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# Impact of Organic Selenium and Vitamin E on Rumen Fermentation, Milk Production, Feed Digestibility, Blood Parameters and Parasitic Response of Lactating Goats

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## ABSTRACT

**Twenty Barki goats were used for evaluating the effects of oral administration of Selenium Yeast Plus vitamin E (SYPE) on rumen fermentation, milk production, feed digestibility, blood parameters and resistance to parasites. Goats were randomly divided into two groups of ten animals, control group without any treatment and treated group with 100 mg of SYPE between days 14 prepartum and 49 postpartum. Rumen fluid and faecal and blood samples were collected on days 7, 21, 35, and 49 after kidding, milk yield was determined biweekly. During the last week of the experiment, daily fresh faecal grab samples were obtained from each animal. Feed and faeces Acid Insoluble Ash (AIA) contents were used as an internal marker to estimate the apparent digestibility coefficients. Administration of SYPE enhanced (P≤ 0.001) total Short Chain Fatty Acids (SCFAs) production especially propionic acid compared to the control. Ammonia N concentration was lower (P≤ 0.036) for SYPE than for the control. Higher milk yield (P≤ 0.001) and protein and lactose percentages were found (P≤ 0.05) in SYPE than in the control group. Digestibility of organic matter, ether extract, neutral detergent fiber, acid detergent fiber and hemicelluloses were higher (P< 0.05) in SYPE than that in the control. Increased serum globulin (P≤ 0.05), glucose (P≤ 0.001) and total cholesterol (P≤ 0.05) by SYPE were found. Selenium yeast plus vitamin E decreased (P≤ 0.05) the faecal egg count compared to the control. Administration of SYPE supported positively the rumen fermentation as was evidenced from the increased milk production, improved nutrients digestibility and the apparent health statues achieved for lactating goats.**

**Keywords**: Faecal egg count, Milk yield, Selenium yeast, Short chain fatty acids.

## INTRODUCTION

During the last few weeks of gestation, the most apparent characteristic is the reduction in feed intake; though extensive metabolic and physiologic changes surround parturition, accompanied with high nutrients demand to fulfil the requirements of the developing conceptus and onset of lactogenesis (Abuelo *et al*., 2019). Such changes are associated with high occurrence of negative energy balance and increasing susceptibility to metabolic and infectious diseases (Hashem and El-Zarkouny, 2017). Several studies have been conducted to improve both nutrients utilization and energy availability during this period using different feed supplementations from synthetic or natural sources (Wang *et al*., 2009; El-Shahat and Amu, 2011; Khajali and Sharifi, 2018). Moreover, an increasing number of consumers demanding healthy and natural foods have pushed organic livestock farming that is reputed to prohibit routine use of synthetic chemical supplementation and encourage

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sustaining animals in good health with high welfare standards. Thus, feed supplements from natural resources have gained a great attention, including Selenium Yeast Plus vitamin E (SYPE). Selenium (Se) and Vitamin E (Vit E) have a close relationship with each other (Moeini *et al*., 2011). They exert similar antioxidant effects on cells via independent biochemical pathways and in different locations (Hamam and Abou-Zeina, 2007). Supplementation of Se-yeast for sheep diets enhanced Short Chain Fatty Acids (SCFAs) production and switched rumen fermentation pattern from acetic to propionic production (Faixova *et al*., 2016). Similar mechanisms were reported by Wang *et al*. (2009) on dairy cows. Abbasi *et al*. (2018) stated that there is an increase in total SCFA and propionic acid production for goats supplemented with 0.3 mg $kg^{-1}$ Se ($Na_2SeO_3$) and Vit E. Ruminal ammonia N content was reduced by Se-yeast supplemented to Simmental steers (Liu *et al*., 2007). Studies on the effects of SYPE supplementation on production and quality of caprine milk are limited if compared to those conducted on bovine and ovine milk (Pechova *et al*., 2008). Actually, Tufarelli and Laudadio (2011) showed that supplementing Se and Vit E to the diet had improved milk yield, fat, and protein in dairy Jonica goat. Also, Wang *et al*. (2009) reported that Se supplementation to cow diets in the form of Se-yeast influenced milk production positively. Previous studies illustrated that diets supplemented with SYPE for dairy cows (Calamari *et al*., 2010) and goats (Tufarelli and Laudadio, 2011) improved milk protein. Conversely, Juniper *et al*. (2006) observed that dietary Se and Vit E concentrations had no effect on milk yields and milk components. Selenium yeast enhanced nutrients digestibility and modulated the digestive microorganisms and enzymes in a dose-dependent manner. (Wang *et al*., 2009). In addition, Chauhan *et al*. (2016) reported that lambs dietary supplementation with supranutritional levels of Se and Vit E during the 3 weeks finishing period improved average Dry Matter Intake (DMI) and Average Daily Gain (ADG). Reo Leal *et al*. (2010) observed a significant decrease in Faecal Egg Count (FEC) for lambs experimentally infected with *Haemonchus contortus* but supplemented with Se and Vit E. Such effect on resistance for parasites could be due to stimulation of the lambs' immune system ( Hamam and Abou-Zeina, 2007). However, little is known about the synergistic effects of Se and Vit E supplementations on specific rumen fermentation parameters, milk performance, nutrient digestibility, and resistance for parasites in goat. Though relations among those parameters are quite complex, feeding is still the fastest way to modify animal performance. Therefore, we hypothesized that SYPE supplementation would enhance ruminal fermentation and apparent nutrient digestibility as well, which, in turn, is reflected on improvement of goat's milk production and general health. Consequently, the objective of this study was to evaluate the effects of SYPE supplementation on rumen fermentation, lactation performance, nutrient digestibility, and resistance to parasites of Barki, an indigenous dairy goat breed native of Egypt, Libya, and Tunisia.

## MATERIALS AND METHODS

The experimental animals were cared for and handled in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999). All chemical analyses were carried out at Livestock Department, Arid Lands Cultivation Research Institute, City of Scientific Research and Technological Applications, in cooperation with Department of Animal and Fish Production, Faculty of Agriculture, Alexandria University.

### Animals and Treatments

Twenty late pregnant Barki goats (32.5 ± 1.5 kg body weight) age (28±1.5 months) were allocated into a completely randomized design between days 14 prepartum and 49 postpartum.





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The does were fed twice a day at 8:00 am and 4:00 pm according to nutrient requirements of NRC (2007), a Total Mixed Ration (TMR) as a basal diet (Table 1). Animals were randomly divided into two groups each of ten goats housed in single pens according to BW and type of birth. Goats of the control group received SYPE free diet, while those of treatment group were orally administrated with 100 mg of SYPE each to provide 0.23 mg Se plus 29.8 IU of vitamin E/doe/day in the morning before access to diet, for a period of 63 days. Selenium yeast plus vitamin E powder supplement produced from *Saccharomyces cerevisiae* CNCM I-3060 (BIOSEL PLUS®, Vetagri Consulting Inc, Brampton, Canada) were diluted in 50 mL fresh water before morning feeding and were administrated to each doe individually using 50 mL syringe to make sure that each doe receives the SYPE dose according to El-Zaiat *et al*. (2018). The animals had free access to water and mineral premix.

## Chemical Analysis

The basal diet, feed refusals, and faeces samples were dried in a forced-air oven at 60ºC for 48 hours, ground to pass 1-mm screen and stored for future analyses. The Dry Matter (DM; ID number 930.15) was determined by oven drying at 105ºC for 24 hours and Organic Matter (OM; ID number 942.05) by difference after heating at 550ºC for 4 hours, Crude Protein (CP as 6.25×N; ID number 954.01) by Kjeldahl technique, and Ether Extract (EE) using the extraction system (ANKON brand, model XT10I, New

**Table 1.** Feed ingredients and chemical composition of experimental TMR diets on DM basis.

| Items | % DM |
|---|---|
| Ingredients | |
| Corn silage | 20.00 |
| Hay | 20.00 |
| Cracked corn | 37.80 |
| Cottonseed meal | 6.00 |
| Linseed meal | 6.00 |
| Wheat bran | 9.00 |
| Salt | 0.30 |
| Limestone | 0.84 |
| Mineral mixtures [a] | 0.06 |
| Chemical composition (DM) | |
| OM | 93.11 |
| CP | 14.35 |
| EE | 3.91 |
| NFC [b] | 36.31 |
| NDFom | 38.54 |
| ADFom | 17.28 |
| Hemicellulose | 19.92 |
| Cellulose | 14.02 |
| Lignin | 3.26 |
| Vitamin E [c] | 51.20 |
| Selenium [c] | 0.18 |

[a] Composition: Each one kg consisting of 45.8g Di calcium phosphate, 15g Magnesium sulfate, 6.15g Ferrous sulfate, 0.393g Potassium iodide, 0.753g Copper sulfate, 0.248g Cobalt sulfate, 0.373g Zinc sulfate, 0.022g Slinatsodium. Carrier on sodium chloride to kg Produced by Asyut Mineral Additives Company, Asyut, Egypt. [b] nonfiber carbohydrates = 100 − (% NDF + % CP + % EE + % ash). DM = dry matter; OM = organic matter; CP = crude protein; EE = ether extract; NDF = neutral detergent fibre expressed inclusive of residual ash; NDFom = neutral detergent fibre expressed exclusive of residual ash. [c] Vitamin E and selenium expressed as (mg/kg).





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York, USA) according to AOAC (2006) method. Contents of Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin (ADL) were determined sequentially from the same sample in filter bags using an ANKOM 220 Fiber Analyzer unit (ANKOM Technology Corporation, Macedon, NY, USA) and expressed exclusive of residual ash (Mertens 2002). The ADL was determined by solubilization of cellulose with sulfuric acid (72%) according to Van Soest *et al*. (1991). Vitamin E was analyzed by HPLC following solvent extraction by the method of McMurray and Blanchflower (1979), while selenium was determined using Microwave Plasma Atomic Emission Spectrometer (MP-AES) (Agilent 4100 MP-AES, USA).

### Data Collection and Analysis

### Ruminal Fermentation Parameters

Rumen fluid samples (40 mL each) were collected on days 7, 21, 35 and 49 after kidding using an esophageal probe 3 h after morning feeding. Rumen pH was measured immediately after sampling using a portable pH meter (AD 1030 model; Szeged, Hungary) according to Azizabadi *et al*. (2014). For SCFA and ammonia determination, samples were stored at –20°C without preservatives. For protozoa determination, 2-mL ruminal fluid samples were diluted in 4 mL of methyl green-formalin-saline solution and stored in glass flasks in a dark place at room temperature (Dehority *et al*., 1993). Protozoa were counted according to Dehority *et al*. (1993) by light microscopy using an Improved Neubauer Bright-Line hemocytomer (LaborOptik, Lancing, UK).

Frozen ruminal fluid samples were thawed and centrifuged at 15,000×g (RC 5B plus; Sorvall, Wilmington, DE) for 20 minutes at 4°C. Individual SCFA concentration was determined using Gas Chromatography (GC) with some modifications. In brief, after thawing, an aliquot of 1.6 mL was prepared with 0.4 mL of 25% metaphosphoric acid (4:1 ratio) and centrifuged at 15,000×g for 20 minutes at 4ºC (K1015 Micro Prime; Centurion Scientific Ltd, Stoughton, Chichester, UK). The supernatant was used to determine SCFA concentrations with a GC (Thermo fisher scientific, Inc., TRACE1300, Rodano, Milan, Italy) fitted with an AS3800 autosampler and equipped with a capillary column HP-FFAP (19091F-112; 0.320 mm od., 0.50 µm id., and 25 m length; J and W Agilent Technologies Inc., Palo Alto, CA). Nitrogen (1.35 mL $min^{-1}$) was used as carrier gas. Air, hydrogen and nitrogen fluxes (make-up gas) were kept at 450, 40, and 35 mL $min^{-1}$, respectively. A 0.1 µL aliquot was injected in splitless mode for the entire run with 31.35 mL $min^{-1}$ of H2 flux (63.432 Pa). Injector and Flame Ionization Detector (FID) temperatures were held isothermally at 250 °C. Oven heating slope was 80°C (1 minute), 120°C (20°C $min^{-1}$ for 3 minutes), and 205°C (10°C $min^{-1}$ for 2 minutes), with 9 minutes overall analytical time. Ruminal $NH_3$-N concentration was measured colorimetrically by spectrophotometer (Alpha-1101 model; Labnics Equipment, California, USA) using commercial lab test described by Konitzer and Voigt (1963).

### Milk Production and Composition

Milk yield was determined biweekly starting day 7 postpartum using the oxytocin protocol (Zamiri et al., 2001). In brief, does were drafted from the kids, penned separately, and then hand-milked by a skilled milker. To elicit milk let-down, does received an intramuscular injection of 3 mL of commercially available product containing 20 IU mg−1 oxytocin (Oxitotina eiana, ctra.Barcelona, Spain); the amount of oxytocin was administrated according to manufacturer's guidelines. Five minutes later, does were milked and the time of milking was recorded. Approximately 4 hours later, does were re-milked, in the same sequence, using the same oxytocin protocol. Collected daily milk and time between milkings were recorded. Milk samples/milking doe were collected and analyzed for





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concentrations of fat, protein, lactose, total solids, solid not fat, and ash by infrared method (EKOMILK-M ultrasonic milk analyzer, EON Trading 2000, INC, Bulgaria). The Somatic Cell Count (SCC) was determined by EKomilk scan somatic cell Milkanalyzer (Bulteh 2000, LTd, Stara Zagora, Bulgaria). Energy-Corrected Milk yield (ECM, kg d-1), Milk Energy Value (MEV, kcal kg-1) and Net Energy for Lactation (NEL, Mcal kg-1) were calculated according to Bernard (1997) and Baldi et al. (1992).

**Apparent Nutrients Digestibility Determination**

During the last week of the experimental period, fresh grab faecal samples (50-100 g) were obtained from each animal for 7 consecutive days 3 hours before feeding. Feed and faeces Acid Insoluble Ash (AIA) contents were used as an internal marker to estimate the apparent digestibility coefficients according to Van Soest *et al*. (1991). All faeces aliquots from each animal were bulked and mixed completely; samples were dried in a forced air oven at 55ºC for 72 hours, ground to pass through 1 mm stainless steel Wiley mill screen, and stored until chemical analysis. Apparent DM, OM, CP, EE, ash-free Neutral Detergent Fiber (NDFom) and ash-free Acid Detergent Fiber (ADFom) digestibility were calculated based on the relative concentrations of these nutrients and of AIA in the feed and faeces.

**Blood Parameters and Faecal Egg Count Analysis**

On days 7, 21, 35 and 49 postpartum, blood samples (10 mL each) were taken from jugular vein of each doe in the morning, before access to feed or water, into non-heparinized tubes (BD Vacutainer®Tubes, NJ, USA). Serum was separated by centrifugation at 4,000×g and 4°C for 20 minutes and frozen at −20°C for later analysis. Concentrations of serum Total Protein (TP), Albumin (A), Glucose (Gl), and Total Cholesterol (CHO) were determined using commercial colorimetric kits (Stanbio, Texas, USA.). Globulin (G) concentration was calculated as the difference between TP and A. The individual faecal samples were also collected on days 7, 21, 35 and 49 under the same conditions as blood samples to measure FEC by the modified McMaster technique (Ueno and Gonçalves.1994). In brief, 2 grams of faeces were weighed and 30 mL of flotation solution (saturated sodium chloride) were added. The sample was crushed and mixed thereafter. While stirring with a pipette, the liquid was sucked to fill the McMaster chambers, which was placed within the microscope stage. The parasite eggs for each species were counted in both chambers and the total number per species was. Multiplied by 25 to obtain the total eggs per gram.

**Statistical Analysis**

Analyses of all recorded data over the course of the experiment were processed using a linear mixed model (PROC MIXED from SAS version 9.1) (SAS, 2002) for repeated measurements and included treatment (Control and SYPE) and sampling times (7, 21, 35 and 49) as fixed factors and the parity as a random. Multiple comparisons among means were performed using the Duncan's test and differences between treatment means were considered significant at $P \leq 0.05$. All results were expressed as Least Square Means (LSM)±Stander Error of Mean (SEM). The SCC was transformed by log10 (X+10) while FEC was transformed using Square-root transformation (value+0.5).

## RESULTS

**Ruminal Fermentation**

Fermentation parameters are shown in Table 2. No difference in ruminal pH was detected





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while SYPE increased (P≤ 0.001) total SCFA compared to the control. There were no differences (P> 0.05) in molar proportion of SCFA, except propionic acid which increased (P≤ 0.001) by SYPE supplementation. Molar proportion of acetic acid was not affected by SYPE (P> 0.05) while propionic acid was higher (P≤ 0.01) for SYPE supplementation than for the control. As a result, the high ratio of acetic to propionic acids ammonia N concentration was lower (P≤ 0.05) for SYPE than for the control. In addition, total protozoa number was not affected (P≥ 0.552) by SYPE.

### Dry Matter Intake, Milk Production and Composition

No significant effect on dry matter intake was detected by SYPE supplementation (Table 3). While milk yield was higher (P≤ 0.01) for SYPE than for the control, ECM and NEL followed similar patterns as milk yield but the proportion of milk fat was not affected. Proportions of milk total solids, solids not fat, ash and SCC were not affected (P> 0.05) but milk protein and lactose were enhanced (P≤ 0.05) by SYPE supplementation compared to the control.

### Apparent Nutrients Digestibility

Nutrient digestibility of goats is shown in Table 4. Digestibility of EE, NDF, ADF and Hemicelluloses was higher (P< 0.05) for SYPE than for the control. While DM, CP and cellulose were not affected (P> 0.05), there was a tendency (P≤ 0.059) for OM digestibility to increase.

### Blood Serum Biochemical and FEC

The effect of SYPE on blood biochemical parameters and FEC are presented in Table 5. Serum total protein and albumin were not affected (P≥ 0.05) by SYPE, while globulin, glucose and total cholesterol increased (P≤ 0.05). Selenium yeast plus vitamin E decreased (P≤ 0.05) the FEC compared to the control.

## DISCUSSION

### Ruminal Fermentation

The reduction in Acetic Propionic ratio (A:P) suggested that supplementing goat diets with SYPE altered rumen fermentation pattern from acetic to propionic acids

**Table 2.** Least square means (±SEM) of ruminal fermentation parameters of Barki goats supplemented with selenium yeast plus vitamin E (SYPE). [a]

| Parameters | Treatments | | SEM | *P* .value |
|---|---|---|---|---|
| | Control | SYPE | | |
| pH | 6.65 | 6.51 | 0.04 | 0.101 |
| Total SCFA mol/100 ml | 132.55[b] | 145.45[a] | 1.91 | 0.001 |
| Acetic (A) | 70.98 | 71.39 | 0.69 | 0.804 |
| Propionic (P) | 31.48[b] | 42.42[a] | 1.36 | 0.001 |
| Butyric | 23.90 | 26.36 | 0.71 | 0.126 |
| Valeric | 2.26 | 2.48 | 0.08 | 0.074 |
| Iso-Butyric | 1.93 | 1.65 | 0.23 | 0.443 |
| Iso-Valeric | 1.97 | 2.03 | 0.09 | 0.509 |
| A:P | 2.27[a] | 1.68[b] | 0.08 | 0.003 |
| Ammonia -N (mg/dl) | 14.89[a] | 12.77[b] | 0.49 | 0.036 |
| Protozoa $\times 10^5$/ml | 3.32 | 3.19 | 0.10 | 0.552 |

[a] (a , b) Means in the same row with different superscripts differ significantly (P<0.05).





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**Table 3**. Least square means (±SEM) of Milk production and composition of Barki goats supplemented with selenium yeast plus vitamin E (SYPE).

| Parameters | Treatments | | SEM | *P* .value |
|---|---|---|---|---|
| | Control | SYPE | | |
| DM Intake (kg/d) | 1.05 | 1.14 | 0.01 | 0.708 |
| Milk Yield (kg/d) | 0.76[b] | 1.05[a] | 0.06 | 0.002 |
| Energy corrected milk (kg/d) | 0.82[b] | 1.11[a] | 0.05 | 0.002 |
| Milk energy value (kcal/kg) | 240.70 | 241.91 | 0.47 | 0.209 |
| Energy for lactation ( Mcal/kg) | 0.64[b] | 0.76[a] | 0.02 | 0.004 |
| Milk composition (%) | | | | |
| Fat | 3.84 | 3.88 | 0.11 | 0.811 |
| Protein | 3.82[b] | 4.00[a] | 0.04 | 0.029 |
| Lactose | 4.17[b] | 4.51[a] | 0.07 | 0.022 |
| Total solids | 10.54 | 11.26 | 0.22 | 0.123 |
| Solids not fat | 7.37 | 7.07 | 0.09 | 0.136 |
| Ash | 0.67 | 0.63 | 0.03 | 0.478 |
| Log SCC | 2.98 | 2.86 | 0.06 | 0.341 |

[a , b] Means in the same row with different superscripts differ significantly (P<0.05).

**Table 4.** Least square means (±SEM) of nutrients digestibility of Barki goats supplemented with selenium yeast plus vitamin E (SYPE).

| Parameters | Treatments | | SEM | *P* .value |
|---|---|---|---|---|
| | Control | SYPE | | |
| Dry matter | 0.681 | 0.721 | 0.01 | 0.085 |
| Organic matter | 0.707 | 0.754 | 0.01 | 0.059 |
| Crude protein | 0.664 | 0.692 | 0.02 | 0.395 |
| Ether extract | 0.688[b] | 0.751[a] | 0.01 | 0.013 |
| Neutral detergent fibre | 0.539[b] | 0.614[a] | 0.02 | 0.013 |
| Acid detergent fibre | 0.484[b] | 0.548[a] | 0.02 | 0.048 |
| Hemicelluloses | 0.589[b] | 0.671[a] | 0.02 | 0.041 |
| Cellulose | 0.595 | 0.624 | 0.01 | 0.249 |

[a , b] Means in the same row with different superscripts differ significantly (P<0.05).

**Table 5.** Least square means (±SEM) of blood serum metabolites and faecal egg counts in Barki goats supplemented with selenium yeast plus vitamin E (SYPE).

| Parameters | Treatments | | SEM | *P* .value |
|---|---|---|---|---|
| | Control | SYPE | | |
| Total protein (g/dl) | 5.63 | 5.68 | 0.16 | 0.862 |
| Albumin (g/dl) | 3.48 | 3.31 | 0.17 | 0.543 |
| Globulin (g/dl) | 2.14[b] | 2.37[a] | 0.06 | 0.027 |
| Gloucose (mg/dl) | 28.88[b] | 37.36[a] | 1.29 | 0.001 |
| Total cholesterol (mg/dl) | 38.09[b] | 44.52[a] | 1.57 | 0.047 |
| FEC[*] | 33.81[a] | 27.43[b] | 2.11 | 0.012 |

[a , b] Means in the same row with different superscripts differ significantly (P<0.05).
[*]FEC=Transformed faecal egg counts using Square-root transformation (Value+0.5).





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production. Similar results were found by Faixova *et al*. (2016). This is attributed to an increase in molar proportion of propionic acid and in SCFA concentrations due to greater ruminal microbial fermentation rate (Wang *et al*., 2009). Supplementation of Se in the form of yeast enhanced the activity of alkaline phosphatase and glutamate dehydrogenase in ruminal fluid (Faixova *et al*., 2007) due to the supportive effect of Se on rumen microbial populations' resistance and activity. In addition, Se and Vit E are essential components of the antioxidant defense system and play an important role in growth through participation in enzymes and critical enzymes reactions (Willshire and Payne, 2011). Antioxidants were found to enhance the activity and growth of ruminal microbes and to promote the digestion and efficiency of diet utilization *in vitro* (Vázquez-A˜nón and Jenkins, 2007; Morsy *et al*., 2015). As most of ruminal microbes are predominantly strict anaerobes with less developed antioxidant capacity than facultative anaerobic and aerobic microbes, it is possible that the addition of antioxidants would reduce oxidative stress, thus promoting better conditions for microbial growth and fermentation (Cattani *et al*., 2012). Other explanation for enhancement of ruminal fermentation by SYPE supplementation could be related to the rise of rumen fluid enzyme activity and the increase of the activity of enzymes involved in nitrogen metabolism in rumen such as gamma-glutamyl transferase and glutamate dehydrogenase (Faixova *et al*., 2016). The current increases in total SCFA and propionic acid production by SYPE supplementation are consistent with the results of Abbasi *et al*. (2018) who reported an increase in total SCFA and propionic acid production when goats were supplemented 0.3 mg $kg^{-1}$ Se ($Na_2SeO_3$) and Vit E. Correspondingly, Liu *et al*. (2007) reported reduction of *A:P* due to an increase in propionic acid production when steers were fed 300 and 600 mg Se-yeast per kg of dietary DM. Xun *et al*. (2012) reported decreased ($P< 0.01$) ruminal ammonia N concentration and *A:P* ratio and increased total SCFA concentration with 4 g nano- Se (4 mg Se $kg^{-1}$ of DM) and 4 g Se-yeast supplementation (provide 4 mg Se $kg^{-1}$ of DM) in ruminally cannulated sheep. This agrees with the results of Shi *et al*. (2011) who obtained higher SCFA concentration in sheep fed with the basal diet supplemented with 3 g of nano-Se (provide 3 mg Se $kg^{-1}$ of DM). The decrease of ammonia N content in the rumen is consistent with the finding by Liu *et al*. (2007) that ammonia N content was reduced by Se-yeast supplementation. An enhanced growth of ruminal microbial populations by Se-yeast additives would increase the ammonia N consumption (Faixova *et al*., 2007). Cellulolytic bacteria obtain N entirely from ammonia N (Soltan *et al*., 2013). Nevertheless, it was assumed that when ruminal ammonia N concentration goes above 5 mg $dL^{-1}$, it maintains optimal microbial growth (Satter and Slyter, 1974).

## Dry Matter Intake, Milk Production and Composition

The observed lack of effect of SYPE supplementation on DMI is in agreement with earlier reports (Givens *et al*., 2004 and Gong *et al*., 2014). Likewise, Juniper *et al*. (2006) found no effects ($P> 0.05$) for source or level of selenium on DMI. An increase in milk yield of goats supplemented with SYPE compared to the control was likely due to an improvement of ruminal fermentation and enhancement of nutrient digestibility under equal amounts of DMI. Wang *et al*. (2009) showed that dietary supplementation of Se-yeast influenced positively cow milk production owing to improvement in ruminal fermentation process and, consequently, digestibility of nutrients contained in the ration. The antioxidant synergistic effect of SYPE mainly lead to an increase in ruminal total SCFA especially propionic acid, which is the most important substrate for hepatic gluconeogenesis; it accounts for 60–74% of glucose formation substrates, and is highly





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associated with dairy ruminants milk yield (Morsy *et al*., 2016). Other explanation for increasing milk yield could be ascribed to an increase in serum glucose concentration, a precursor of lactose and an osmotic constituent of milk, which increases water secretion and, consequently, milk production (Morsy *et al*., 2016). In addition, SYPE used in this study changed metabolic profile of the treated goats. It increased blood serum albumin, glucose and total cholesterol. The increase in these metabolites was associated with improved milk production and positive energy balance in small ruminants (Hashem and El-Zarkouny, 2016). This generates another suitable explanation for enhancing milk of the treated animals. Such enhancement was consistent with higher ECM and NEL and with results of Liu *et al*. (2008) on diets supplemented with SYPE. Conversely, Petrera *et al*. (2009) reported similar milk yield for Saanen dairy goats fed diets containing Se derived from either Na-selenite or Se–yeast. The high milk protein contents of goats supplemented with SYPE in this study may have been influenced by rumen fermentation, since the main precursors of milk protein originate in the rumen. Our results confirmed the results obtained from (Calamari et al., 2010 : Tufarelli and Laudadio, 20111) on dairy cows and goats. Calamari *et al*., 2010) and (Tufarelli and Laudadio, 2011). Previous research conducted throughout the whole lactation period of dairy goats (270 days) showed an increase in daily milk yield, protein, and lactose and, thus, in DM and solid not fat when diets were supplemented with the organic form of Se compared to those supplemented with sodium selenate (Bagnicka *et al*., 2014).

## Apparent Digestibility

The consistent improvement in apparent nutrients digestibility and total SCFA production under SYPE supplementation confirmed the enhanced rumen fermentation. These results are also in agreement with previous findings that the digestibility of nutrients and utilization of nitrogen of lactating dairy cow supplemented with 0, 150, 300 and 450 mg Se-yeast $kg^{-1}$ of DM were higher than those of un-supplemented (Wang *et al*., 2009). According to the authors, the optimum dose of Se-yeast should be 300 mg $kg^{-1}$ of ration DM. This further suggested that Se- yeast modulates the digestive microorganisms or enzymes in a dose-dependent manner (Wang *et al*., 2009). In addition, Chauhan *et al*. (2016) reported that supplementation of lambs diet with supra-nutritional levels of Se and Vit E during the 3-week finishing period improved average DMI and ADG, probably owing to the fact that Se and Vit E are critical constituents of the antioxidant defense system and play an important role in growth through their participation in enzymes and essential enzymes reactions.

## Serum Biochemicals and Parasitic Response

A synergistic action existing between Se and Vit E resulted in more powerful beneficial effects on Immunoglobulins (Igs) levels than administration of either alone (Hamam and Abou-Zeina, 2007). Such effect explains the significant increase of serum globulin in SYPE treated goats. In agreement with this, combined supplementation of diet with Se and Vit E led to an increase in plasma globulin of experimental ewes and their lambs (Soliman *et al*., 2012). Similar increase in total serum globulin was reported on Baladi ewes fed on diet supplemented with 3 mg Se/kg plus 50 mg Vit E 2 weeks before mating untill lambing (El-Shahat and Amu, 2011). Previous study on the concentration of total serum cholesterol of lambs confirmed that the administration of 1 mL 0.1% $Na_2SeO_4$, and 60 mg Vit E /lamb/day during fattening resulted in a decrease of low density lipoprotein (LDL) level and an increase of High Density Lipoprotein





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(HDL) level of the experimental lambs compared to the control (Gabryszuk *et al*., 2007). Accordingly, though not assessed, the increase of serum total cholesterol in the current study could be due to the increase of HDL.

Our results on FEC are in agreement with Reo Leal *et al*. (2010) who observed significant decrease in FEC for lambs experimentally infected with *Haemonchus contortus* while supplemented with Se and Vit E. The reduction of FEC under SYPE treatment was related to the stimulation of the immune system of goats against parasitic infection ( Hamam and Abou-Zeina, 2007). The ability of Se and Vit E to provide great antioxidant protection against the oxidative stress is attributable to the activity of Glutathione-Peroxidase (GSH-Px). Such enzyme is one of the most vital antioxidants present in the organism. It is associated with the normal function of the immune system and can modulate a chain reaction that catalyzes the formation of prostacyclins, leukotrienes, prostaglandins and thromboxanes (Halliwell and Gutteridge, 2007). Though Se and Vit E are two chemically different compounds with distinct antioxidant properties, they have overlapping functional goal in the biological system (Hamam and Abou-Zeina, 2007). The metabolic function of Se is intimately linked to Vit E and both compounds protect the cellular membranes against oxidative degeneration and improve the immunocompetence and responsiveness of the host (Reo Leal *et al*., 2010).

## CONCLUSIONS

Supplementation of lactating goats with SYPE increased rumen SCFA concentration and switched rumen fermentation pattern into more propionic acid production. Improved milk yield and quality was likely due to the increased digestibility of nutrients since DMI was not affected. Selenium yeast and vitamin E enhanced goats' defense against parasitic infection.

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## اثر سلنیوم آلی و ویتامین E روی تخمیر شکمبه ، تولید شیر، گوارش پذیری غذا، پارامترهای خون و واکنش بزهای شیرده به انگل ها

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### چکیده

به منظور ارزیابی اثر مصرف دهانی سلنیوم مخمر به اضافه ویتامین E (SYPE) روی تخمیر شکمبه ای، تولید شیر و گوارش پذیری غذا، پارامترهای خون، و مقاومت بزهای شیرده به انگل ها، ۲۰ بز Bakri بررسی شدند. بزها به دو گروه تصادفی ده تایی گروه بندی شد که گروه شاهد بدون تیمار بود ولی به گروه آزمایشی بین ۱۴ روز قبل از زایمان و ۴۹ روز پس از زایمان، ۱۰۰ میلی گرم SYPE داده شد. نمونه مایع شکمبه به همراه مدفوع و خون در ۳۵،۲۱،۷ و ۴۹ روزبعد از زایش بزها برداشت شد و تولید شیر به صورت دو هفته ای تعیین شد. در طی هفته آخر آزمایش، نمونه های مدفوع به طور روزانه از هر بز گرفته میشد. خاکستر نامحلول در اسید (AIA) غذا و مدفوع به عنوان یک نشانگر داخلی برای تخمین ضریب ظاهری گوارش پذیری استفاده شد. در مقایسه با شاهد، کاربرد SYPE تولید کل اسیدهای چرب زنجیره کوتاه (SCFA) را به ویژه در مورد پروپیونیک اسید ارتقا داد ($P\leq0.001$). غلظت نیتروژن آمونیاکی در تیمارهایSYPE درمقایسه با شاهد کمتر بود ($P\leq0.036$). اما در تیمارهایSYPE، تولید شیر($P\leq0.001$) و درصد پروتئین و لاکتوز($P\leq 0.05$) افزایش نشان داد. همچنین، گوارش پذیری مواد آلی، عصاره اتر، فیبر شوینده خنثی،فیبر شوینده اسید، و همیسلولز در تیمارهایSYPEبیشتر از شاهد بود ($P\leq 0.05$) . نیز، در تیمارهایSYPE ، گلوبولین سرم ($P\leq 0.05$)، گلوکز ($P\leq0.001$)، و کلسترول کل ($P\leq 0.05$) بیشتری یافت شد.سلنیوم مخمر به اضافه ویتامین E باعث کاهش تعداد تخم درمدفوع در مقایسه با شاهد شد ($P\leq0.001$). در نتیجه، به شهادت





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افزایش تولید شیر، بهبود گوارش پذیری مواد غذایی، و وضعیت ظاهری سلامت بزهای شیرده، می توان گفت که کاربرد SYPE به طور مثبتی تخمیر شکمبه را بهبود داد.



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