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Effect of Adding Some Chemical Agents to Ensiled Vegetable and Fruit Market Wastes on Silage Quality and the Performance of Lactating Goats

[1]S.M. Kholif, [1]S.A.H. Abo El-Nor and [2]M.M. Khorshed
[1]Department of Dairy Science, National Research Centre, Dokki, Cairo, Egypt
[2]Department of Animal Production, Faculty of Agriculture, Ain Shams Univ., Cairo, Egypt

Abstract: Five types of silage were made from Vegetable and Fruit Market Wastes (VFMW) to evaluate silage quality. The different types of silage were, VFMW (S_1), VFMW+5% ortho-p-acid (S_2), VFMW+5% formic acid (S_3), VFMW+5% 1: 1 ortho-p-acid: formic acid (S_4) and VFMW+5% sodium acetate (S_5). After 21, 42 and 64 days the siloes were opend and the silages characteristics were examined. Supplementation of chemical agents to VFMW silage (S_2, S_3, S_4 and S_5) were significantly increased dry matter, organic matter, crude protein, ether extract and nitrogen free extract contents, while crude fiber content was significantly decreased ($p<0.01$) with treated silage compared with control (S_1). *In vitro* dry matter ($p<0.01$) and organic matter ($p<0.05$) disappearances were significantly higher with formic acid+ortho-p-acid and sodium acetate (S_4 and S_5) treated silage followed by ortho-p-acid and formic acid (S_2 and S_3) and then control (S_1). Silage pH value was decreased ($p<0.01$) with adding ortho-p-acid and sodium acetate to silage, while, silage butyric acid concentration was increased ($p<0.01$) with ortho-p-acid and decreased ($p<0.01$) with the combination of acids adding to silage compared with control. On the other hand, ammonia-N, lactic acid were not among treatments. Silage pH, ammonia-N, butyric acid and lactic acid concentrations were increased ($p<0.01$) with time of ensiling. Nine castrated goat's male average (26.2 kg and 4 years age) were divided into three groups using 3×3 Latin square design with 30 day periods to study the effect of treatments on rumen activity and nutrient digetibilities. DM, OM, CP, CF, EE and NFE digestibilities were increased ($p<0.05$) with treated groups compared with control. Rumen total nitrogen, true protein nitrogen and non protein nitrogen contents were increased ($p<0.05$) while, ammonia-N content was decreased ($p<0.05$) with treated groups compared with control. Fifteen lactating Zaraibi goats after seven days of parturition were ranked to three groups using 3×3 Latin square design with 30 day periods to study the effect of treatments on milk yield and composition. Animals were fed on Concentrate Feed Mixture (CFM): VFMW silage (S_1), CFM: VFMW treated with 5% formic acid (S_2) and CFM: VFMW treated with 5% sodium acetate (S_3). Milk yield and 4% FCM were increased ($p<0.01$) with treated silage. Yields of milk contents were higher ($p<0.05$) in treated group compared with control. However in milk, total protein, fat, lactose and solids not fat contents were not differed significantly among treatments. Chemical treated silage improved ($p<0.05$) feed efficiency (milk Yield/Dry Matter Intake (DMI) and 4% FCM/DMI) of VFMW silage. Blood serum glucose increased ($p<0.05$) while, urea and total lipids decreased ($p<0.05$) with treated groups compared with control.

Key words: Vegetable and fruit market wastes, silage quality, nutrient digestibility, rumen parameters, milk production, goats

INTRODUCTION

In Egypt, the yield of vegetable and fruit were estimated about 14.1 and 7.1 million tons per year, respectively (General Statistics Year Book, 1998) of which about 3.95 million tons from both of them

Corresponding Author: S.M. Kholif, Department of Dairy Science, National Research Centre, Dokki, Cairo, Egypt

are wasted yearly during marketing. Many agricultural an agro-industrial by-products have considerable potential as animal feed. Many of theses by-products currently go either unused or largely wasted. Consequently these by-products often become pollutants (Kayouli and Lee, 1998). The problem usually encountered with agro by-product is seasonality of supply, which is often accentuated by their high moisture content. Dehydration increases cost about 250-300 L of fuel and 200 kwh of electricity and required to produce one ton of dry product (88-90% DM). Research has shown that the ensiling of by-product is the most suitable method of conservation for long period (Bouque and Fiems, 1988; Kayouli *et al*., 1993; Kayouli and Lee, 1998). Successful silage fermentation depends on achieving both anaerobic conditions and a low pH. The low pH, which is usually accomplished through the fermentation of sugars in the ensiled materials to lactic acid by lactic acid bacteria or by addition of some organic and inorganic acids as formic, propionic and sulphoric acids (O'Kiely, 1996; Kung and Ranjit, 2001; Adesogan and Salawu, 2004) or organic salts propionate and formate (Adesogan *et al*., 2003). Application rates of formic acid (2-5 L t^{-1} grass) resulted in substantial increase in silage intake and improved animal performance even when the untreated silages were well preserved (Henderson *et al*., 1989, 1990; Parker and Crawshaw, 1982). Many studies were used formic acid only or with chemical additives to improved silage quality (O'Kiely and Moloney, 1994; O'Kiely, 1993, 1996; Adesogan and Salawu, 2004) and their effect on rumen fermentation and digestibility (Moloney and O'Kiely, 1994). However, low published studies on this subject have focused on dairy animals performance.

The present research is an attempt to supplement of some chemical agents to ensiled VFMW and their effect on silage quality, nutrient digestibilities, rumen parameters and milk yield and composition of lactating goats.

MATERIALS AND METHODS

A mixture of orange waste, potato waste and pea-pods collected from market wastes, were ensiled without (S_1) or with the following chemical supplements: 5% ortho-p-acid (S_2), 5% formic acid (S_3), 5% ortho-p-acid: formic acid (1:1) (S_4) or 5% sodium acetate (S_5) in five silos (750 kg capacity). After 21, 42 and 64 days, the silos were opened. Color and odder were estimated and samples were taken for chemical analysis according to the official methods of the AOAC (1995). Other samples were pressed and the juice was collected for the estimation of pH (digital pH meter), ammonia nitrogen (kjeldahl), butyric acid and lactic acid (Hawk *et al*., 1954). Then *in vitro* dry matter and organic matter disappearances were done on samples of different treatments according to Tilley and Terry (1963), modified by Norris (1976).

Digestibility Trial

The coefficients of digestibility, nutritive value and rumen activity were determined for selected silage using castrated male goats. Nine animals (average 26.2 kg and 4 years age) were divided into three groups (three animals each) using 3×3 Latin square design with 30 day periods. Animals were fed on Concentrated Feed Mixture (CFM): VFMW silage (S_1) (50:50), CFM: VFMW treated with 5% formic acid (S_2) (50:50) and CFM: VFMW treated with 5% sodium acetate (S_3) (50:50). The CFM consisting of 35% yellow corn, 25% wheat bran, 22% decorticated cotton seed cake, 15% rice bran, 1.5% ground limestone and 1.5% common salt. The chemical composition of different silage type are showed in Table 1. The offered feeds were assessed to cover the requirements for each animal (ARC, 1965). The CFM was offered for each animal individually once daily at 8.00 am while silage was offered at 10.00 am. Dry matter intake was measured during the last refusals of the previous day. Water was available at all time.

Fifteen lactating Zaraibi goats (average 29.4 kg and 4 years age) were divided into three groups (five animals each) using 3×3 Latin square design with 30 day periods to study the effect of different types of silage on milk yield and composition. The same rations and managements of digestibility trial were used on lactation trial.

Sampling and Analysis of Rumen Liquor

At the last day of each period of digestibility trial, rumen liquor samples were collected from each animal at 4 h. post morning feeding by a stomach tube. The samples were strained through two layers of cheese cloth and then stored in glass bottles (10 mL) with 3 drops of toluene and a thin layer of paraffin oil just to cover the surface to stop microbial activity and to prevent volatilization and stored at -18°C till they were analyzed. Ruminal pH was determined using a digital pH-meter, Total Nitrogen (TN), Non-Protein-Nitrogen (NPN) and ammonia-N were determined according to AOAC (1995). True Protein Nitrogen (TPN) was calculated by difference. Total Volatile Fatty Acids (TVFA's) were determined by steam distillation as described by Warner (1964).

Sampling and Analysis of Milk

At the last 3 days of each period, Zaraibi goats were hand milked (twice/day), milk yield was recorded and pH of milk was determined. Milk samples were also, analyzed for fat, Total Solids (TS), Total Protein (TP), ash (Ling, 1963) and lactose (Barrnett and Abd El-Tawab, 1957). Solids-Not-Fat (SNF) was calculated by difference.

Sampling and Analysis of Blood Serum

Blood samples were collected from the jugular vein of each animal at the last day of each period (4 h post morning feeding). The collected blood samples were centrifuged at 4000 rpm/20 min to separate the serum. The obtained serum was stored at -18°C till it was analyzed. Serum total protein was determined as described by Armstrong and Carr (1964), while, albumin (Doumas *et al*., 1971), urea (Patton and Crouch, 1977), glucose (Siest *et al*., 1981), total lipids (Postma and Stroes 1968), serum Glutamic-Oxaloacetate-Transaminase (GOT) and Glutamic-Pyruvate-Transaminase (GPT) (Reitman and Frankel, 1957). Globulin and albumin/globulin ratio were calculated.

Statistical Analysis

Data obtained from this study were statistically analyzed according to procedures outlined by Snedecor and Cochran (1982). These procedures were:

- Latin square design for nutrients digestibility, yield and composition of milk and blood parameters using the general linear model procedure:

$$Y_{ijk} = \mu + R_i + C_j + T_k + e_{ijk}$$

Where Y_{ijk} is the parameter under analysis of the ijk goat, μ is the overall mean, R_i is the effect due to the lactation period on the parameter under analysis, C_j is the effect due to the animals on the parameter under analysis, T_k is the effect due to treatment on the parameter under analysis, e_{ijk} is the experimental error for ijk on the observation,

- Splite plot design for rumen liquid parameter:

$$Y_{ijk} = \mu + R_i + T_j + (RT)_{ij} + B_{kt} + (TB)_{jk} + E_{ijk}$$

Where, R_i: Replicate, T_j: Treatment, $(RT)_{ij}$: Interaction, B_{kl}: sampling time, $(TB)_{jk}$: interaction (TB) and E_{ijk}: Experimental error.

The Duncan's multiple range test was used to test the significance between means (Duncan, 1955).

RESULTS AND DISCUSSION

Silage Quality

The present results showed that supplementation of chemical agents to VFMW silage (S_2, S_3, S_4 and S_5) were significantly increased dry matter, organic matter, crude protein, ether extract and nitrogen free extract contents, while crude fiber content was significantly decreased ($p<0.01$) with treated silage compared with control (S_1) (Table 1). Ortho-p-acid increased crude protein content of silage by binding proteins and protecting protein from proteolysis. The effect of added formic acid in this study was applied at an adequate rate. It is capable of promoting a lactic acid fermentation under conditions where a clostridial fermentation would otherwise have occurred (Wilson and Wilkins, 1973). These results were due to the reduction of dry matter losses of treated silage (Adesogan *et al*., 2003). Similar results were obtained by Moloney and O'Kiely (1994). According sampling time of silage, dry matter, organic matter, nitrogen free extract and crude protein contents were significantly increased ($p<0.01$). However, crude fiber and ether extract contents were decreased ($p<0.01$) with time.

In vitro dry matter ($p<0.01$) and organic matter ($p<0.05$) disappearances were significantly higher with formic acid + ortho-p-acid and sodium acetate (S_4 and S_5) treated silage followed by ortho-p-acid and formic acid (S_2 and S_3) and then control (S_1) (Table 2). IVDMD and IVOMD were slightly increased ($p>0.05$) with time while there were no difference effect between 42 and 64 days of silo.

Table 1: Chemical composition of experimental silage at different ensiled stages

Treatments	DM	OM	CP	EE	CF	NFE
S_1	34.3^{C}	86.76^{A}	15.36^{b}	2.20^{c}	21.32^{A}	47.87^{B}
S_2	37.45^{B}	84.84^{B}	15.85^{ab}	2.67^{a}	17.91^{C}	48.41^{AB}
S_3	37.96^{B}	85.16^{B}	16.17^{a}	2.55^{ab}	18.49^{BC}	47.94^{B}
S_4	38.15^{AB}	85.81^{AB}	15.42^{b}	2.51^{b}	19.37^{B}	48.51^{AB}
S_5	39.41^{A}	86.38^{A}	16.16^{a}	2.46^{b}	17.83^{C}	49.92^{A}
± SE	0.082	0.033	0.065	0.151	0.116	0.113
Ensiling time (day)						
21	36.6^{B}	85.25^{B}	15.41^{b}	2.88^{A}	19.87^{A}	47.1^{B}
42	37.74^{AB}	85.82^{AB}	15.8^{ab}	2.49^{AB}	18.85^{AB}	48.68^{AB}
64	38.02^{A}	86.29^{A}	16.16^{a}	2.07^{B}	18.24^{B}	49.82^{A}
± SE	0.140	0.040	0.062	0.057	0.150	0.056

^{A,B,C}Means with different superscripts are significant ($p<0.01$) difference; ^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

Table 2: Silage quality and dry matter and organic matter disappearances of untreated and treated vegetable and fruit market wastes silage at different ensiled times (% DM)

Treatments	pH	Ammonia-N	Lactic acid	Butyric acid	IVDMD	IVOMD
S_1	4.72^{A}	2.06	7.25	0.40^{B}	57.23^{B}	62.23^{b}
S_2	4.26^{B}	2.11	7.41	0.48^{A}	60.67^{AB}	68.34^{ab}
S_3	4.40^{AB}	2.36	7.24	0.42^{B}	60.92^{AB}	67.66^{ab}
S_4	4.97^{A}	2.64	7.48	0.31^{C}	61.52^{A}	70.21^{a}
S_5	4.33^{B}	2.36	7.21	0.43^{B}	63.51^{A}	71.28^{a}
± SE	0.063	0.205	0.217	0.132	0.088	0.195
Ensiling time (day)						
21	4.30^{B}	1.72^{B}	6.15^{B}	0.25^{C}	59.77	65.98
42	4.57^{AB}	2.60^{A}	7.91^{A}	0.46^{B}	61.38	69.12
64	4.74^{A}	2.60^{A}	7.90^{A}	0.53^{A}	61.16	68.73
± SE	0.065	0.093	0.022	0.046	0.136	0.221

^{A,B,C}Means with different superscripts are significant ($p<0.01$) difference; ^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

Adesgan *et al*. (2003) found that *in vitro* dry matter and organic matter digestibility values were not affected by addition of ammonium formate, propionate, ethyle benzoate and benzoate to crimped wheat grains.

The pH values of juice pressed from the silages were within the desirable range of pH (3.9 to 4.8) of good quality silage. S_2 and S_5 silage were significantly decreased pH values compared with control (Table 2). Our results were slightly higher than results of Adesogan *et al*. (2003) and Adesogan and Salawu (2004) who reported that pH value was significantly decreased in the juice of pea silage added with formic acid. Ammonia-N and lactic acid concentrations were not affected by treatments. Adesogan and Salawu (2004) found that ammonia-N concentration decreased with Magnus pea treated by formic acid. Butyric acid concentration was significantly higher ($p<0.01$) with ortho-p-acid and lower ($p<0.01$) with formic and ortho-p-acids compared with control. Formic acid treated silage recorded the lowest value while, ortho-p-acid treated silage recorded the highest value of butyric acid. Adesogan and Salawu (2004) reported that concentration of lactic acid and butyric acids were lower in formic acid treated silage than in control. pH value, ammonia-N, lactic acid and butyric acid concentrations were significantly increased ($p<0.01$) with ensiling time (Table 2).

Digestibility Trial

Formic acid (S_2) and sodium acetate (S_3) increased ($p<0.05$) the intake of silage by goats fed on treated silage compared with control. Formic acid (S_2) and sodium acetate (S_3) had higher ($p<0.05$) digestion coefficients of DM, OM, CP, CF, EE and NFE compared with control silage. The silage additives were also improved ($p<0.05$) nutritive value of silage than control (Table 3 and 4). These increases of digestibility coefficients may be due to the increases of OM, EE and NFE contents and the decrease of CF content of treated silage (Table 1), which improved animals utilization of treated silage compared with control silage. Similar results were obtained by Moloney and O'Kiely (1994).

Rumen Parameters

Table 5 results showed that sodium acetate slightly decreased rumen pH than other treatments. All pH values were above 6.0 which indicated a better digestion of cellulolytic materials (Mertens, 1978). On the other hand, TVFA's concentration were higher ($p>0.05$) with treated silage than control. The lower TVFA's concentration for the control silage reflects the lower intake of digestible dry matter from this silage compared with treated silages (Table 4). Similar results were obtained by Moloney and O'Kiely (1994) with formic acid or organic acid complex treated grass silage. Ammonia-N concentration decreased ($p<0.05$) while, total nitrogen, true protein nitrogen and non protein nitrogen increased ($p<0.05$) with animals fed on treated silages compared to control group. These finding explain the improvement occurred in the rumen lead to higher microbial protein synthesis of animals fed treated silages. El-Sayed (2002) and Abo El-Nor and Kholif (2005) obtained similar results with goats fed on sodium acetate supplemented rations.

Milk Yield and Composition

Data presented in Table 6 showed that dry matter intake was slightly increased ($p<0.05$) with animals fed on treated silage compared with control. Milk yield and 4% FCM were significantly higher

Table 3: Chemical analysis of feedstuff ingredients used in formulation rations (on DM basis)

Items	DM	OM	Ash	CP	EE	CF	NFE
CFM	90.17	88.90	11.10	16.50	3.50	12.12	56.78
S_1	34.21	86.86	13.14	15.10	2.10	21.87	47.79
S_2	38.21	85.13	14.87	16.19	2.57	18.33	48.04
S_3	39.84	86.35	13.65	16.46	2.33	17.45	50.11

CFM: concentrate feed mixture; S_1: Untreated silage; S_2: Treated silage with formic acid; S_3: Treated silage with sodium acetate

Table 4: Average daily dry matter intake, nutrient digestibility coefficients and nutritive value of goats fed on experimental rations

Items	S_1	S_2	S_3	± SE
No. of animals	3.00	3.00	3.00	-
Live body weight	26.20	26.10	26.30	0.082
Dry matter intake (g/h/d)				
Total	715.00	756.00	756.00	5.15
From CFM	430.00	451.00	456.00	3.31
From silage	285.00^b	305.00^a	300.00^a	2.53
Nutrient digestibilities				
DM	60.00^b	67.46^a	66.79^a	2.09
OM	67.50^b	72.04^a	71.78^a	2.23
CP	71.86^b	76.97^a	74.38^a	2.47
CF	44.66^b	56.96^a	55.26^a	2.35
EE	64.68^b	72.25^a	70.21^a	3.31
NFE	63.43^b	69.36^a	67.48^a	1.86
Nutritive value				
TDN	54.54^b	67.35^a	66.29^a	2.03
DP	7.96^b	9.17^a	8.85^a	1.91

S_1: Untreated silage; S_2: Treated silage with formic acid; S_3: Treated silage with sodium acetate; ^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

Table 5: Average rumen liquor parameters of goats fed on experimental rations

Items	S_1	S_2	S_3	± SE
pH	6.67	6.65	6.50	0.10
TVFA's (meq dL^{-1})	6.0	6.4	6.6	0.22
Total nitrogen (mg dL^{-1})	209^b	230^a	249^a	9.32
True protein nitrogen (mg dL^{-1})	123^b	123^b	145^a	6.11
Non protein nitrogen (mg dL^{-1})	86^b	107^a	104^a	2.38
Ammonia-N (mg dL^{-1})	24^a	20^b	21^b	1.22

^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

($p<0.01$) in animals fed on treated silages compared with control. As an increase of milk yield, daily yields of milk fat, protein, lactose and solids not fat were significantly higher ($p<0.05$) in group fed on S_2 and S_3 than control. Data of milk composition showed that milk fat, protein and lactose contents were slightly higher ($p>0.05$) in animals fed on treated silages than control. El-Sayed (2002) and Abo El-Nor and Kholif (2005) found similar results with goats fed on sodium acetate supplemented rations. These results indicate the same trend of silage quality, nutrient digestibility values and rumen parameters which lead to higher utilization of nutrients and higher digestible nutrients reach to mammary gland for milk constituents synthesis. Generally, feed efficiency calculated as milk yield/DMI and 4% FCM/DMI were improved by S_3 followed by S_2 and then S_1 (Table 6).

Blood Serum Parameters

Animals fed on treated silage have a higher value of serum glucose content than control animals (Table 7) which was in accordance with the results of Clark *et al*. (1977) who claimed a positive correlation between blood glucose and milk yield. Treated silages tended to decreased serum urea content while, S_3 decreased ($p<0.05$) serum total lipids and increased ($p<0.05$) Glutamic-Oxaloacetate-Transaminase (GOT) contents compared with control.

Animals fed on treated silage have a slightly higher ($p>0.05$) total protein, albumine and Glutamic-Pyruvate-Transaminase (GPT) than animals fed on control silage. These results indicated that supplementing formic acid or sodium acetate to VFMW silage for lactating goats were not affecting on liver activity or animals health.

Table 6: Average daily milk yield and composition of goats fed on experimental rations

Items	S_1	S_2	S_3	± SE
No. of animals	5.00	5.00	5.00	
Live body weight	29.60	29.00	29.30	0.08
Dry matter intake (g/h/d)	922.50	947.60	975.30	5.01
Yield (g/d)				
Milk	849.26^{B}	1016.92^{A}	1091.00^{A}	39.21
4% FCM	741.00^{B}	951.30^{A}	989.50^{A}	28.40
Fat	26.75^{b}	36.30^{a}	40.04^{a}	3.31
Protein	26.84^{b}	33.56^{a}	38.40^{a}	1.71
Lactose	33.04^{b}	42.41^{a}	43.97^{a}	3.40
SNF	75.16^{b}	86.95^{a}	94.15^{a}	3.80
Milk composition (%)				
Fat	3.15	3.57	3.67	0.15
Protein	3.16	3.30	3.52	0.26
Lactose	3.89	4.17	4.03	0.13
SNF	8.85	8.55	8.63	0.15
Feed efficiency				
Milk yield/DMI	0.97^{b}	1.07^{a}	1.12^{a}	0.06
FCM yield/DMI	0.80^{b}	1.00^{a}	1.01^{a}	0.04

^{A,B,C}Means with different superscripts are significant ($p<0.01$) difference; ^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

Table 7: Effect of experimental treatments on some blood serum parameters of lactating goats

Items	S_1	S_2	S_3	± SE
Total protein (g dL^{-1})	6.13	6.32	6.49	0.53
Albumin (A) (g dL^{-1})	3.00	3.23	3.26	0.18
Globulin (G) (g dL^{-1})	3.13	3.09	3.23	0.23
A/G ratio	0.95	1.05	1.01	0.03
Urea (g dL^{-1})	40.25^{a}	30.69^{b}	24.60^{b}	0.76
GOT (U dL^{-1})	31.77^{ab}	27.97^{b}	35.74^{a}	1.76
GPT (U dL^{-1})	13.02	13.64	14.63	0.38
Total lipids (mg dL^{-1})	314.30^{a}	314.20^{a}	269.9^{b}	4.41
Glucose (mg dL^{-1})	55.35^{b}	62.08^{a}	60.17^{a}	3.83

^{a,b,c}Means with different superscripts are significant ($p<0.05$) difference

CONCLUSIONS

It could be concluded that supplementing formic acid or sodium acetate to VFMW silage for lactating goats improved silage quality, nutrients digestibility, dry matter intake, rumen activity, feed efficiency and increased milk production and composition with no deleterious effect on general health of the treated animals as compared to animals fed the control silage.

REFERENCES

Abo El-Nor, S.A.H. and S.M. Kholif, 2005. Impact of sodium acetate and sodium succinate supplemental to rations of lactating goats on milk production, milk composition and some ruminal and blood parameters. Egypt. J. Nutr. Feeds, 8: 15.

Adesogan, A.T., M.B. Salawu, A.B. Ross, D.R. Davies and A.E. Brooks, 2003. Effect of *Lactobacillus buchneri*, *Lactobacillus fermentum*, *Leuconostoc mesenteroides* inoculants, or a chemical additive on the fermentation, aerobic stability and nutritive value of crimped wheat grains. J. Dairy Sci., 86: 1789.

Adesogan, A.T. and M.B. Salawu, 2004. Effect of applying formic acid, heterolactic bacteria or homolactic and heterolactic bacteria on the fermentation of bi-crops of peas and wheat. J. Sci. Food Agric., 84: 983.

AOAC., 1995. Official Methods of Analysis of AOAC International, 16th Edn., Vol. 1, Agricultural, Chemicals, Contaminats, Drugs. Washington, DC., USA.

ARC., 1965. The Nutrient Requirement of Livestock. No. 2. Ruminants Tech. Rev. Summaries Agric. Res. Council, London.

Armstrong, W.D. and C.W. Carr, 1964. Physiological Chemistry: Laboratory Directions, 3rd Edn., Bures Publishing Co. Minneapolis, Minnesota, pp: 75.

Barrnett, A.J.G. and G. Abd El-Tawab, 1957. Determination of lactose in milk and cheese. J. Sci. Food Agric., 8: 437.

Bouquet, C.V. and L.O. Fiems, 1988. Vegetable by products of agro-industrial origin. Livestock Prod. Sci., 19: 97.

Clark, J.H., H.R. Derring and M.R. Bennink, 1977. Milk production, nitrogen utilization and glucose synthesis in lactating cows infused postruminal with sodium caseinate and glucose. J. Nutr., 107: 631.

Doumas, B., W. Wabson and H. Biggs, 1971. Albumin standards and measurement of serum with bromocresol green. Clin. Chem. Acta, 31: 87.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1.

El-Sayed, H.M., 2002. Influence of sodium acetate supplement in the ration on productive performance of lactating goats. Egyptian J. Nutr. Feeds, 5: 71.

General Statistics Year Book, 1998. Ministry of Agriculture and Land Reclamation. Economic Affairs Sector, Central Administration for Economic.

Hawk, P.B., B.L. Oser and W.H. Summerson, 1954. Practical Physiological Chemistry. 13th Edn., London J. and A. Churchill. LTD.

Henderson, A.R., D.H. Anderson, D.R. Neilson, E.A. Hunter and P. Phillips, 1989. The effect of a high rate of application of formic acid during ensilage of ryegrass on silage dry matter intake of sheep and cattle. Anim. Prod., 48: 663.

Henderson, A.R., D.H. Anderson, N.A. Scott and E.A. Hunter, 1990. A Comparison of the Nutritive Value of Silages Treated with Either a Bacterial Inoculant/enzyme or a High Level of Formic Acid. Proceeding of the 9th Silage Conferance, University of Newcastle Upon Tyne, pp: 70-71.

Kayouli, C., D. Demeyer and M. Accacha, 1993. Evaluation of poultry litter and olive cakes as an alternative feed for ruminant production in Tunisia. Proceeding the International Conferance on Increasing Livestock production through utilization of local researches. Oct. 18-22, Bejing, China, pp: 420-440.

Kayouli, C. and S. Lee, 1998. Silage from by-products for smallholder. Information from the FAO Electronic Conference on Tropical Silage. September-December, pp: 67-101.

Kung, L. and N.K. Ranjit, 2001. The effect of *Lactobacillus buchneri* and other additives on the fermentation and aerobic stability of barley silage. J. Dairy Sci., 84: 1149.

Ling, E.R., 1963. Text Book of Dairy Chemistry Vol. II. Practical Chapman and Hall, L.T.D., London. 3rd Edn.

Mertens, D.R., 1978. Effect of Buffers upon Fiber Digestion. Invited Paper at Regulation of Acid-Base Balance Symposium, Arizona Inn, Tucson, Arizona, Nov., 8-9, 1978, pp: 65.

Moloney, A.P. and P.O. O'Kiely, 1994. Rumen fermentation and degradability in steers offered grass silage made without an additive, with formic acid or with partially neutralized blend of aliphatic organic acids. Irish J. Agric. Food Res., 33: 11.

Norris, K.H., 1976. Predicting forage quality by infrared reflectance spectroscopy. J. Anim. Sci., 43: 889.

O'Kiely, P.O., 1993. Influence of a partially neutralised blend of aliphatic organic acids on fermentation, effluent production and aerobic stability of autumn grass silage. Irish J. Agric. Food Res., 32: 13.

O'Kiely, P.O. and A.P. Moloney, 1994. Silage characteristics and performance of cattle offered grass silage made without an additive, with formic acid or with partially neutralized blend of aliphatic organic acids. Irish J. Agric. Food Res., 33: 25.

O'Kiely, P.O., 1996. Performance of beef cattle offered grass silages made using bacterial inoculants, formic acid or sulphuric acid. Irish J. Agric. Food Res., 35: 1.

Parker, J.W.G. and R. Crawshaw, 1982. Effects of formic acid on silage fermentation, digestibility, intake and performance of young cattle. Grass and Forage Sci., 37: 53.

Patton, C.J. and S.R. Crouch, 1977. Spectrophotometric and kinetics investigation of the berthelot reaction for the determination of ammonia. Anal. Chem., 49: 469.

Postma, T. and J.A. Stroes, 1968. Lipids screening in clinical chemistry. Clin. Chim. Acta, 22: 569.

Reitman, S. and S. Frankel, 1957. Colorimetric method for the determination of serum glutamic-oxaloacetic and glutamic-pyrovate transaminase. Ann. J. Clin. Path., 28: 56.

Siest, G., J. Henny and F. Schiele, 1981. Interpretation des examens de laboratoire. Karger (Ed.), 206.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical Methods. 7th Edn. Iowa State Unvi. Press, Ames, Iowa, USA.

Tilley, J.M.H. and R.A. Terry, 1963. A two stage technique for the *in vitro* digestion of forage crops. J. Brit. Grass Soc., 18: 104.

Warner, A.C.J., 1964. Production of volatile fatty acids in the rumen. Methods of Measurements. Nutr. Abst. Rev., 34: 339.

Wilson, R.F. and R.J. Wilkins, 1973. Formic acid as a silage additive. 1. Effect of formic acid on fermentation in laboratory silos. J. Agric. Sci., Cambridge, 81: 117.