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Effects of Dietary Supplementation of *Saccharomyces cerevisiae* on Milk Production, Oxidative Stress, and Blood Metabolites of Holstein Dairy Cows during Summer Season

Research Article

F. Sehati[1], A. Towhidi[1*], M. Zhandi[1], M. Ganjkhanlou[1], A.H. Nasiri[1] and F. Parnian-Khajehdizaj[2]

[1] Department of Animal Science, College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran
[2] Department of Animal Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

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*Correspondence E-mail: atowhidi@ut.ac.ir

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ABSTRACT

The effects of dietary live *Saccharomyces cerevisiae* as a probiotic on milk production, oxidant/antioxidant status, and lipid metabolism of Holstein dairy cows through the transition and early lactation period during the summer season were investigated. Twelve lactating multiparous dairy cows were randomly allocated to two dietary treatments (n=6) including a control and probiotic-fed groups. Blood samples were collected on days -21, 0, 14, 28, 42, 60 days relative to parturition and analyzed for calcium, iron, cholesterol, triglyceride, low-density lipoprotein, high-density lipoprotein, total antioxidant capacity, malondialdehyde, and albumin. Serum concentrations of triglycerides, cholesterol, and low-density lipoprotein were lower in the probiotic-fed cows compared to those offered the control diet. Albumin concentration did not differ between the groups. The contents of total antioxidant capacity and high-density lipoprotein in the yeast-fed group was greater than the control group (P=0.01 and 0.02, respectively). In addition, serum calcium and iron tended to be higher in the yeast-fed group (P=0.08). Malondialdehyde level did not change between groups, but there was a decrease at calving time in the probiotic-fed group. Yeast-fed cows produced more milk and had higher concentrations of milk fat and non-fat solids than control cows (P<0.05). Rectal temperature was lower in the probiotic-fed group on parturition day. In conclusion, dietary supplementation of *Saccharomyces cerevisiae* in dairy cows may be a beneficial strategy to alleviate the heat stress and improve the antioxidative defense system and milk production during the transition and the early lactating period.

KEY WORDS cattle, oxidative stress, probiotic, *Saccharomyces cerevisiae*, summer season, yealth, yeast.

INTRODUCTION

During the transition period, dairy cattle often experience negative energy balance because of decreased energy availability and increased energy utilization. Moreover, this period is characterized by depressed feed intake and a severe increase in nutrient demands after the onset of lactation contributing to the incidence of health problems in early lactation (Callaway and Martin, 1997). Under these conditions, dairy cows show an increase in the levels of oxidative stress after parturition, which is presumably associated with hyperketonemia and higher plasma non-esterified fatty acid concentrations, contributing to a more risk factor of oxidative stress (Abuelo *et al*. 2013). The immunity and immune functions are suppressed in the transition period resulting in consequent incidence of clinical and subclinical inflammations (Abuelo *et al*. 2013). Additional stress can be caused when transition dairy cows are exposed to high ambient

temperatures, in which heat-stressed cows have increased energy maintenance costs (Upadhyay *et al*. 2018). As the availability of nutrients and energy is affected by heat stress, the nutritional strategies during the transition period should be considered to maintain dry matter intake (DMI) and thus reducing excessive fat mobilization. Increasing the energy density of postpartum diets during summer heat stress, by feeding more grains or supplemental fats, is suggested to reduce the extent of negative energy balance and improve the performance of dairy cows by increasing energy intake (Li *et al*. 2016).

The *Saccharomyces cerevisiae* (S. *cerevisiae*) has been included widely in dairy cow diets to improve dietary energy status and nutrient availability and milk production by promoting cellulolytic, proteolytic, and lactate-utilizing bacteria activity in the rumen (Bruno *et al*. 2009). The use of a culture of *Aspergillus* during heat stress periods improved milk yield and reduced rectal temperature in lactating dairy cows (Morrison, 1983).

However, most studies indicate that supplementing *S. cerevisiae* positively affects rumen pH, DMI, milk yield, fermentation patterns, and immune function (Erasmus *et al*. 2005; Zaworski *et al*. 2014; Yuan *et al*. 2015). Moreover, previous studies demonstrated that supplementing S. *cerevisiae* has beneficial effects on cows´ immune system response during heat stress conditions (Bruno *et al*. 2009; Zhu *et al*. 2016). Hence, we hypothesized that supplementing S. *cerevisiae* alleviate partially the negative consequences of heat stress on key immune and stress indicators in dairy cows in transition and early lactation period. Therefore, study objectives were to evaluate the effects of dietary supplementation of live S. *cerevisiae* on serum biomarkers of oxidative stress, lipid metabolism, and productive performance of dairy cows in the transition and early lactation period during heat stress conditions.

MATERIALS AND METHODS

All experimental procedures were based on guidelines for use of experimental animals and met the Animal Ethics and Environment Committee requirements of the University of Tehran (6/6/30854).

Experimental design and feed intake

This study was performed in the central area of Iran, Isfahan (32.65˚ N, 51.66˚ E; with a semi-arid climate) from June to late August 2017 with maximum monthly temperature of 40.8 ˚C. Average daily temperature and relative humidity were used to calculate daily THI using the following formula: THI= (0.8×temperature) + [(% relative humidity/100) × (temperature−14.4)] + 46.4, according to Amundson *et al*. (2006). A THI ≥ 68 (dashed line, Figure 1) was considered an indicator of high environmental temperatures and potential heat stress (Zimbelman *et al*. 2009; De Rensis *et al*. 2015).

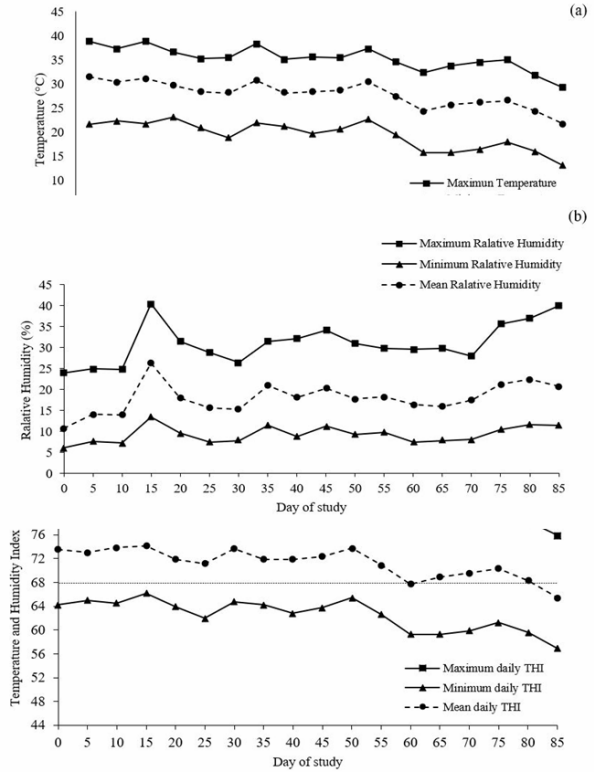


Figure 1 Average (±SD) daily maximum, mean and minimum temperature (a), daily maximum, mean and minimum relative humidity (B), and daily maximum, mean and minimum temperature and humidity index (THI), (Amundson *et al*. 2006); C) for study barn during the experiment. Dashed line represents THI ≥ 68 that was considered an indicator of high environmental temperatures and potential heat stress (Zimbelman *et al*. 2009; De Rensis *et al*. 2015)

Twelve clinically healthy multiparous Holstein dairy cows on day 21 before expected time to parturition were kept confined in free stall barn without any heat stress mitigation system up to two months after parturition (Adaptation period was two weeks). Cows were randomly allocated into two groups (n=6) including control (CG) and yeast-fed group (YG). Both groups were fed with the same diet, but the YG recieved the daily inclusion of 4 g/cow/day of the probiotic *S. cerevisiae* (Probio-Sacc®, Biochem GmbH, Germany). Treatment was top-dressed with S. *cerevisiae* on the TMR at the time of feeding every day. The yeast product provided 15×10^9 cfu of *S. cerevisiae* per g of product. Cows were housed individually and fed on a total mixed ration to meet the recommendations of the National Research Council (NRC, 2001). Three different diets (Table 1) including prepartum (21 days pre-parturition to parturition), fresh (from parturition to 21 days-in-milk (DIM)), and lactation diet (from 21 DIM up to 60 DIM) were fed to cows.

Table 1 Ration ingredients and chemical composition of the prepartum, postpartum and lactation diets on a dry matter (DM) basis

Ingredients, % of DM	Diets[1]		
	Close-up	Fresh	Lactation
Alfalfa hay, mature	14.5	19.7	11.1
Corn silage, normal	44.8	19.6	22.1
Sugar beet pulp, dried	–	9.21	9.10
Barley grain, ground	10.47	20.2	23.0
Corn grain, ground	12.01	7.25	11.4
Soybean meal, solve	2.44	9.45	12.1
Extruded full-fat soybean	1.22	2.64	1.72
Cottonseed, whole with lint	1.22	4.92	1.16
Fish meal	2.04	2.19	1.16
Canola meal, mech extract	6.92	1.45	–
Meat meal	–	–	1.16
Distillers dried grains	–	–	1.16
Fat supplement[2]	–	–	1.40
Calcium–carbonate	1.42	0.73	0.58
Calcium phosphate (Di-)	–	0.26	0.19
Bentonite	0.43	0.36	0.35
Monensin	0.01	0.02	0.01
Magnesium oxide	0.12	0.26	0.19
Biotin	0.01	0.01	–
Magnesium sulfate	0.73	–	–
Sodium bicarbonate	–	0.52	0.58
Salt	0.61	0.26	0.29
Potassium carbonate	0.16	–	0.23
Availa®Cr[3]	0.03	0.03	–
Selenium	0.004	0.004	–
Niacin	0.04	0.04	–
Alkobaf	–	0.36	0.63
Mineral mix[4]	0.41	0.28	0.22
Vitamin mix[4]	0.41	0.26	0.17
Chemical composition			
ME, Mcal/kg	2.32	2.48	2.62
NE_L, Mcal/kg	–	1.60	1.69
Crude protein, % of DM	14.1	16.0	16.2
NDF, % of DM	34.4	30.8	26.8
NFC, % of DM[5]	38.5	40.0	43.9

[1] Close-up: cows in the last 3 wk of gestation; Fresh: cows in the first 3 wk of lactation, and Lactation: cows after 3 wk of lactation.
[2] Megalac (Behparvaran Co., Esfahan, Iran).
[3] Provided as chromium methionine; Zinpro Corp., Eden Prairie, USA.
[4] Premix contained: Co: 0.32 g; Cu: 13.3 g; I: 0.5 g; Fe: 0.04 g; Mn: 33.4 g; Se: 8 g and Zn: 56.2 g.
[4] Premix contained: vitamin A: 1800000 IU; vitamin D: 200000 IU and vitamin E: 15000 IU.
[5] Calculated according to NRC (2001), NFC= [1000 – (g/kg aNDFom+g/kg CP+g/kg ash+g/kg ether extract)].

The feeding rate was adjusted daily to yield orts of about 5% of offered feed to obtain *ad libitum* intake. Animals were not cooled during the experimental period. Rectal temperature was measured using a clinical veterinary thermometer (Yasa Teb Co.) on the day –21, 0, 21 and 42 after parturition.

Milk yield and composition

Cows were milked 3 times per day (02:00, 12:00 and 18:00 h) and milk samples were weekly collected and recorded individually from three consecutive milkings using a Waikato MKV milk meters (Inter Ag, Hamilton, New Zealand).

Sterile tubes containing potassium dichromate were used to store milk samples until analysis at 4 ˚C. Milk composition including fat, protein, lactose, and somatic cell counts (SCC) were analyzed using a Foss Milko-Scan (Foss Electric, Hil lerød, Denmark).

Blood sampling and analyses

Blood samples from coccygeal vein were collected two hours after the morning feeding at the beginning of the experiment (day -21), and days 0, 14, 28, 42, and 60 after parturition. Blood samples were centrifuged (1000×g for 15 min) after collecting, to separate blood serum and then, sera

were stored at –20 ˚C until its analysis. Serum concentrations of total cholesterol, triglycerides, high-density lipoproteins (HDL), low-density lipoproteins (LDL), albumin, calcium, and iron were analyzed using the commercial kits (ZistChem diagnostics, Tehran, Iran).

Serum total antioxidant capacity (TAC) level was measured by ZellBio kit (Germany). Malondialdehyde (MDA) content in serum was determined based on the method reaction with thiobarbituric acid (Yoshioka *et al*. 1979).

Statistical analysis

The repeated data were analyzed as a completely randomized design with 2 treatments and 6 replicates each, by the mixed procedure of SAS (2001) according to the following model:

$$Y_{ijk}= \mu + \alpha_i + A_{ij} + T_k + (\alpha T)_{ik} + e_{ijk}$$

Where:
Y_{ijk}: response at time k on animal j in treatment i.
μ: overall mean.
α_i: fixed effect of treatment i.
A_{ij}: random effect of animal j in treatment group i.
T_k: fixed effect of time k.
$(\alpha T)_{ik}$: fixed interaction effect of treatment i with time k.
e_{ijk}: random error at time k on animal j in treatment i.

The autoregressive order 1 covariance structure [AR (1)] was selected from several covariance structures evaluations based on the smallest Akaike's information criterion. Significance among treatments was determined by the LSMEANS test and results were considered as significant when the P-value was less than 0.05. Means with different superscript letter groups were obtained with "pdmix 800 SAS macro" (Saxton, 1998). Blood metabolites were analyzed by principal components analysis (PCA) using the R Studio and R software (version i386 3.6.1) among the treatment groups via the function of PCA from "FactoMineR" package and the functions of fviz_eig, fviz_pca_ind and fviz_pca_var from "factoextra" package to plot the results.

RESULTS AND DISCUSSION

All animals remained healthy throughout the experimental period. Table 2 summarize the effect of *S. cerevisiae* on milk yield and milk composition after parturition. Milk protein, lactose, and somatic cell count were not affected (P>0.05) by feeding the yeast supplement. However, cows fed *S. cerevisiae* had increased milk yield (P<0.05), milk fat (P=0.02) and milk solid non-fat content (P=0.01) when compared to control treatment.

The effect of *S. cerevisiae* on serum parameters is presented in Table 3. Serum calcium and iron were numerically tended to increase. HDL and TAC levels were higher (P<0.05) in YG than CG, while the concentration of triglyceride, cholesterol, and LDL was significantly decreased in the YG (P<0.05). Feeding yeast did not affect albumin or MDA concentration in serum during the experimental period.

Figure 2-a illustrates the changes in total antioxidant capacity levels during the transition and early lactation periods. There was differences for serum TAC concentration on day 14, 28 (P<0.01), and 42 (P<0.05) between groups. According to the Figure 2-b, serum MDA value tended (P=0.09) to decrease in the compared to CG, except for calving day where it was significantly lower in the YG (P<0.05) compared with CG. For serum albumin levels, no significant differences were detected between groups during the experimental period but time had a significant effect (Figure 2-c). The highest mean was related to parturition time.

Figure 3a shows the significant effect of feeding yeast on triglyceride level during the trial. Serum triglyceride concentration was decreased in the YG on days –21, 0, 14, 28, and 60 when compared to the CG. Serum cholesterol content in the YG was similar than CG in prepartum but its concentration decreased on days 14, 28, 42, and 60 postpartum via CG (Figure 3-b). Figure 3-c shows the changes of LDL levels in serum during the study period. The LDL levels in the YG was lowest on days 28, 42, and 60 compared to CG. As indicated in the Figure 3-d, there was a difference between CG and YG at different times except on day 28.

Serum calcium concentrations on days –21, 0, 14, 28, 42, and 60 relative to the parturition are shown in Figure 4-a. Mean value of serum calcium increased during the trial in both groups but with higher values o YG after parturation. Figure 4-b shows the blood iron levels during the experimental period. The highest means of YG were found on days 42 and 60. Feeding *S. cerevisiae* significantly reduced rectal temperature at calving day (Figure 5). As can be seen in scree plot (Figures 6-a to c), the fifth dimension (7.6%) at which the plot showed a bend (elbow point) was considered as indicating an optimal dimensionality by which 91.3 % of information (variances) contained in the data are retained by the first five principal components. By choosing eigenvalues greater than one (>1), the dimensionality was reduced from 8 variables to 2 principal components (PC) or dimension (Dim) with eigenvalues of 3.212 and 1.723 as observed by the slope of the scree plot of the respective samples. The first two principal components accounted for a variability of 61.7% (Dim. 1=40.2%, Dim. 2=21.5%) of the total variability treatments (Figure 6-d).

Table 2 Milk yield and composition of dairy cows unsupplemented (control) or supplemented with live probiotic (*Saccharomyces cerevisiae*)

Items	Treatment[1]		SEM	P-value
	Control	Yeast-fed		
Production, kg/d				
Actual milk yield	41.9	43.4	1.87	0.05
FCM[2]	36.8	39.5	1.73	0.01
ECM[3]	32.2	33.4	1.69	0.04
Milk composition, %				
Fat	3.14	3.37	0.140	0.02
Protein	2.40	2.46	0.090	0.95
Lactose	3.98	4.01	0.080	0.88
Solids not-fat	9.3	10.5	0.12	0.01
Milk component yield, kg/d				
Fat	1.11	1.47	0.330	0.01
Protein	1.00	1.03	0.040	0.78
Lactose	1.85	2.00	0.06	0.11
Solids not-fat	4.20	4.78	0.520	0.03
Somatic cell count, cells/mL × 10^3	38.1	37.0	22.10	0.22

[1] Control: formulated to supplement 0 g yeast/d and yeast-fed: formulated to supplement 4 g yeast/d.
[2] Fat-corrected milk= 0.399 × [milk yield (kg/d)] + 15.02 × [fat yield (kg/d)].
[3] Energy-corrected milk= milk (kg/d) × [38.3 × fat (g/kg) + 24.2 × protein (g/kg) + 16.54 × lactose (g/kg) + 20.7] / 3140.
SEM: standard error of the means.

Table 3 Effect of feeding *Saccharomyces cerevisiae* during the transition and early lactation period on blood parameters of Holstein dairy cows

Items	Treatment[1]		SEM	P-value
	Control (n=6)	Yeast-fed (n=6)		
TAC (µmol)	1.9	2.4	0.12	0.01
MDA (nmol/mL)	1.7	1.4	0.11	0.20
Calcium (mg/dL)	7.4	7.9	0.15	0.08
Iron (mg/dL)	97	114.1	5.78	0.06
Albumin (g/dL)	3.4	3.2	0.20	0.69
Triglycerides (mg/dL)	138.2	119.8	4.32	0.01
Cholesterol (mg/dL)	151.0	119.6	7.45	0.01
Low density lipoprotein LDL (mg/dL)	36.8	27.4	3.10	0.05
High density lipoprotein (HDL) (mg/dL)	57.4	76.8	5.07	0.02

[1] Control: formulated to supplement 0 g yeast/d and yeast-fed: formulated to supplement 4 g yeast/d.
SEM: standard error of the means.

The variable correlation plot showed that positively correlated variables are grouped together while albumin was correlated negatively as is positioned on opposite side of the plot origin in the opposed quadrant. The distance between variables and the origin indicates the quality of representation of the variables on factor map (cos2). The variable of Iron had the highest cos2 value (0.804) that was positioned close to circumference of the correlation circle and indicates a good representation on the principal component Dim. 1, while the lowest cos2 value (0.242), close to the center of the circle, for albumin was not perfectly represented by the principal components. The results from the PCA (Figure 6-d) represented the high separation of the dairy cow in their treatment group. Hence, according to the nature of components which is a combination of traits, it is deduced that dietary supplementation of *S. cerevisiae* had a general effect on all traits. Finaly DMI had no difference between groups (supplementary Figure).

In this study we investigated the antioxidant capacity of *S. cerevisiae* and its effects on dairy cow performance and its health. Additionaly, we also wanted to assess the effects of yeast supplementation on lipid metabolism. It has been suggested that probiotics (*Lactobacillus* strains) have antioxidant properties (Kapila and Sinha, 2006). Now the results of this study confirm the antioxidant ability of *S. cerevisiae*. In our experiment serum TAC was decreased gradually by two weeks postpartum in both groups with low effects for yeast-fed cows. This was in consistence with Castillo *et al.* (2005) in which antioxidant capacity in the first weeks of lactation was decreased. Total antioxidant capacity includes the effect of all antioxidant factors such as uric acid, ascorbic acid, bilirubin, vitamin E, and albumin (Woodford and Whitehead, 1998). Blood concentrations of these antioxidants depend on the intake amount and specific organs capacity, especially the liver (Benzie and Strain, 1996).

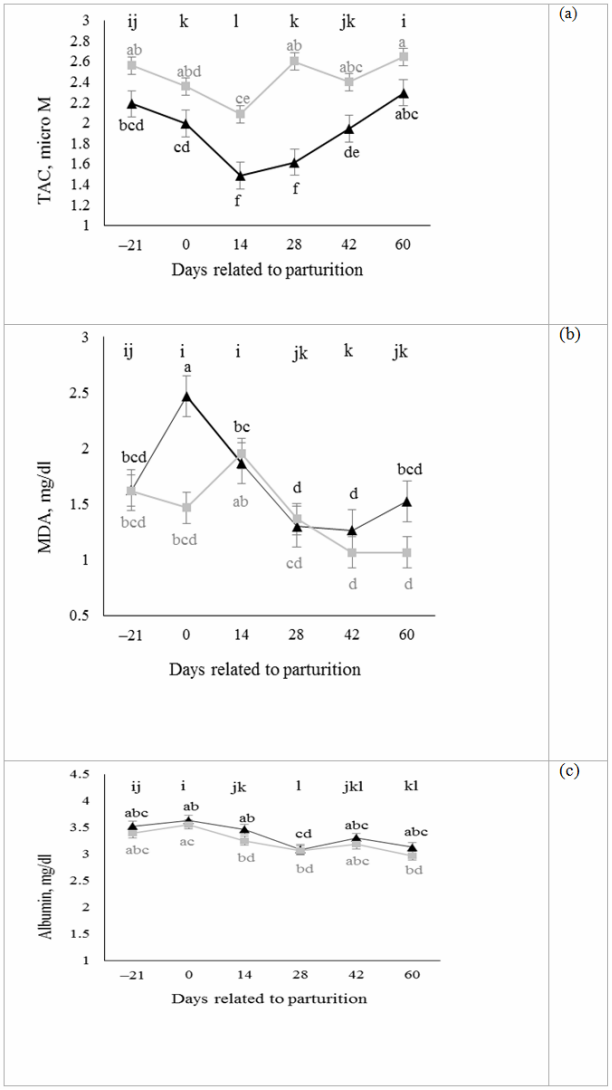


Figure 2 Least squares means of serum (a) serum total antioxidant capacity (TAC), (b) malondialdehyde (MDA), and (c) albumin levels for control (▲) and yeast-fed (■) groups measured from –21 to 60 days related to parturition. Error bars represent standard error (SE) and letters on error bars present statistical difference between treatment and time. The letters on the top of the plots show the statistical difference between times

It seems that the reduction of feed intake in cows from a week prepartum to a few weeks postpartum is responsible to deplete the concentration of antioxidants in serum (Karimi *et al*. 2016).

Lipid peroxidation is one of the most important results of oxidative stress (Kankofer, 2002). Free radicals attack carbon double bonds of n-3 and n-6 polyunsaturated fatty acids during lipid peroxidation process. Whereas the end products of this process are reactive aldehydes, such as MDA (Kapusta *et al*. 2018). In our study, serum MDA level showed a decrease in the yeast group compared to control only at calving day, indicating an improvement in antioxidant status at that moment. Our finding on serum calcium level showed an increase on day 42 and 60 in the yeast-fed group when compared with the control. Calcium as a secondary messenger regulates various cellular functions, such as metabolism, gene expression, and cell death (Berridge, 2012). During oxidative stress, the ROS can be generated from different pathways, not only as by-products of mitochondrial respiratory chain activity, but also by the several extra-mitochondrial enzymes such as NADPH oxidases, cyclooxygenases, and lipoxygenases (Sauer *et al.* 2001; Holmström and Finkel, 2014) that most of these enzymatic systems can be modulated by calcium. Therefore, a severe drop in serum calcium level can impair signaling in various cells as well as immune cells (Görlach *et al*. 2015). In this study, adding yeast supplement caused an increase in serum iron concentration. Deficiencies of iron as one of the essential factors for living cells, leads to a defect in the function of antioxidant enzymes of erythrocytes and total antioxidant capacity of plasma (Bami *et al*. 2008). It has also been reported that the level of the oxidation is increased in patients with iron-deficiency anemia (Yoo *et al*. 2009).

The great part of the antioxidant properties of the serum can be attributed to albumin. Previous studies have shown that about 70% of the free radical-trapping property of serum was attributed to serum albumin (Bourdon and Blache, 2001). On the other hand, the high concentration of blood albumin makes it an important antioxidant factor. However, our results demonstrated that feeding *S. cerevisiae* could not affect serum albumin levels in dairy cows during the period of study.

Serum concentrations of triglycerides, cholesterol and LDL were lower in the yeast-fed cows than the control cows. In a study by Paik *et al*. (2005) receiving a diet supplemented with yeasts declined concentrations of cholesterol and LDL in rats with fatty liver. In another study, feeding *S. cerevisiae* slightly decreased NEFA concentration in cows under heat stress. However, triglyceride and cholesterol are not affected by *S. cerevisiae* which this could be due to the usage of variant doses of yeast in different studies (Lim *et al.* 2021). Cholesterol adhesion to the cell membrane of yeast probiotic can prevent the absorption of dietary cholesterol that it suggesting a mechanism for serum lipid reduction (Begley *et al*. 2006). Yeast supplements may also be effective in lowering blood TG in the same way as lowering cholesterol levels. On the other hand, increasing lipid metabolism and utilization because of enhanced milk production could be the reason for this reduction (Stein *et al*. 2006). The level of serum lipids estimated in the current study is in agreement with reports by other researchers (Taranto *et al.* 1998; Begley *et al.* 2006).

Serum HDL contents were higher in the yeast-fed group than the control group. Previous studies reported that dietary supplemental yeasts in rats showed 20% increase in HDL:LDL ratio than control (Spady *et al.* 1993; Begley *et al.* 2006).

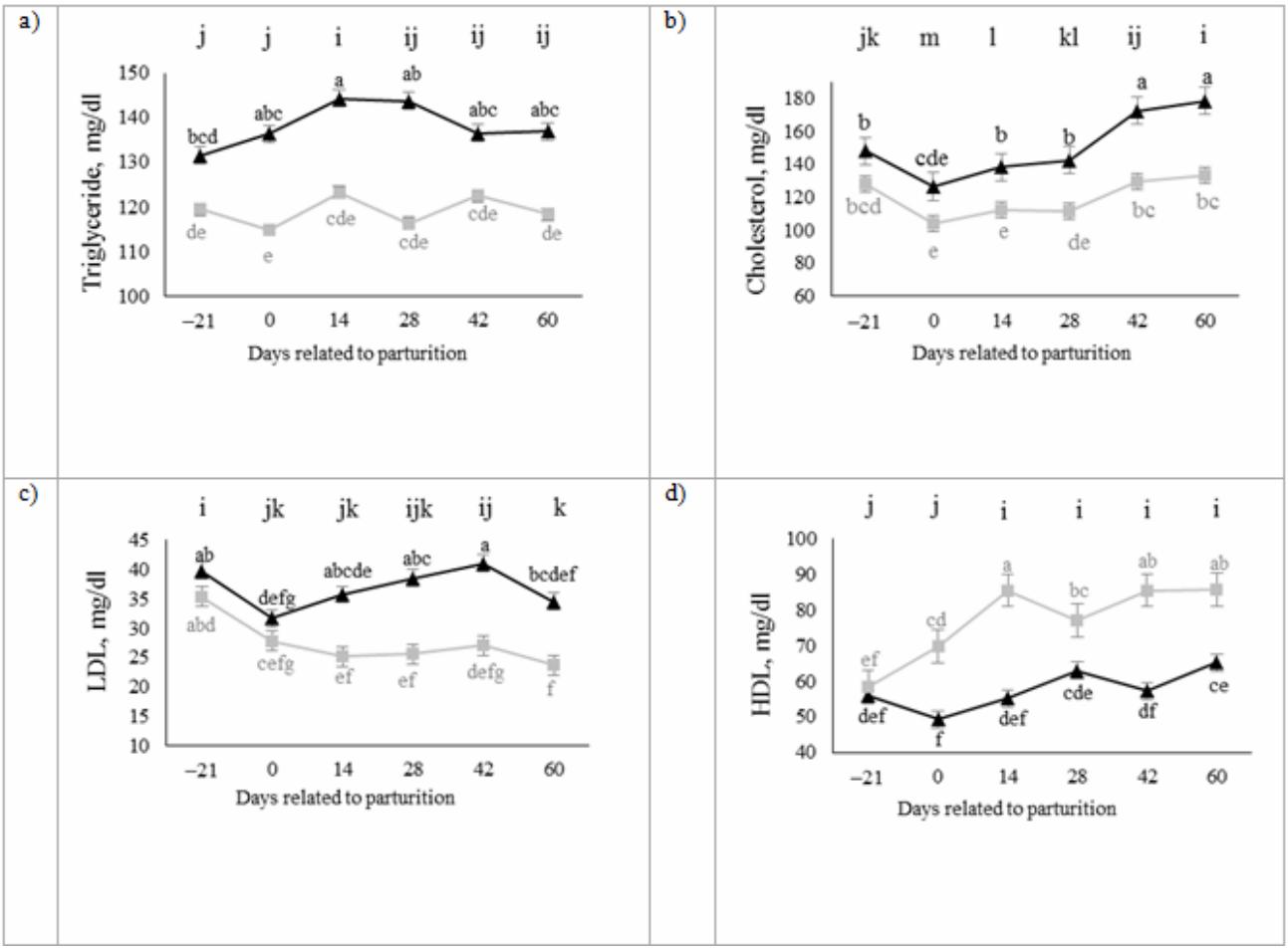


Figure 3 Least squares means of (a) serum triglyceride; (b) cholesterol; (c) LDL and (d) HDL levels for (▲) control and (■) yeast-fed groups measured from –21 to 60 days related to parturition. Error bars represent standard error (SE) and letters on error bars present statistical difference between treatment and time. The letters on the top of the plots show the statistical difference between times

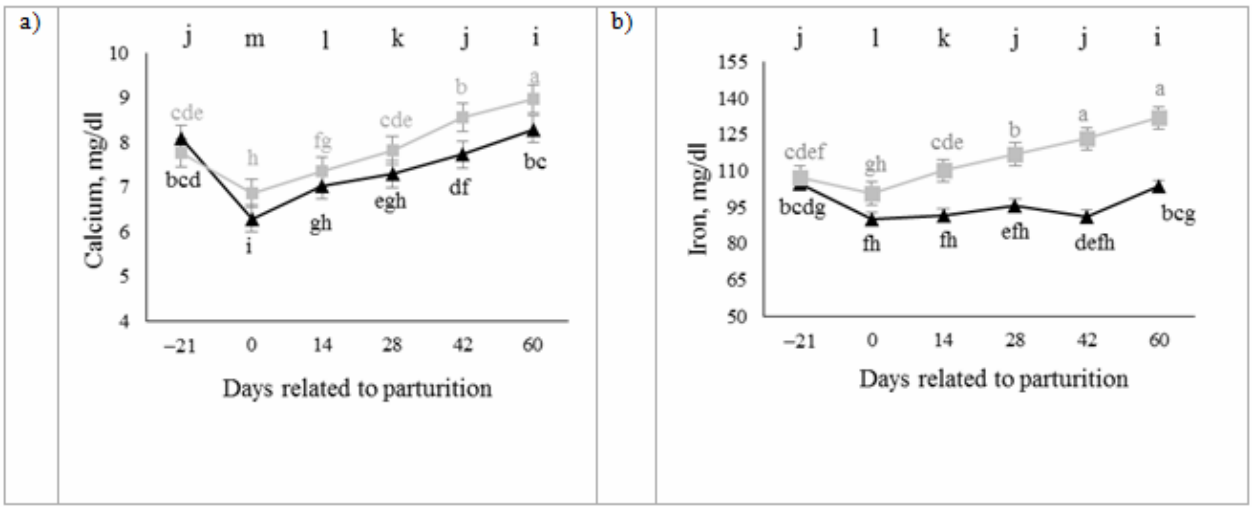


Figure 4 Least squares means of (a) serum calcium; (b) malondialdehyde (MDA) and (c) iron levels for (▲) control and (■) yeast-fed groups measured from –21 to 60 days related to parturition. Error bars represent standard error (SE) and letters on error bars present statistical difference between treatment and time. The letters on the top of the plots show the statistical difference between times

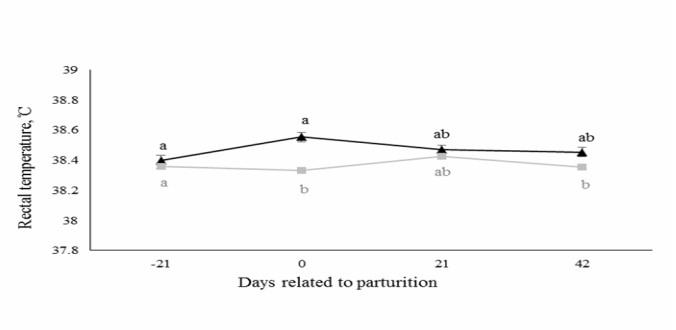


Figure 5 Least squares means of rectal temperature for control and yeast-fed groups measured from –21 to 42 days related to parturition. Letters indicate P<0.05 and error bars represent standard error (SE). ((▲) control group and (■) yeast-fed group)

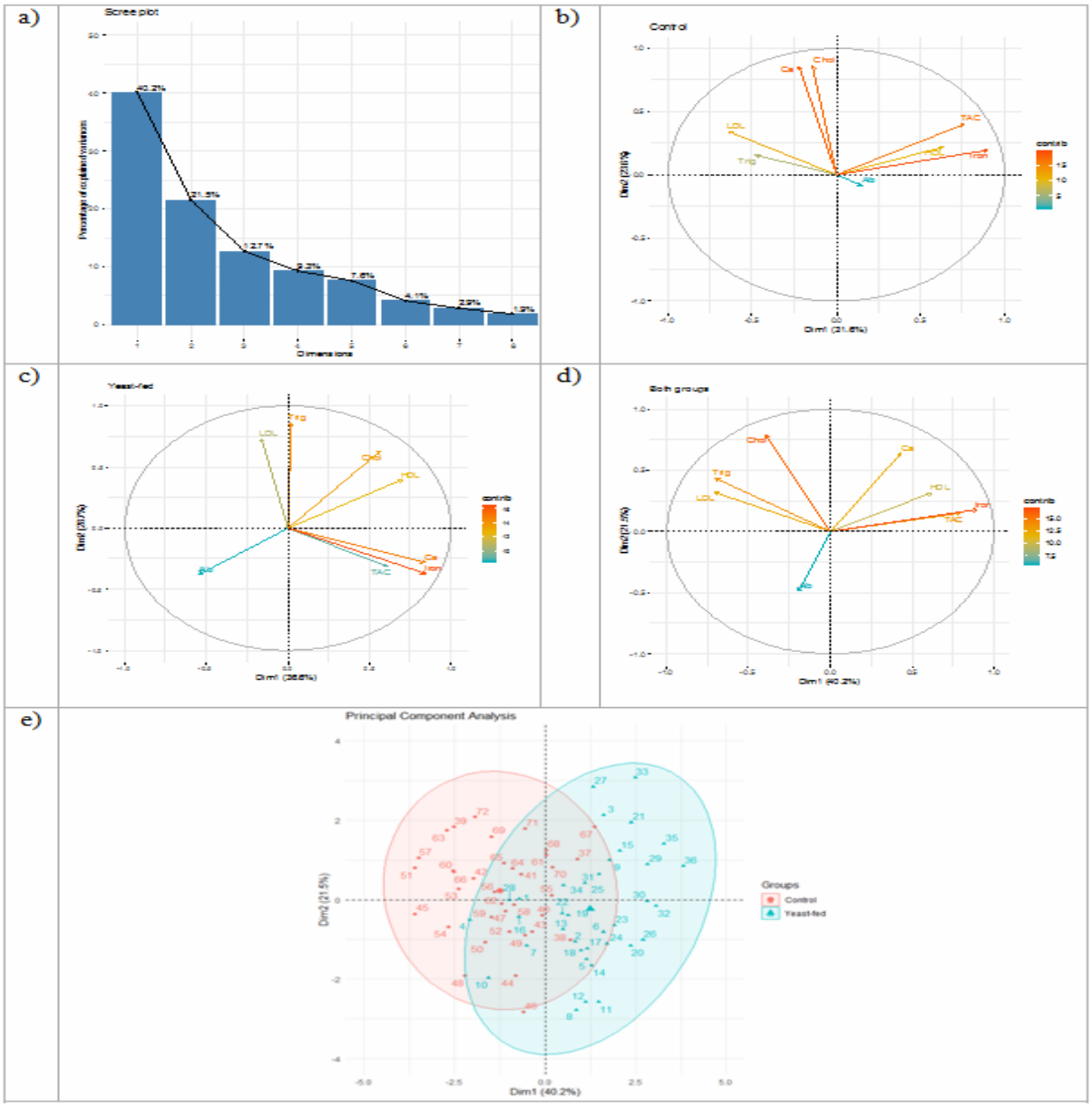
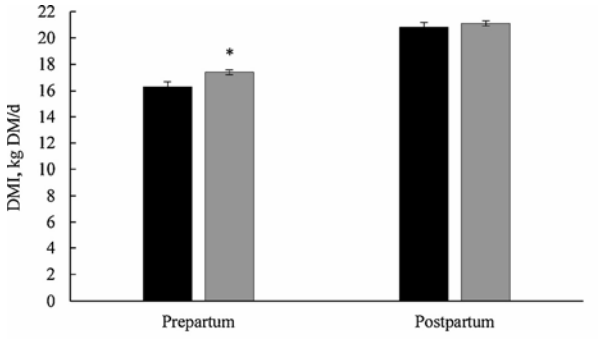


Figure 6 Scree plot (a), biplot and variable correlation or contribution to the principal components of control (b), Yeast-fed (c), both groups (d), and scatter (e) plot with component 1 and component 2 during both prepartum and postpartum periods. Alb: albumin; LDL: low density lipoprotein; Trig: triglyceride; Chol: cholesterol; Ca: calcium; HDL: high density lipoprotein; Iron: Iron and TAC: total antioxidant capacity. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article)



Supplementary Figure Pre-and post-partum DMI of control (closed bar) or yeast-fed cows (grey bar)
Error bars represent standard error (SE)
* (P<0.05)

In addition, the feeding of fermented milk resulted in increased HDL cholesterol level in experimental rats by 14-29% (Kapila and Sinha, 2006). HDL is mainly secreted by the liver and small intestine (Eisenberg, 1984).

Since one of the yeast beneficial effects is the formation of a stable intestine epithelial and improving epithelial performance (Samli *et al*. 2007), it is expected that use of *S. cerevisiae* improves the HDL secretion.

Milk yield, corrected milk yield, milk fat, and milk non-fat solids percentage and content were increased in the yeast-fed group compared to the control group. In agreement with this result, Stein *et al*. (2006) showed that feeding yeast as a probiotic resulted in an increase in fat-corrected and energy-corrected milk yields. Previous studies have also indicated that yeast supplementation could increase the plasma glucose level in cows during the heat stress conditions (Dehghan-Banadaky *et al*. 2013). Increased glucose availability in mammary gland could lead to raising milk yield production in live yeast-fed cows during heat stress periods (Salvati *et al*. 2015). Previous researches (Lambert, 2009; Baumgard and Rhoads, 2013) have demonstrated that heat stress can cause an epithelial damage in the animals causing a chronic inflammatory status, thus compromising nutrient absorption as well as performance. However, it has been reported that probiotics may alter the structure of gut epithelium and improve nutrient absorption by increasing area of absorptive surface (Giraffa *et al*. 2010). According to Table 2, no difference was found for milk protein, SCC, and milk lactose level between the groups.

In comparison with control, dairy cows received *S. cerevisiae* showed a decrease in rectal temperature on calving day that was in agreement with result of Huber *et al*. (1994) who declared that supplementing yeast culture to the cattle's diet during heat stress conditions may reduce rectal temperature and respiration rate. Moreover, Bhimte *et al*. (2018) observed that rectal temperature of dairy cattle was decreased by supplemental antioxidants on calving day. In our study, the decreased rectal temperature on calving day in dairy cows by feeding *S. cerevisiae*, seems to be attributed to antioxidant effect of yeast as observed by increased TAC and decreased MDA levels on calving day. The PCA-biplot analysis procedure (Figure 6-a to c) provides an overall description of the changes in serum metabolites in a clear view.

CONCLUSION

In conclusion, cows fed 4 g/cow/day *S. cerevisiae* reduced the oxidative stress level and body temperature, while enhanced milk production. Moreover, supplemental yeast changed lipid metabolism. It is unavoidable that the transition cows experience oxidative stress during the transition period, and the heat stress exacerbates this situation. Hence, feeding yeast supplement may be a beneficial strategy to alleviate health status and milk production in dairy cows.

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