

Alleviation of Oxidative Stress by Using Olive Pomace in Crossbred (Brown Swiss X Baladi) Calves Under Hot Environmental Conditions

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ABSTRACT

Ten female crossbred (Brown Swiss X Baladi) calves, 8 – 10 months old with average live body weight of 112 kg at the beginning of experimental period were used to investigate the effect of olive pomace (OP) supplementation which contains phenolic compounds on oxidant and antioxidant agents and some blood constituents, and its relation with growth performance in heat stressed calves. The animals were maintained under hot summer environmental conditions, where, ambient temperature and relative humidity averaged $37.48^{\circ}\text{C} \pm 0.32$ and $64.58\% \pm 0.77$, (equivalent to THI 91) during day, and $28.38^{\circ}\text{C} \pm 0.22$ and $78.23\% \pm 0.69$, (equivalent to THI 80) during night, respectively. The animals were divided into two equal groups (5 calves each). The first group (control) received 0 % OP of the concentrate mixture, while, the second group (treated) received 15 % OP of the concentrate mixture, for two months. Body weight of calves was recorded twice at the beginning and at the end of experimental period, and daily gain was calculated for each animal. Blood samples were taken from each animal at the end of experimental period to determine antioxidant and oxidant indices, some blood constituents and T_3 concentration.

Our results showed that supplementation of OP significantly increased antioxidant status including catalase enzyme activity, total antioxidant capacity, uric acid as a non-enzymatic antioxidant and copper as a specific antioxidant protecting macromolecules. Moreover, OP significantly reduced serum malondialdehyde as a lipid peroxidation marker, iron concentration which act as a pro-oxidant, lipids profile including total cholesterol, low density lipoprotein (LDL – cholesterol), very low density lipoprotein (VLDL – cholesterol), triglycerides and phospholipids. Also, OP caused a significant decrease in serum creatinine and urea-N concentrations as well as AST activity. However, OP significantly elevated T_3 level, and improved feed efficiency and daily gain.

It can be concluded that supplementation of OP at the level of 15 % of concentrate mixture under Egyptian hot summer environmental conditions reduced the negative effect of oxidative stress as shown by significantly improving antioxidant status, most blood constituents and T_3 level as well as growth performance in growing crossbred calves.

Key words: olive pomace / oxidative stress / blood constituents / growing calves.

INTRODUCTION

High ambient temperature, relative humidity, and radiant energy impair the ability of farm animals, particularly the feedlot calves to dissipate heat, resulting in heat stress (Kamal, 1976; El-Masry and Marai, 1991; Abdalla *et al.*, 2009a). Also, it is well known that heat stress is one of the

main reasons for oxidative stress in animals occurred as they exposed to high ambient temperature during hot summer, Oxidative stress is a consequence of disorder or imbalance between reactive oxygen species (ROS) generation and efficiency of the antioxidant defense system, leads to damage of biological macromolecules and disruption of normal metabolism and physiology (Merlob *et al.*, 2008; Kowalska and Jankowiak, 2009).

However, oxidative stress in animals must be controlled by supplying all known antioxidant nutrients and by minimizing the effects of substances that stimulate the formation of ROS (Ganaie *et al.*, 2013). So, addition of antioxidants additives to feedstuff can help to counteract the detrimental effects of oxidative stress, which occurs as the animals expose to heat stress during hot summer conditions (Wresburger, 2002).

Olive pomace (OP) is one of the agro-industrial by-products that represent an important group of feed resources for ruminants and play important economic and social roles in Mediterranean Sea countries (Vasta *et al.*, 2008; Molina and Yanez, 2008). Moreover, OP is considered natural antioxidant, which has been widely accepted as one of the highest antioxidant activity, it is due to the presence of some important antioxidant and phenolic compounds (Jemai *et al.*, 2009). These phenolic compounds (oleuropein, verbascoside, ligstroside, lutein, apigenine, tyrosol, and hydroxytyrosol) have shown biological activities as antioxidants (Visioli *et al.*, 2002; Bonilla *et al.*, 2006 and Fares *et al.*, 2011).

Therefore, in order to reduce the side effect of oxidative stress in heat stressed calves, OP has been used in our experiment. But because the response of growth performance to OP in heat stressed calves are limited and controversial. Thus, the objective of the present study was to evaluate the effect of supplemental OP on some antioxidant enzymes, blood constituents, T₃ level and growth performance in heat-stressed calves.

MATERIALS AND METHODS

1- Animals and Experimental Design

In this experiment, OP was used as a supplement with the concentrate of calves, where the OP is considered as a residue left after extracting the oil and purchased from new EL-Salheya olive mill factory – sharkia Governorate, Egypt. This factory extracts the olive oil by wet crushing the whole fruits with and extracting the oil by centrifugation and the residual product after extracting was sun dried for about 15 days. Ten female crossbred (Brown Swiss x Baladi) calves of 8 – 10 months old were used in the present study, with average live body weight (BW) of 112 kg at the beginning of experimental period. The animals were divided into two equal groups (5 calves each), the first group served as control and received 0 % OP of the concentrate mixture, while, the second group received 15 % OP of the concentrate, for a period of two months.

2-Feed and Feeding

Feed allowances were offered once a day in the morning. The animals were fed in groups. The concentrate feed mixture (CFM) was offered on the base of the average body weight according to NRC (2001), while, rice straw was offered *ad libitum*. The fresh tap water was available to all animals at all times in basins that were daily filled with fresh water after well cleaning. Samples were taken from the CFM and rice straw for proximate analysis for dry matter (DM), crude protein (CP), crude fiber (CF), ether extracts (EE) and ash content according to A.O.A.C. (1996). Nitrogen free extract (NFE) was calculated by differences. The ingredients of CFM are shown in Table (1). The chemical compositions and nutritive values of the experimental feedstuffs on dry matter basis are shown in Table (2).

Table (1): Ingredients of the concentrate feed mixture (CFM).

<u>Items</u>	<u>CFM</u>
Ingredients (%)	
Crushed yellow maize	50.00
Wheat bran	20.00
Soybean meal	5.00
Uncorticated cotton seed meal	22.50
Lime stone	1.00
Sodium chloride	1.00
Minerals mixture*	0.10
Vitamin mixture**	0.10
Sodium bicarbonate	0.20
Antitoxin	0.10

* mineral mixture contains: 5g Cu ,30g Fe , 40g Mn , 45g Zn , 0.3g I, 0.1g Se and 881.6g Caco3/ kg mixture.

**vitamin mixture contains: 20 million (I.U) vit A, 2 million (I.U) vit D3 and 2g vit E / kg mixture.

Table (2): The chemical compositions and nutritive values of the experimental feedstuffs on dry matter basis

<u>Items</u>	<u>CFM</u>	<u>Rice straw</u>
Chemical composition (%):		
Moisture	12.40	7.50
Dry matter (DM)	100	100
Organic matter (OM)	94.10	81.82
Crude protein (CP)	16.80	3.20
Crude fiber (CF)	8.00	34.05
Ether extract (EE)	2.60	1.94
Ash	5.90	18.18
Nitrogen – free extract (NFE)	66.70	42.63
Nutritive values:		
	<u>CFM</u>	<u>Rice straw</u>
GE (Mcal/kg DM)*	4.30	3.55
NE (Mcal/kg DM)**	1.60	0.94
TDN (%/kg DM)**	70.20	43.24

% NFE = % DM - (% EE + % CP + % ash + % CF) *, GE (Mcal/kg DM) = 0.057 CP % + 0.094 ether extract (EE) % + 0.0415 carbohydrate % (NRC, 2001); **, NE (Mcal/kg DM) = 0.0245 X TDN % - 0.12 (NRC, 2001);***, TDN (%/kg DM) according to the Central Lab for Food and Feed (CLFF), Agric. Res. Center, Egypt (2001).

3- Environmental Conditions

The animals were housed in a free – stall barn with force shade during day and night and kept under the same environmental and managerial conditions to the termination of the trail.

This experiment was carried out during July and August 2012, for two months. where, ambient temperature (AT) and relative humidity (RH) averaged 37.48°C ± 0.32 and 64.58 % ± 0.77, respectively equivalent to THI of 91 during day, while, AT and RH averaged 28.38 °C ± 0.22 and 78.23 % ± 0.69, respectively equivalent to THI of 80 during night. THI was calculated according to the equation proposed by (Amundson *et al.*, 2006) as follow: $THI = (0.8 * AT \text{ } ^\circ C) + ((RH \text{ } \%) * ((AT \text{ } ^\circ C - 14.4) / 100)) + 46.4$.

4- Blood Sampling and Analysis

Fasting blood samples were collected from the jugular vein of each animal in clean sterile tubes at the beginning and at the end of experimental period. Serum was separated by centrifugation (20 min, 3000×g) and stored at -20°C until analysis. Peroxidative marker, antioxidant enzymes and T₃ level were immediately determined after serum separation. Other biochemical determinations were carried out at the end of experimental period.

All the following parameters were determined: Serum antioxidant enzyme activities (glutathione reductase and catalase) , non-enzymatic antioxidant (uric acid), total antioxidant capacity as antioxidant biomarkers, serum malondialdehyde (MDA) as a lipid peroxidation marker, concentrations of serum total cholesterol, high density lipoprotein - cholesterol (HDL - cholesterol), low density lipoprotein - cholesterol (LDL- cholesterol), and triglycerides as lipids profile, serum concentration of urea-N and creatinine as kidney functions, serum activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) as liver functions, and serum concentration of iron and copper were determined using commercial kits manufactured by Bio-Diagnostic Company, Egypt.

Values of serum very low density lipoprotein - cholesterol (VLDL- cholesterol) and phospholipids were determined according to **Ellefson and Caraway (1982)**.

Serum concentration of triiodothyronine (T₃) was determined by using ¹²⁵I- RIA and antibody-coated tubes kits purchased from Immunotech Beckman Coulter, Inc., Prague, Czech Republic, Europe.

5- Growth Performance

Body weight of calves was recorded (before eating and watering) at the beginning and the end of experimental period, then total and daily gain was calculated for each calf. Dry matter intake was determined as kg per day for each calf. Feed efficiency was calculated as kg gain / kg dry matter intake.

6- Statistical Analysis

the differences between the mean values of treatment and control groups were tested using the un-paired varieties of "t" test of significance, according to statistical analysis system (**SAS**) software program (**SAS, 2009**).

The model used is:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Y = the dependent variable, μ = the overall mean, T_i = the fixed effect of treatment (1= control, 2= treatment), e_{ij} = random error.

RESULTS AND DISCUSSION

Effect of olive pomace supplementation (15 % of concentrate) on growing calves maintained under hot environmental conditions:

1- Oxidant and Antioxidant Status

Data presented in table (3) showed that when the heat stressed calves were supplemented with OP (15 % of concentrate), malondialdehyde (MDA) level as indicator of the damage of cell membrane was significantly (P < 0.01) decreased by -31.48 % and glutathione reductase (GR) as antioxidant was decreased but insignificantly. However, a significant (p< 0.01) increase in both catalase enzyme activity as antioxidant and total antioxidant concentrations were recorded by 24.02 and 15.19 %, respectively.

Table (3): Effect of olive pomace supplementation (15 % of concentrate) on oxidant and antioxidant status in growing calves maintained under hot environmental conditions.

Items	Control (Mean ± S E)	Treatment (Mean ± S E)	Change %	Significance
MDA (nmol/ml)	1.153 ± 0.04	0.790 ± 0.03	-31.48	P < 0.01
Glutathione reductase (U/L)	2482.25 ± 21.85	2419.25 ± 29.45	-2.50	not- Significant
Catalase (U/L)	358 ± 5.38	444 ± 4.30	24.02	P < 0.01
Total Antioxidant (mM/L)	0.619 ± 0.01	0.713 ± 0.01	15.19	P < 0.01

Concerning the relationship between hot summer conditions and oxidative stress, **Wresburger (2002)** reported that antioxidants additives to feedstuff that can help to counter the detrimental effects of oxidative stress, which occur when the animals exposed to heat stress during hot summer conditions.

Also, **Burke et al. (2007)** found that the activity of glutathione reductase (GR) was less under hot summer compared to mild conditions. As the predominant low-molecular weight thiol in animal cells reduced glutathione (GSH) serves as a crucial antioxidant to offset environmentally derived oxidative stress, and **Ganaie et al. (2013)** reported that heat stress is one of the main reasons for oxidative stress in animals. Moreover, **El-Damrawy (2014)** reported that heat stressed broilers without any supplementations exhibited an increase of MDA by 92.65 % and a decrease of GSH by 34.01%, as compared with control group.

Among natural antioxidants, OP has been widely accepted as one of the highest antioxidant activity, due to the presence of some important antioxidant and phenolic compounds (**Jemai et al., 2009**). These phenolic compounds such as oleuropein, verbascoside, ligstroside, lutein, apigenine, tyrosol and hydroxytyrosol have shown biological activities as antioxidants (**Visioli et al., 2002; Bonilla et al., 2006 and Fares et al., 2011**). Moreover, its high concentration of biophenols protects from oxidative stress status possibly by inhibition of lipid peroxidation and enhancing antioxidant enzyme activities (**Tavafi et al., 2012**).

So, we can attribute our results which show a decrease of MDA and the increase of antioxidant enzyme activities under heat stress to the antioxidant power of polyphenols found in OP (**Visioli et al., 2009**). Also, the effect of polyphenols as antioxidant were found in other seeds, since the antioxidant properties of poly phenols were found in grape seeds (**El-Damrawy, 2014**) and tamarind seed coat (**Aengwanich and Suttajit, 2010**) had a significant effect to decrease MDA and increase antioxidant enzyme activities in broiler under high ambient temperature.

2- Lipids Profile

As shown in table (4) supplementation of OP to heat stressed calves induced a significant decrease in concentration of each of total cholesterol (p <0.01) by – 4.69 % , triglycerides (p <0.01) by -22.49, phospholipids (p <0.01) by – 3.14, LDL-cholesterol (p <0.01) by – 22.96, and VLDL-cholesterol (P < 0.01)by – 22.47 % , while, a significant (p < 0.01) increase by 8.22 % in HDL-cholesterol concentration was observed.

Several investigators reported that there are significant increases in cholesterol, phospholipids, total lipids and triglycerides under hot summer conditions in white rabbit males (**El-Masry et al., 1994**), and in LDL, VLDL and triglycerides in heat stressed calves (**Abdalla et al., 2009a and Attia et al., 2010**), while adding OP to the basal diets of calves reduce a the negative effect of hot conditions on lipids profile as shown in (Table 4).

Table (4): Effect of olive pomace supplementation (15 % of concentrate) on lipids profile in growing calves maintained under hot environmental conditions.

Items	Control (Mean ± S E)	Treatment (Mean ± S E)	Change %	Significance
Cholesterol (mg / dL)	154.70 ± 1.19	147.45 ± 1.92	-4.69	P < 0.01
Triglycerides (mg / dL)	51.40 ± 1.60	39.84 ± 2.60	-22.49	P < 0.01
Phospholipids (mg / dL)	205.68 ± 1.06	199.23 ± 1.71	-3.14	P < 0.01
LDL- cholesterol (mg / dL)	53.92 ± 1.23	41.54 ± 1.47	-22.96	P < 0.01
VLDL- cholesterol (mg / dL)	10.28 ± 0.32	7.97 ± 0.52	-22.47	P < 0.01
HDL- cholesterol (mg / dL)	90.50 ± 1.93	97.94 ± 1.30	8.22	P < 0.01

Our results are in agreement with **Mustafa (2011)** who found that the replacement of 15% of sugar beet pulp with OP in the concentrate mixture leads to a significant decrease in the cholesterol level and he attributed this decrease to OP which contains high levels of omega-3 fatty acids which are responsible for decreasing the level of cholesterol. On the other side, the level of HDL was significantly increased as a consequence of OP supplementation, which may be due to the same reason mentioned above.

Oxidation of LDL is considered one of the primary mechanisms of lipids abnormalities, and in this respect, **Devaraj and Jialal (2000)**, and **Teissedre and Waterhouse (2000)** noted a high correlation between the total phenol content of the feed and low density lipoprotein oxidation, especially the correlation between the inhibition of LDL oxidation and the increase in concentration of tyrosol as reported by **Covas et al. (2001)**.

So, we can attribute the decrease in lipid fractions in heat stressed calves supplemented with OP to its high concentration of phenols (**Tavafi et al., 2012**), or to its high content of monounsaturated fatty acids (MUFAs) as suggested by **Servili et al. (2014)** who attributed LDL-cholesterol reduction to high MUFAs content in extra virgin olive oil, while MUFAs are effective in reducing LDL-cholesterol, even though the associated mechanisms are not well known.

3-Kidney and Liver Functions

When the OP was added to the ration of heat stressed calves, the results showed that serum uric acid as non-enzymatic antioxidant was significantly (P < 0.01) increased by 53.48 %, while serum creatinine and urea-N concentrations as well as AST activity were significantly (P < 0.01) decreased by – 15.43, - 16.11 and – 26.50 %, respectively which was accompanied with insignificant decrease in ALT activity (Table 5).

Uric acid has been proved to be a selective antioxidant capable of reaction with hydroxy radicals and hypochlorous acid. In this respect, **Yao et al. (1998)** found that plasma, uric acid, albumin and ascorbic acid account for more than 85% of total antioxidant capacity.

Chaudhari et al., (2010) reported that lower levels of serum uric acid under stress could be referred to the increased utilization of uric acid for scavenging free radicals. However, we can attribute the increased level of uric acid as a non-enzymatic antioxidant observed in OP treated calves under heat stress to the antioxidant properties of polyphenols which found in OP (**Jemai et al. 2009**).

Urea – N values were significantly higher in summer than in winter in crossbred and baladi cows (**El-Masry et al., 2010**) and in growing heat stressed calves (**Atta et al., 2014**), also, **Al- Jubury**

(2013) recorded a significant increase of urea and creatinine levels in sera of heat stressed rabbits. The increase in plasma urea nitrogen during heat stress may be due to an improved rumen nitrogen balance (Erasmus *et al.*, 1992) or an increase in muscle breakdown (Kamiya *et al.*, 2006).

The present results showed a significant decline in the levels of urea and creatinine due to OP supplement in heat stressed calves. These results are in agreement with Al- Jubury (2013) who recorded a decrease in urea and creatinine levels in the heat stressed rabbits treated with the dried and aqueous olive leaves extract, confirming the positive healthful properties of olive as anti-heat stress product, which decrease the negative effects of heat stress conditions.

Under hot condition, the significant increase in AST and ALT activities in cows, was recorded by El- Masry *et al.* (2010). Marai *et al.* (1995) who attributed the increase in activities of serum AST and ALT in heat stressed animals to the increase in stimulation of gluconogenesis by corticoids. However, the improvement in liver enzymes in heat stressed calves fed on OP was observed (Table 5). This may be ascribed to the physiological effect of phenolic compounds found in OP as hepatoprotective role (Abdel-Hamid *et al.*, 2011).

Table (5): Effect of olive pomace supplementation (15 % of concentrate) on kidney and liver functions, copper, iron and T₃ concentrations in growing calves maintained under hot environmental conditions .

Items	Control (Mean ± S E)	Treatment (Mean ± S E)	Change %	Significance
Uric acid (mg / dL)	0.531± 0.01	0.815 ± 0.02	53.48	P < 0.01
Creatinine (mg / dL)	1.128 ± 0.01	0.954 ± 0.01	-15.43	P < 0.01
Urea (mg / dL)	21.98 ± 0.03	1.844 ± 0.05	-16.11	P < 0.01
AST (U / mL)	63.40 ± 1.21	46.60 ± 0.93	-26.50	P < 0.01
ALT (U / mL)	31.00 ± 0.84	29.00 ± 0.95	-6.45	N.S
Copper (µg / dL)	270.63 ± 3.30	330.16 ± 3.28	21.99	P < 0.01
Iron (µg / dL)	120.95 ± 2.00	99.50 ± 1.76	-17.73	P < 0.01
T ₃ (nmol/L)	1.277 ± 0.02	1.798 ± 0.07	40.80	P < 0.01

4- Serum Minerals

Supplementation of heat stressed calves with OP had a great effect on Cu and Fe concentrations where, serum Cu as antioxidant was significantly (P < 0.01) increased by 21.99 %, while serum Fe as pro-oxidative mineral was significantly (P < 0.01) decreased by – 17.73 % Table (5).

One of the main reasons for oxidative stress in animals was the depression in Cu and the increase in Fe concentration due to RBCs destruction in heat stressed animals and the changes in these elements was considered as indicator of oxidative stress (Perucchiatti and Litjens, 2010). The same authors reported that many types of macromolecules are affected by oxidative stress and accompanied with environmental stresses. Moreover, elevated concentration of iron (act as pro-oxidant) was correlated with increased protein carbonyl concentrations, which contributed to oxidative damage in animals.

A decrease in zinc, manganese, copper or selenium can contribute to tissue oxidative damage. These are the active components of the well known antioxidant enzymes such as superoxide dismutase (SOD) and Glutathione peroxidase (GSH-Px). Also, these minerals can act as specific antioxidant

protecting macromolecules against the negative effects of oxidative stress (**Perucchiatti and Litjens, 2010**), and the same author attributed the decrease of copper under oxidative stress condition to the relatively high level of iron, which lead to depressed or lowered absorption of zinc, manganese and copper.

5- Triiodothyronine (T₃) Hormone

Supplementation of heat stressed calves with OP had a great effect on T₃ level, where serum T₃ WAS significantly (P < 0.01) increased by 40.80 % but around its normal range Table (5).

Supplementation of heat stressed calves with OP reduces the negative effect of hot conditions on thyroid activity. In this point, **Kumar et al. (2005)** found that heat stress decreased plasma T₃ level during the summer season that may help the animals to decrease the endogenous heat production in order to tolerate the heat. Moreover, **EL-Masry et al. (2010)** recorded a significant decrease in T₃ hormone level under hot conditions in cows.

Concerning Supplementation of OP to heat stressed calves and its relation with T₃ level, our results are in agreement with the findings of **Abd-Alla et al. (2007)** who reported that feeding olive pulp during hot summer season resulted in a significant improvement in thyroid activity and the hormonal profile olive pulp treatment showed significant increase in T₃ concentration by (14.7%) in heat stressed growing lambs.

On the other side, the increase in serum T₃ concentrations may be related to the highest antioxidant activity of OP due to its content of several antioxidants such as carotenoids, tocopherols and phenolic compounds (**Bouaziz et al., 2005**), since, the hypothyroidism is accompanied with increased oxidative stress (**Sarandol et al., 2005**), and OP supplementation exerts beneficial effects on this condition.

6- Growth Performance

Data presented in table (6) show that the difference between the control and treated group concerning initial body weight was insignificant. However, daily gain, total gain and final body weight were significantly (p <0.01) increased by 37.68, 38.50 and 11.75 %, respectively as a function of supplementation OP to heat stressed calves as compared with non-supplemented control. Also, the improvement in feed efficiency in calves due to OP supplementation was recorded by 39.13 % in comparison to the control diet and the difference was found to be significant (P < 0.01).

Table (6): Effect of olive pomace supplementation (15 % of concentrate) on growth performance in growing calves maintained under hot environmental conditions.

Items	Control (Mean ± S E)	Treatment (Mean ± S E)	Change %	Significance
Initial body weight (kg)	111.00 ± 14.56	113.00 ± 11.67	1.80	not- Significant
Daily gain (kg / day)	0.69 ± 0.02	0.95 ± 0.03	37.68	P < 0.01
Total gain (kg)	41.30 ± 0.96	57.20 ± 1.87	38.50	P < 0.01
Final body weight (kg)	152.30 ± 14.64	170.20 ± 13.34	11.75	P < 0.01
Feed efficiency (kg, gain / kg, DM)	0.23 ± 0.02	0.32 ± 0.03	39.13	P < 0.01

The results about the depression in growth performance specially, daily gain in heat stressed animals was observed in growing buffalo calves (**El-Masry and Marai, 1991**), and in growing heat stressed calves (**Atta et al., 2014**). Such decrease in daily gain may be mostly attributed to a decrease

in dry matter intake which inevitably decreases feed efficiency (**El-Masry and Marai, 1991 and Abdel-Samee et al., 1992**).

Moreover, the negative changes in protein metabolism, most blood constituents and hormonal levels (**Abdalla et al., 2009a; Abdalla et al., 2009b; El-Masry et al., 2009 and Atta et al., 2014**), may be contribute in such decrease in growth performance. However, adding OP to the basal diets showing significant alleviation in growth performance of heat stressed calves. So, our results are in agreement with previous studies which indicated that using olive oil by-products in diets for buffalo calves (**Gad, 2013**), local ewes (**Mustafa, 2011**), Zel sheep (**Sadeghi et al., 2009**), small ruminants (**Mengesha, 2012**) showed a significant improvement on total gain and daily body weight gain.

Also, **Abd-Alla et al. (2007)** found that daily gain and relative growth rate were improved significantly in heat stressed lambs as a response to OP feeding, this can be attributed to concomitant improvement in serum T₃ level and increasing the appetite of sheep. Also, previously published observations (**Abdel-Samee et al., 1992**) proved that feeding OP resulted in a significant increase in daily live weight gain and relative growth rate in heat stressed lactating goats.

On the other hand, the lower amount of crude fiber for OP, confirms the observations of **El-Masry and Abdel-Samee (1991)** who found that the increase in the amount of protein reaching the small intestine with low fiber diet lead to an increase in weight gain and relative growth rate.

CONCLUSIONS

From the present results it can be concluded that high environmental temperature induced oxidative stress in growing calves. However, OP which contains antioxidant compounds can be used for ameliorating the negative effect of heat stress specially, oxidative enzymes, some blood constituents and growth performance in heat stressed calves.

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