, R., (2000). Utilization of *Acacia saligna* in feeding growing rabbits under the desert and newly reclaimed areas. Egypt. Poul. Sci. 20 (III), 497–515.

Abdel Samee, A.M., El-Gendy, K.M., Ibrahim, H., (1992). Growth performance and some related physiological changes in rabbits as affected by feeding Acacia under subtropical conditions. Egypt. J. Rabbit Sci. 2, 13–22.

Abdel Samee, A.M., El-Gendy, K.M., Ibrahim, H., (1994). Rabbits growth and reproductive performance as influenced by feeding desert forage (*Acacia saligna* and *Atriplex mumularia*) at North Sinai. Egypt. J. Rabbit Sci. 4, 25–36.

Abdulrazak, S. A., Fujihara, T., Ondiek, T., Ørskov, E. R., (2000). Nutritive evaluation of some Acacia from Kenya. Anim. Feed Sci. Technol. 85, 89–98.

Abecia, L, M. Fondevila, J. Balcells and A. Belenguer (2005). Effect of fumaric acid on diet digestibility and the caecal environment of growing rabbits. Anim. Res. 54: 493-498.

Abou El Nasr, H. M., Kandil, H. M., El Kerdawy, D. A., Khamis, H. S., El-Shaer, H. M., (1997). Value of processed saltbush and Acacia shrubs as sheep fodders under the arid conditions of Egypt. Small Ruminant Res. 24: (1), 15–20.

Abou-Zeid A. E., Mohamed F. F., Radwan M. S. M. (2001). Assessment of the nutritive value of dried azolla hay as a possible feed ingredient for growing NZW rabbits. Egyptian Journal of Rabbit Science 11:1-21.

Adisa, A. O., and A. A. Odutuga. 1998. Changes in the activities of three diagnostic enzymes in the heart of rats following. Journal of Animal Science. 60: 1286-1290

Akbar, M.A. and Gupta, P. C., (1985). Proximate composition tannin and mineral contents of different cultivars of various plant parts of subabul (*Leucaena leucocephala*). Ind. Anim. Sci., 55: 808-812.

Al-Mustafa, Z. H. and Dafallah, A. A. (2000) A study on the toxicology of *Acacia nilotica*. Am J Chin Med.; 28(1): 123-9.

Al-Redhaiman, K. N., Salad, M. A., and Adam, S. E., (2003). Effect of feeding Acacia abyssinica and of its extracts given by different routes on rats. Am. J. Chin. Med. 31 (2): 259-266.

Anderson, D. M., Ashby, P., Busuttil, A., Eastwood, M. A., (1982). Sub chronic effects of gum Arabic (Acacia) in the rat. Hobson Toxicol. Lett Dec; 14(3-4):221-7.
Asanuma, K., Yagihashi, A., Watanabe, N., (1997). Characterization of the aspartate aminotranferase ± immunoglobulin M complex in a Japanese woman. Clin. Chem. 43, 686-687.

Attia, Y. A.; Abd EI-Rahman, S. A and Qota, E. M. A. (2001a) Effects of microbial phytase without or with cell-wall splitting enzymes on the performance of broilers fed marginal levels of dietary protein and metabolizable energy. Egypt poultry Sci. 21:521-547.

Ben Salem, H., Nefzaoui, A., Ben Salem, L., Tisserand, J.L., (1999a). Different means of administering polyethylene glycol to sheep; effect on the nutritive value of *Acacia cyanophylla* Lindl. foliage. Anim. Sci. 68, 809–818.

Ben Salem, H., Nefzaoui, A., Ben Salem, L., Tisserand, J.L., (2000). Deactivation of condensed tannins in *Acacia cyanophylla* Lindl. foliage by polyethylene glycol in feed blocks. Effect on feed intake, diet digestibility, nitrogen balance, microbial synthesis and growth by sheep. Livest. Prod. Sci. 64, 51–60.

Berchieri, A. J. R., and Barrow, P. A.(1996) Reduction in incidence of experimental fowl typhoid by incorporation of a commercial formic acid preparation (Bio-Add) into poultry feed. Poult Sci. Mar;75(3):339-41.

Bhattachrya, A.N. (1989). Nutrient utilization of acacia, haloxylon and *atriplex* species by Najdi sheep. Journal of Range Management 42, 28-31.

Bolduan, G., Jung, H., Schneider, R., Block, J. and Klenke, B. (1988). Effect of propionic and formic acid in piglets. J. Anim. Physiol. Anim. Nutr., 59: 72-78.

Brul, S. and P. Coote (1999). Preservative agents in foods, mode of action and microbial resistance mechanisms. InH. J. Food Microbiology 50: 1-17.

Burnell, T. W.; Cormwell, G. L. and Stahly, T. S. (1988). Effects of dried whey and copper sulfate on the growth responses to organic acid in diets for weanling pigs. J Anim Sci. 66: 1100-1108.

Cañas-Rodriguez A, Smith HW(1966).The identification of the antimicrobial factors of the stomach contents of sucking rabbits. Biochem J. 1966 Jul;100(1):79-82.

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

Cave, N.A.G. (1978). The influence of non-sterified fatty acids on feeding activity of chicks. Poultry Science, Vol. 57: 1124-1128.

Cenci F.B., Louvandini H. McManus C.M. Dell'Porto A. Costa D.MArau´jo . S.C. Minho A.P. Abdalla A.L. (2006). Effects of condensed tannin from *Acacia mearnsii* on sheep infected naturally with gastrointestinal helminthes 13 September 2006Veterinary Parasitology.

CHALUPA, W, RICKABAUGH, B, KRONFELD, DS, SKLAN, D (1984): Rumen fermentation in vitro as influenced by long chain fatty acids. J Dairy Sci 67: 1439-1444.

Cherrington CA, Hinton M, Chopra I. (1990) Effect of short-chain organic acids on macromolecular synthesis in Escherichia coli. J Appl Bacteriol. 1990 Jan; 68(1):69-74.

Cherrington, C. A., M. Hinton, G. C. Mead and I. Chopra (1991) Organic acids: Chemistry Antibacterial activity and practical applications. Advances in Microbial Physiology, 32:87-107.

Christ, B., Lange, K. & Jeroch, H. (1996). Effect of soybean oil in rabbit concentrate meals and cereal grains. Journal of Science, conditions. Australian Journal of Experimental.

Conková E, Para L, Kocisová A.(1997)Inhibition of growth of microscopic fungi with organic acids Vet Med (Praha). 1993; 38(12):723-7.

CORNELIUS CE, KANEKO JJ. (1960). Serum transaminase activities in cats with hepatic necrosis. J Am Vet Med Assoc. Jul 1;137:62–66.

Cortez, S., Brandeburger, H., Greuel, E., Sundrum, A., (1992). Investigations of the relationships between feed and health status on the intestinal flora of rabbits. Tierarztl. Umsch. 47, 544–549.

Craig, A. M. Pearson, E. G.;, Meyer, C. Schmitz, J. A. (1991). Serum liver enzyme and histopathologic changes in calves with chronic and chronic-delayed Senecio jacobaea toxicosis. Am J Vet Res. Dec; 52(12):1969-78.

Dafallah, A.A., Al-Mustafa, Z., (1996). Investigation of the anti-inflammatory activity of *Acacia nilotica* and *Hibiscus sabdariffa*. Am. J. Chin. Med. 24 (3-4), 263–269.

DE RITIS F.(1958) Plasma enzymes in diagnosis of liver diseases. Minerva Med. 1958 May 5; 49(36):1757-8. Italian.

Degen, A.A., Blanke, A., Becker, K., Kam, M., Benjamin, R.W., Makkar, H.P.S., (1997). The nutritive value of *Acacia saligna* and *Acacia saligna* for goats and sheep. Anim. Sci. 64, 253– 259.

Devendra, C. (ed.) 1989. Introduction of shrubs and tree fodders for farm animals. IRDC, Canada.

Dumancic, D.; and Le Houeraus, H.N. (1981). *Acacia cyanophylla* lindl, as a supplementary feed for small stock in libya. J. Arid Environments, 4: 161-167.

Duyen, N.T., Bien, L.T., Mui, N.T., Binh, D.V. & Preston, T.R. 1996. Foliage of *Trichantera gigantea*, Jackfruit (*Artocapus heterophyllus*), banana (*Musa* sp) and *Acacia mangium* as protein sources for lactating goats fed a basal diet of rice straw and sugar cane tops. Livest. Res. Rural Dev. 8:3, 1-5.

Easter, R.A. (1988). Acidification of diets for pigs. In: *Recent Advances in Animal Nutrition*, Haresign, W. and Cole, D.J.A. (eds). Butterworths, London, pp. 61-71.

Eckel, B., Kirchgessner, M. and Roth, F.X. (1992a). Influence of formic acid on daily weight gain, feed intake, feed conversion rate and digestibility. l. Communication: Investigations about the nutritive efficacy of organic acidsin the rearing of piglets. J. Anim. fhysiol. Anim. Nufr., 67: 93-100.

Egli CP, Blum JW(1998).Clinical, haematological, metabolic and endocrine traits during the first three months of life of suckling simmentaler calves held in a cow-calf operation. Zentralbl Veterinarmed A. Mar;45(2):99-118.

Eidelsburger, U. (1997) Optimierung der Futterqualität ist nur ein Teilaspekt. In: Schweinewelt, Nr. Januar, p. 18-21.

Eidelsburger, U., Kirchgessner, M. and Roth, F.X. (1992b). Influence of fumaric acid, hydrochloric acid, sodium formate, tylosin and toyocerin on daily weight gain, feed intake, feed conversion rate and digestibility. II. Investigations about the nutritive efficacy of organic acids in the rearing of piglets. *J.* Anim. fhysiol. Anim. Nutr., 68: 82-92.

El-Deek, A. A., Y. A. Attia and Amal A. Soliman (2003a). Productivity response of broiler breeder hens when fed practical or vegetable diets containing high levels of barley, sunflower meal or barley and sunflower meal without or with enzyme mixture supplementation 1-Barley. Egypt Poult. Sci. 23:239-257.

El-Eraky, W.M., Mohamed, W.M., (1996). Growth performance, carcass traits and some related physiological changes of growing rabbits fed on Acacia and water Hyacinth. Egypt. J. Rabbit Sci. 6, 87–98.

EL-GENDY K. M., (1999). Effect of dietary inclusion of acacia leaves meal (*Acacia saligna*) on digestibility, growth performance and blood constituents of growing rabbits. Egyptian Journal of Rabbit Science 9: 271-283.

El-Kerdawy D.M.A., (1996) Acidified feeds for growing rabbits, Egypt J. Rabbit Sci. (6) 143–156.

El-Lakany, M.H., Mahmoud, S., Bishay, A., (1991). Agroforestry as a desert farming system; biomass production and feeding quality of *Acacia saligna*. In: Proceeding of the Second International Desert Development Conference, Cairo, Egypt, pp. 423–433.

El-Moghazy, G. M., M. F. Emara, H. Youssef. Mervat and S. Hamza, Akila (2003). Antifungal activity o some organic acids used as feed preservatives. J. Agric. Sci. Mansoura Univ. 28 (12): 8053-8061.

El-Shaer, H.M.; Tag El-Din, S.S. and Kandil, H.M. (1984). Nutritive evaluation of some introduced pasture plants in North Sinai. 1st Egyptian British Conference on Animal and Poultry Production, September 11-13, Zagazig, Egypt, 135-145.

Falkowski, J. F. and F. X. Aherne. 1984. Fumaric and citric acid as feed additives in starter pig nutri- tion. J. Anim. Sei. 58:935.

Farran MT, Barbour GW, Uwayjan MG, Ashkarian VM.(2001) Metabolizable energy values and amino acid availability of vetch (*Vicia sativa*) and ervil (*Vicia ervilia*) seeds soaked in water and acetic acid.Poult Sci. Jul;80(7):931-6.

Farverdin, P., Baumont, R. & Ingvartsen, K.L. (1995). Control and prediction of feed intake in ruminants. Proceeding of the IVth International Symposium on the nutrition of herbivores, recent developments in the nutrition of herbivores. INRA Edition, Paris, pp. 95-120.

Ferket, P.R. ve T. Middelton, (1999), Antinutrients in Feddstuff, Poultry International, March, 46- 55.

FEVRIER, C., GOTTERBARM, G. , JAGHELIN-PEYRAUD, Y., LEBRETON, Y., LEGOUEVEC , F. & AUMAITRE, A. (2001). Effects of adding potassium diformate and phytase excess for weaned piglet. In: Digestive physiology of pigs, Ed. by Lindberg J E, Ogle B, CABI publishing, p 136-138.

Forbes, T. D. A., Carpenter, B. B.; Tolleson, D. R. Randel, R. D. (1994). Effects of N-methyl-phenethylamine on GnRH stimulated luteinizing hormone release and plasma catecholamine concentrations in weathers. J. Anim. Sci, : 464-469.

Fran, K.; Donald, E. and James, G. (2000) Research trends in healthful foods. Food Tec., 54 (10): 45-52.

Gabert, V. M. (1994) The effect of supplementation of organic acids, oligosaccharides and lactitol on the digestibility of amino acids and bacterial populations and metabolites in the digestive tract of early-weaned pigs. M. Sc. Thesis. University of Alberta, Edmonton, Canada.

Gabert, V.M. and W. C. Sauer (1994) The effects of supplementing diets for weanling pigs with organic acids. A review. Journal of Animal and Feed Sciences, 3:73-87.

Galbraith, H., and T. B. Miller. 1973. Ef fects of long chain fatty acids on bacterial respiration and amino acid uptake. J. Appl. Bacteriol. 36:659–675.

Garcia, J. ; Carabaño, R. ; and de Blas, J. C. (1999). Effect of fiber source on cell wall digestibility and rate of passage in rabbits. J. Anim. Sci. 77 : 898-905.

Garcia, J. ; Carabaño, R. ; Perez-Alba L. and de Blas J. C. (2000). Effect of fiber on caecal fermentation and nitrogen recycled through cecotrophy in rabbits. J. Anim. Sc. 78 :638-646.

Gedek, B., Kirchgessner, M., Eidelsburger, U., Wiehler, S., Bott, A. and Roth, F.X. (1992a). Influence of formic acid on the microflora in different segments of the gastrointestinal tract. 5. Investigations about the nutritive efficacy of organic acids in the rearing of piglets. *J.* Anim. Physiol. Anim. Nutr., 67: 206-214.

Gidenne T., (1997). Caeco-colic digestion in the growing rabbit: impact of nutritional factors and related disturbances, Livest. Prod. Sci. 51: 73–88.

Giesting, D.W. and Easter, R.A. (1985). Response of starter pigs to supplementation of corn soybean *meal diets with organic acids. J*A.n im. Sci., 60: 1288-1294.

Goldslein, J.L. & Swain, T. 1963. Changes in tannins in ripening fruits. Phytochem. 2, 371-383. Aregheore, E. M., (2002). Voluntary intake and digestibility of fresh wilted and dry Leucaena (*Leucaena leucocephala*) at four levels to a basal diet of Guinea grass (*Panicum maximum*). Asian-Aust. J. Anim. Sci. 15, 1139-1146.

Grassmann, E. and T. Klasna (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.

Hassan, N.I., Abd El Aziz, H.M. and El Tabbkh, A.E., (1979). Evaluation of some forages introduced to newly-reclaimed areas in Egypt. World Rev. Anim. Product., 15: 2- 10.

HENDERSON, C (1973). The effects of fatty acids on pure cultures of rumen bacteria. J Agric Sci (Camb) 81: 107–112.

Hinton, A. Jr., Buhr, R: J. and Ingram, K. D. (2000) Reduction of *Salmonella* in the crop of broiler chickens subjected to feed withdrawal. Poultry Science, 79:1566-1570.

Hinton, M., Linton, A. H. (1988).Control of salmonella infections in broiler chickens by the acid treatment of their feed.Vet Rec. Oct 15;123(16):416-21.

Hua, Y. & Bee-Lian, O. (2000). Photosynthesis and respiration. http//www. abstracts. aspb. org/ asp. Public/ p42/ 0575. html.

Hullar I., Fekete S., Szigeti G., Bokori J., (1996). Sodium butyrate as a natural growth promoter for rabbits, 6th World Rabbit Congress, Toulouse, France, Vol. 2, : 175–179.

Hume, M. E., Corrier, D. E., Ivie, G. W. and Deloach, J. R. (1993) Metabolism of [14 C] propionic acid in broiler chicks. Poultry Science, 72:786-793.

IBA, A. M.& BERCHIERI, A. JR. (1995) Studies on the use of a formic acid-propionic acid mixture (Bio-add™) to control experimental Salmonella infection in broiler chickens. Avian Pathology, 24:303-311.

Ibrahim Sh.A.M., El-Ghamry A.A., El-Mallah G.M. (2000). Effect of some medicinal plants of Labiatae family as feed additives on growth and metabolic changes of rabbits. pages: 105-120Volume 10, Number 1.

Inoue', T., Brookes, I.M., John, A., Kolver, E.S. & Barry, T.N. 1994. Effects of leaf shear breaking load on the feeding value of perennial ryegrass (*Lolium perenne*) for sheep. 2. Effects on feed intake, particle breakdow, rumen digesta outflow and animal performance. J. Agricult. Sci. 123, 137-147.

Isobe, Y., Shibata, F., Komaki, H. and Kamada, A. (1994). Influence of fumaric acid administration on l intestinal microorganism in weanling pigs. *Anim. Sci*, Technol., 65: 59-66.

Izat, A.L.; M. H. Adams, M. C. Cabel, M. Colberg, M. A. Reiber, J. T. Skinner and P. W. Waldroup, (1990a). Effects of formic acid or calcium format in feed on performance and microbiological characteristics of broilers. Poultry Science, Vol. 69: 1876-1882.

Jeroch,H.;and Danicke,S(1995).Barley in poultry feeding : a review World,s Poult.Sci.J,51: 271-290.

Kakengi, A.M., Shem, M.N., Mtengeti, E.P., Otsyina, R.,(2001). *Leucaena leucocephala* leaf meal as a supplement to diet of grazing dairy cattle in semiarid western Tanzania. Agrof. Syst. 52, 305–314.

Kamel, K. I. and Mervat Ali A. Brekaa (2005). Growth performance hematological, blood and biochemical changes and carcass traits in rabbit feed *Acacia saligna*. Egypt Poultry. Science. Vol (25) (I): (125-145).

Kirchgessner, M. and Roth, F. X. (1988) Ergotrope Effekte durch organische Säuren in der Ferkelaufzucht und Schweinemast. Übersichten zur Tierernährung, 16:93-108.

Kishi M, Fukaya M, Tsukamoto Y, Nagasawa T, Takehana K, Nishizawa N.(1999)Enhancing effect of dietary vinegar on the intestinal absorption of calcium in ovariectomized rats. Biosci Biotechnol Biochem. 1999 May;63(5):905-10.

Knarreborg A., Miquel N., Granli T., Jensen B.B., (2002). Establishment and application of an in vitro methodology to study the effects of organic acids on coliform and lactic acid bacteria in the proximal part of the gastrointestinal tract of piglets, Anim. Feed Sci. Technol. 99 131–140.

Knarreborg, A. , Miquel, N., Granlt, T. and Jensen, B: B. (2001) *In vitro* methodology to evaluate the effect of various additives on the microflora in gastrointestinal tract of pigs. In.: Digestive Physiology in Pigs: Proceedings of the 8th symposium (eds. Lindberg, J,-E. and Ogle, B.) p.302-304.

Knowles, T. g., Edwards, J. E., Bazeley, K. J., Brown, S. N., Butterworth, A., Warriss, P. D., 2000 Changes in the blood biochemical and haematological profile of neonatal calves with age . Veterinary Record 147, 593- 598.

KUTTLER KL, MARBLE DW (1958). Relationship of serum transaminase to naturally occurring and artificially induced white muscle disease in calves and lambs. Am J Vet Res. Jul; 19(72):632–636.

Langhout, P. (2000) New additives for broiler chickens. FEED MIX Special: Alternatives to antibiotics. pp 24-27.

LEBAS F., FORTUN-LAMOTHE L. (1996). Effects of dietary energy level and origin (starch vs oil) on performance of rabbit does and their litters: average situation after 4 weaning. 6th World Rabbit Congress, Toulouse 1:217-222.

Licois D. (2004). Domestic rabbit enteropathies, pp. 385-403 in proc.8th World Rabbit Congress (CD-ROM), Puebla City (Mexico).

MACZULAK, AE, DEHORITY, BA, PALMQUIST, DL (1981): Effects of long–chain fatty acids on growth of rumen bacteria. Appl Environ Microbiol 42: 856–862.

Makled, M. N.; Sharara, H. H. And Abd El-Fattah, H. (2003). Tolerance of California rabbits to different levels of dietary tannic acid. Egypt. Poult. Sci. Vol. 23 (III): (641-654).

Man, N.V., Hao, N.V. & Tri, V.M. (1995). Biomass production of some leguminous shrubs and trees in Vietnam. Livest. Res. Rural Dev. 7, 1-4.

Maribo, H., Olsen, L. E., Jensen, B. B., and Miquel, N. (2000) Produkter til smågrise: kombinationen af mælkesyre og myresyre og benzoesyre. Landsudvalget for Svin, Danske Slagterier, meddelese, pp 13

Marine, S., M. E. Guyont, P. Neira, M. Bernado, V. Sanchis and A. J. Ramos (2002). Risk assessment of the use of sub-optimal levels of weak acids preservatives in the control of mould growth on bakery products. International J. Food Microbiol. 79: 203-211.

Marounek M, Dusková D, Skrivanová V. (2003) Hydrolysis of phytic acid and its availability in rabbits. Br J Nutr. 2003 Mar;89(3):287-94.

MAROUNEK, M, SK¤IVANOV?, V, SAVKA, O (2002). Effect of caprylic, capric and oleic acid on growth of rumen and rabbit caecal bacteria. J Anim Feed Sci 11: 507-516.

Mathew, A. G., Sutton, A. L., Scheidt, A., Bforsyth, D. M., Patterson, J. A. and Kelly D. T. (1991) Effects of a propionic acid containing feed additive on performance and intestinal microbial fermentation of teh weanling pig. In: Proceedings of the Vth International Symposium on Digestibe Physiology in pigs. Wageningen, Netherlands, 24-26 April 1991. Eaap Publication No. 54, pp.464-469.

Mike Rankin (2004). Preserving Baled Hay with Organic Acids *by* Crops and Soils Agent - Fond du Lac County. Focus on Forage is a forage crop information resource of the University of Wisconsin.

Mohri M, Sharifi K, Eidi S. 2006 Hematology and serum biochemistry of Holstein dairy calves: age related changes and comparison with blood composition in adults. Res Vet Sci. 2007 Aug;83(1):30-9. Epub 2006 Dec 22.

Moujahed, N., Salem, H.B. & Kayouli, C. 2005. Effects of frequency of polyethylene glycol and protein supplementation on intake and digestion of *Acacia cyanophylla* Lindl. Foliage fed to sheep and goats. Small Rumin. Res. 56, 65-73.

Mroz RM, Chyczewska E, Holownia A, Izycki T, Chyczewski L, Braszko JJ.(2001). Proliferating activity, DNA ploidy changes of lung cancer cells before and after chemotherapy.Folia Histochem Cytobiol. 2001;39 Suppl 2:161-2.

Namur, A.P., J. Morel, and H. Bichek (1988). Compound animal feed and feed additives. In Deboer, F.; H. BICHEL, eds. Livestock feed resources and feed evaluation in Europe. Elsevier. Sci. Publ., Amsterdam.

Naughton, P.J. and Jensen, B. B. (2001) A bioreactor system to study survival of *Salmonella* typhimurium in pig gut content. Berliner und Münchener Tierärztliche Wochenschrift, 114: 1-4.

Odonker, L.N.; and Kristo, P. (1979). 10 A NEW METHOD FOR RABBIT PRODUCTION. Trop. Anim. Prod., 4 (3) : 297

Onifade, A.A., 1997. Growth performance, carcass characteristics, organ measurements and haematology of broiler chickens fed a high fibre diet supplemented with antibiotics or dried yeast. Die Nahrung. 41, 370± 374.

Onifade, A.A., Abu, A.O., 1998. Productive performance of rabbits fed supplemental copper in a diet based on tropical feedstuffs. J. Appl. Anim. Res. 13, 129±135.

Onifade, A.A., Tewe, O.O., 1993. Alternative tropical energy feed resources in rabbit diets: Growth performance, diet's digestibility and blood composition. Wld. Rabbit. Sci. 1, 17±24.

Overland, M., Granli, T., Kios, N. P. Fietland, O. Steien, S. H. and Stokstad, M.(2000)Effect of dietary formates on growth performance, carcass traits, sensory quality, intestinal microflora, and stomach alterations in growing-finishing pigs.J Anim Sci. 2000 Jul;78(7):1875-84.

Pallauf, J.; W. Got"Ert, and K. Kramer, K. (1988). Influence of citric acid on the digestibility of nutrients and N-balance in piglets. Deutsche Tierarztliche Wochenschrift, 95(4): 146-150.

Partanen, K. H. and Mroz, Z. (1999) Organic acids for performance enhancement in pig diets. Nutrition Research Reviews, 12: 1-30.

Patten, J.D., and P. W. Waldroup (1988). Use of organic acids in broiler diets. Poultry Science, Vol. 67: 1178-1182.

PINCHASOV, Y.; JENSEN, L.S. Effect of short-chain fatty acids on voluntary feed of broiler chicks. Poultry Science, v.68, p.1612-1618, 1989.

Radecki SV, Juhl MR, Miller ER (1988) Fumaric and citric acids as feed additives in starter pig diets: effect on performance and nutrient balance. J Anim Sci. Oct;66(10):2598-605.

Radwan,M.S.M.; Hataba,N.A.; El-Faham,A.I.; and Ibrahim,S.A. (1997). Using date stone meal in grower chicks and layer diets.Egyptian J.of Nutrtion and Feeds 1 (special issue) : 321-333 .

RAMCHURN R., DULLULL Z. B., RUGGOO A., RAGGOO J. , (2000) Effects of feeding star grass (Cynodon plectostachyus) on growth and digestibility of nutrients in the domestic rabbit. Livestock Research for Rural Development 12:1-6.

Ravindran, V. and Kornegay, E.T. (1993). Acidification of weaner pig diets: a review. *J. Sci.* Food Agr., 62: 313-322

Reddy, K.R., G.A. O'Connor, and C.L. Schelske (1999). Symposium overview and synthesis, *in* Phosphorus biogeochemistry in subtropical ecosystems. Lewis Publishers, Boca Raton, FL.

Reed, J. D., H. Soller, and A. Woodward. 1990. Fodder tree and straw diets for sheep: Intake, growth and digestibility and the effects of phenolics on nitrogen utilization. Anim. Feed Sci. Technol. 30:39.

Risley, C. R., Kornegay, E. T., Lindemann, M. D., Wood C. M and Eigel, W.N. (1990) Effect of feeding organic acids on selected intestinal content measurements at varying times postweaning in pigs. Journal of Animal Science 70: 196-206.

ROBYN A.D. AND ANTHONY C.S.(2002)Livestock potential of Australian species of AcaciaLivestock potential of Australian species of Acacia.

Rosenthal, P., (1997). Assessing liver function and hyperbilirubinemia in the new born. Clin. Chem. 43, 228–234.

Roth, F.X. and Kirchgessner, M. (1998). Organic acids as feed additives for young pigs: Nutritional and gastrointestinal effects. Journal of Animal and Feed Sciences, 7: 25-33.

Rubanza , C.D.K. Shem, M.N Bakengesa . S.S., Ichinohe , Fujihara T. T. (2006) Effects of *Acacia nilotica*, *A. polyacantha* and *Leucaena leucocephala* leaf meal supplementation on performance of Small East African goats fed native pasture hay basal forages 27 February 2006Small Ruminant Research.

Rubanza, C.D.K., Shem, M.N., Otsyina, E.R., Fujihara, T., (2005a). Performance of Zebu steers grazing on western Tanzania native forages supplemented with *Leucaena leucocephala* leaf meal. Agrof. Syst. 65, 165–174.

Rubanza, C.D.K., Shem, M.N., Otsyina, E.R., Ichinohe, I., Fujihara, T., (2003). Nutritive potential of some browse tree legume foliages native to semi-arid areas in western Tanzania. Asia-Aust. J. Anim. Sci. 16, 1429–1437.

Russell, J. B. (1992) Another explanation for the toxicity of fermentation acids at low pH: anion accumulation versus uncoupling. Journal of Applied Bacteriology, 73: 363-370.

Russell, J. B. and Diez-Gonzales, F. (1998) The effects of fermentation acids on bacterial growth. Advances in Microbial Physiology, 39:205-234.

Saleem A, Ahotupa M, Pihlaja K. (2001). Total phenolics concentration and antioxidant potential of extracts of medicinal plants of Pakistan. Naturforsch [C]. 2001 Nov-Dec;56(11-12):973-8.

SCAPINELLO C., FARIA H. G. DE., FURLAN A. C., MARTINS E. N., MOREIRA I. (1999). Performance of growing rabbits fed with different levels of restorative yeast (*Saccharomyces* sp), dried by rotative roller or by spray-dry. Revista Brasileira de Zootecnia 28:334-342.

Scapinello C., Faria H.G., Furlan A.C., Michelan A.C., (2001). Efeito da utilizaçao de oligossacarídeo manose e acidificantes sobre o desempenho de coelhos em crescimento, Rev. Bras. Zootec. 30 (2001) 1272–1277.

Schulenberg, R.; Rabeling, H. A. Flachowsky, G and Kampbues, J.(1996). Adsorbed organic acids for the preservation of animalfeed components. Proceedings of the workshop, unconventional feedstuffs, held in the Bundesforschungsonsalt fur landwirtschaft, Braunschweig- volkenrode, Sonderhelft.No. 169, 290-294.

Scipioni, R, G. Zaghini and A. Biavati (1978): Acidified diets in early weaning piglets. Zoow. Nutr. Anim., 4: 201.

Skrivanová V, Skrivan M, Marounek M, Baran M. (2002). Effect of feeding supplemental copper on performance, fatty acid profile and on cholesterol contents and oxidative stability of meat of rabbits. Arch Tierernahr.; 54(4):329-39.

Sotelo, A., Migliaro, P.,Toledo, A and Contreras, J (1999). Chemical composition, digestibility and antinutritional factors content of two wild legumes: Styphonolobium burseroides and Acacia bilimekii. Plant Foods Hum Nutr. 1999;54(1):59-65.

Sutton, A. L., Mathew, A. G., Scheidt, A. B., Patterson, J. A. and Kelly, D. T. (1991) Effects of carbohydrate sources and organic acids on intestinal microflora and performance of the weanling pig. In: Proceedings of the Vth International Symposium on Digestible Physiology in pigs. Wageningen, Netherlands, 24-26 April 1991. Eaap Publication No. 54, pp. 422-427.

Sweet, L.R., Kornegay, E.T. and Lindemann, M.D. (1990). The effect of dietary Luprosil NC on the growth performance and scouring indeoxf weanling pigs.*A gribiol. Res.*, 43: 271-282.

Thompson, J. L. and Hinton, M. (1997) Antibacterial activity of formic and propionic acids in the diet of hens on salmonellas in the crop. British Poultry Science 38: 59-65.

Topps, J. H., 1992. Potential composition and use of legume shrubs and trees as fodder for livestock in the tropics. J. Agri. Sci., (Cambridge) 118: 1-8.

Tzatzarakis MN, Tsatsakis AM, Lotter MM, Shtilman MI, Vakalounakis DJ. (2000) Effect of novel water-soluble polymeric forms of sorbic acid against *Fusarium oxysporum* f.sp. radicis-cucumerinum. Food Addit Contam. Dec; 17(12):965-71.

Van Soest (1996) Allometry and Ecology of Feeding Behavior and Digestive Capacity in Herbivores: A Review Zoo Biology 15:455 – 479.

Waldroup, A., S. Kaniawati and A. Mauromoustakos (1995). Performance characteristics and microbiological aspects of broilers fed diets supplemented with organic acids. Journal of Food Protection, Vol. 58: 482-489.

Wyatt, C. L. and Goodman, T. (1993). Utilization of feed enzymes in laying hens ration. J. App. Poult. Res. 2: 68 -74.

Yousef, M. I. (2005). Reproductive performance, blood testosterone, lipid peroxidation and seminal plasma biochemistry of rabbits as affected by feeding *Acacia saligna* under subtropical conditions. Food Chem. Toxicol. 2005 Feb;43(2):333-9.

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

Zanker, I. A. Hammon, H. M.; Blum, J. W. (2001a). Delayed feeding of first colostrums: are there prolonged effects on hematological, metabolic and endocrine parameters and on growth performance in calves? Journal of Animal Physiology and Animal Nutrition 85, 53-66.

Zi Lin G., Ren Lu H., Wen She R., Guo Xian Z., Yu Ting H., (1996). The effects of BFA on weight gain and coccidiosis in meat rabbits, 6th World Rabbit Congress, Toulouse, France, Vol. 3, 1996, pp. 73–76.