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HEALTH SCIENCES

Effects of the inclusion of açai oil in diet of prepartum Holstein cows on milk production, somatic cell counts and future lactation

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Abstract: We measured the effects of açai oil in the diets of prepartum cows to evaluate health, milk production and quality. Sixteen Holstein cows were divided into two groups: SOY used as control, and AÇAI, test group. Occurred inclusion of 4% soybean or açai oils was provided in the concentrate starting at 20 days prepartum [d -20 to d 0 (partum-day)]. The AÇAI diet increased (P=0.01) milk production (d 10 and 20) and reduced somatic cell count (d 20). In milk, no effects were detected (P≥0.10) for concentration of fat, lactose or protein as well as in terms of serum concentration of calcium, albumin or triglycerides. AÇAI diet tended to increase (P=0.09) serum concentrations of total protein, glutathione transferase (d 4), and total antioxidant capacity (d 4 and 10) and increased (P≤0.05) globulin, gamma-glutamyl transferase, superoxide dismutase and glutathione peroxidase (d 4). Further, AÇAI diet reduced the serum concentration of creatine kinase (P≤0.05) (d 0, 4 and 10), reactive oxygen species (d 0 and 4) and lipoperoxidation (d 0) and tended to reduce aspartate transaminase activity (P=0.07; d 0 and 4). Açai oil in the diets in prepartum cows improved their health as well as milk production and quality.

Key words: açai oil, antioxidant, cows, prepartum, productive efficiency, SCC.

INTRODUCTION

The transition period is challenging for dairy cows. It coincides with the peak incidence of metabolic and nutritional disorders; this is the period when cows are most susceptible to infectious diseases because of lower concentrations of inflammatory mediators (Mulligan & Doherty 2008). According to Leblanc (2010), up to 50% of cows in the transition period will develop infectious or metabolic diseases. These animals also undergo drastic physiological changes and endure metabolic stresses (Goff & Horst 1997, Drackley 1999). According to Leblanc (2010), metabolic disorders begin two weeks before birth, affecting the productive and reproductive life of the animal as well as the quality of future lactation.

At least 30 days before calving, cows need to consume a different diet, anticipating subsequent lactation, so as to avoid metabolic disorders that may adversely affect milk production and quality (Wittwer 2000). For these reasons, it is necessary to identify feeds rich in energy and protein. Ingredients that stimulate immunological activity such as vegetable oils are desirable components of diets of prepartum cows (Caldeira et al. 2007). Fats and oils are important nutrients because they are highly concentrated sources of energy, in addition to being important components of the physical

and functional structure of cells (Cunningham & Klein 2004).

Açai oil is a by-product of açai fruit (*Euterpe oleracea*), and has been used by humans because the fruit is rich in proteins, fiber, lipids, vitamin E and minerals (Yuyama et al. 2011); nevertheless, very little is known about its effects on animal feed. It contains good-quality fatty acids, with 60% of monounsaturates and 13% of polyunsaturates (Homma 2006). Açai oil also contains substantial amounts of anthocyanins, potent antioxidants that belong to the family of flavonoids responsible for the coloring for the fruit (Pereira et al. 2010).

Açai production in the northern region of Brazil has increased exponentially in recent years, due to the greater consumption of juices and products from the fruit. The by-products (oil and flour) are used as additives or ingredients in animal feed, primarily because of their favorable biological properties. In previous research, our research group observed increased milk production in lactating Lacaune sheep that were fed 2% açai oil in the concentrate (Santos et al. 2019). Therefore, our hypothesis was that the inclusion of açaí oil in the prepartum diet would have desirable effect as an antioxidant stimulation that would minimize the negative impacts as oxidative stress during the transition period (end of gestation, delivery and beginning of lactation). Indirectly, the consumption of açai oil would cause the animals to have better productive rates. Thus, the objective of this study was to evaluate the effects of açai oil by-product in the diets in prepartum dairy cows in terms of health, milk production and quality during the transition period.

MATERIALS AND METHODS

Animals, experimental design, diets

The study was carried out in a farm specialized in raising of dairy cattle, located in the city of Tunápolis, western region of Santa Catarina, in southern Brazil. The n-sample was calculated considering a confidence interval of 0.95 and test power at 95%. Sixteen Holstein multiparous cows (three or four gestations), were used in the prepartum phase divided according to the number of gestations in two homogeneous groups (n = 8 cows/treatment). The experimental period was an average of 40 days, 20 days prepartum and 20 days postpartum. It is important to note that açai or soybean oils were only included in the diet of the cows in the prepartum period (time of 20 days); soon after calving, the cows of both groups consumed the same concentrate (without oils as ingredients). All feeding management during the experimental period was carried out by the authors of this manuscript, i.e. formulation and production of the concentrate, as well as the supply of the concentrate, hay and silage.

In the prepartum period, cows were housed in 2 pens (1 pen/treatment) in a covered free-stall barn (200 m^2) with access to water ad libitum and fed in individual feed bunks (70 cm/cow). The two groups were: SOY, including animals that received the concentrate with 4% soybean oil (control group); and AÇAI, including cows that ate a concentrate with 4% açai oil (test group). Therefore, oils were mixed in the concentrate at a proportion of 40 g/kg of concentrate.

The prepartum feed (green matter) included 18 kg of silage, 3 kg Tifton grass and 3 kg of concentrate, supplied daily in an individual feeder. The cows were fed twice a day, i.e. 0600 and 1700 hours. Feed composition is presented in Table I. Knowing that each cow consumed 3 kg of concentrate/day, the daily consumption of

Table I. Feed and chemical composition of the diets prepartum.

Ingredients	Organic matter (Kg/animal/day)	Dry matter (Kg/animal/day)		
Silage	18.0	6.4		
Hay	3.0	2.7		
Concentrate	3.0	2.7		
Chemical composition	**Silage**	**Hay**	**Control**	**Treatment**
Dry matter (DM; %)	37.12	84.87	89.75	89.46
Ash (% DM)	6.87	7.92	13.46	11.86
Crude protein (% DM)	8.16	6.06	20.38	20.18
Neutral detergent fiber (% DM)	34.61	70.76	8.01	8.02
Acid detergent fiber (% DM)	21.15	33.23	1.34	1.36
Ether extract (% DM)	3.5	1.19	6.09	5.95

Note: The same corn silage was used for cows during the postpartum period.

oil (açai or soy) was calculated, corresponding to 120 g/cow/day.

After calving, the cows were transferred to a yard with a shaded area, where an open shed was used to supply silage and had free access to water. The cows had access to an oat pasture (*Avena sativa*) for 0300 h, divided into two feeding access (0700 h to 0830 h and 1600 h to 1730 h), with access to Tifton grass throughout the night. A concentrate of ground corn (43%), soybean meal (33.5%), soybean hull (20%) and 3.5% of mineral and vitamin premix (Agility Modulate LM 7500/2®) was offered twice a day in individual feeders during the milking process. The chemical composition of the concentrate was 90.1% of dry matter (DM), and 22.2% DM of crude protein. The supply of concentrate per cow was based on the milk daily production, i.e., for every 10 liters, 1 kg of concentrate was supplied (10:1). On average the cows consumed 3 kg of concentrate/day, 20 kg of silage/day and forage *ad libitum*.

Oils

Açai oil was extracted by cold pressing, according to manufacturer's information (Gran oils, São Paulo, SP, Brazil) and soybean oil (Soya, Brasília, DF, Brazil) was purchased at a local supermarket. The soybean oil was used as a control group in this study, with the purpose of creating isoenergetic diets. According to the manufacturer's guarantee levels, both oils had similar energy value (108 kcal).

The concentration of fatty acids from oils was analyzed. About 30 mg of oil samples were used for derivatization in fatty acid methyl esters (FAME) according to Hartman & Lago (1973) with some modifications describes by Santos et al. (2019). The FAME was analyzed using gas chromatography with flame ionization detector (GC-FID; model Star 3600, Varian, USA) with the injection of 1 µL into a split/splitless injector with ratio 20:1, heated to 250 °C. The FAME identification was performed by comparing the sample retention times with those of the FAME

Mix-37 (P/N 47885-U; Sigma-Aldrich, USA) and the results are expressed as percentage of the total area considering the FID correction factors.

The main fatty acid profile in oils was palmitic acid (C16:0) [soybean oil 14.3%; açai oil 11.0%], stearic acid (C18:0) [soybean oil 3.23%; açai oil 1.86%], oleic acid (C18:1n9c) [soybean oil 30.8%; açai oil 38.7%], linoleic acid (C18:2n6c) [soybean oil 44.3%; açai oil 44.9%], linolenic acid (C18:3n3) [soybean oil 5.06%; açai oil 3.71%].

Chemical analysis of feed

Samples of the total diet provided (concentrate, silage and hay) for cows from both groups were collected and analyzed (Table I). In this material, dry matter (DM), ash, ether extract (EE), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) were measured following the methodology described by AOAC (1990) and Silva & Queiroz (2002).

Production, composition and somatic cell counts in milk

Milk production was measured individually on d 4, 10 and 20 during mornings (0600 h) and in the afternoon (1700 h) using electronic meters (Cow Milking Equipment - GEA Metatron®). From a measuring cup, 40 mL of milk was collected in tubes containing bronopol for analysis of somatic cell counts (SCC), determined using a digital counter (Ekomilk Scan Somatic Cell Analyzer®). Milk composition was analyzed (protein, lactose and fat) on d 4, 10 and 20, using specific automatic equipment (LactoStar Funke Gerber®). The samples were immediately stored at 4 ºC until further analysis of SCC and the protein, lactose, and fat content.

Blood sample collection

Blood samples were collected 20 d prior to calving (before starting the diet with oils), on the day of calving and on 4, 10 and 20 days postpartum. Blood samples were collected via the caudal vein using tubes without anticoagulant. Samples collected from the cows were centrifuged at 7000 rpm for 10 minutes to obtain serum and were stored at -20 ºC.

Serum biochemistry

Serum levels of total proteins, albumin, cholesterol, triglycerides, aspartate aminotransferase (AST), creatine kinase (CK) and calcium were evaluated using commercial kits (Gold Analisa Diagnóstica Ltda®, Carlos Prates, Belo Horizonte – MG, Brazil) on semiautomatic equipment (Bio Plus 2000®, São Paulo, Brazil). Globulin levels were calculated by subtracting albumin levels from total protein levels.

Oxidant and antioxidant status

Serum levels of lipoperoxidation (LPO) were measured using the methodology described by Hermes-Lima et al. (1995). The quantification of the production of reactive oxygen species (ROS) was evaluated using the determination of oxidation of 2',7' –dichlorofluorescein diacetate (DCFH) (LeBel et al. 1992), where DCFH was hydrolyzed by intracellular esterases to form non-fluorescent DCFH, subsequently rapidly oxidized to form highly fluorescent 2',7-dichlorofluorescein (DCF) in the presence of free radicals.

The total antioxidant capacity against peroxyl radicals (ACAP) was determined according to Amado et al. (2009). The activity of antioxidant enzymes such as superoxide dismutase (SOD) was also evaluated in the serum using the methodology described by Beutler (1984); glutathione S-transferase (GST) activity was determined by the method described by Habig et al. (1974); and glutathione peroxidase (GPx) activity was determined using tert-butylhydroperoxide as substrate and following the method described by Wendel (1981).

Statistical analysis

Each animal was considered the experimental unit for all analyses. All dependent variables were tested for normality using the Univariate procedure of SAS (SAS Inst. Inc., Cary, NC, USA; version 9.4) and all were normally distributed. Then, all data were analyzed using the MIXED procedure of SAS, with Satterthwaite approximation to determine the denominator degrees of freedom for the test of fixed effects. All variables of the study were analyzed as repeated measures and tested for fixed effects of treatment, day, and treatment × day, using animal(treatment) as random variables and animal(treatment) as subjects. All results obtained on d -20 for each variable were included as covariates in each respective analysis, but were removed from the model when $P > 0.10$. The compound symmetric covariance structure was selected for milk production and serum concentration of SOD and ROS, the Toeplitz covariance structure was selected for serum concentration of CK and GPx and the first-order autoregressive covariance structure was selected for all others variables. The covariance structures were selected according to the lowest Akaike information criterion. Means were separated using PDIFF and all results were reported as LSMEANS followed by SEM. Significance was defined when $P \leq 0.05$, and tendency when $P > 0.05$ and ≤ 0.10.

Ethics committee

The project was approved by the Animal Ethics Committee (CEUA) of the State University of Santa Catarina, protocol number 6834240518.

RESULTS

Milk production, composition and SCC

Effects of treatment × day and treatment were detected ($P = 0.01$) for milk production. AÇAI-treated cows had greater milk production on d 10 and 20, compared to SOY-treated cows (Table II). Effects of treatment × day and treatment were detected ($P = 0.01$) for SCC. AÇAI-treated cows had less SCC on d 20, compared to SOY-treated cows (Table II). However, no effects of treatment × day and treatment were detected ($P \geq 0.10$) for milk concentration of fat, lactose or protein (Table II).

Serum biochemistry

Serum biochemistry results are presented in Table III. No effects of treatment × day and treatment were detected ($P \geq 0.17$) for serum concentration of calcium, albumin and triglycerides. Effects of treatment ($P = 0.09$) but not treatment × day ($P = 0.31$) tended to be detected for total protein. AÇAI-treated cows tended to have greater concentration of total protein, compared to SOY-treated cows. Effects of treatment ($P \leq 0.05$) but not treatment × day ($P \geq 0.39$), were detected for serum concentrations of globulin and GGT. AÇAI-treated cows had greater concentrations than did SOY-treated cows. Effects of treatment × day ($P = 0.05$), but not treatment ($P = 0.43$) were detected for serum concentration of cholesterol. AÇAI-treated cows had greater concentration on d 0 than did SOY-treated cows. Effects of treatment × day ($P = 0.07$), but not treatment ($P = 0.20$) tended to be detected for serum concentration of AST. AÇAI-treated cows tended to have lower concentrations on d 0 and 4 than did SOY-treated cows. Effects of treatment × day and treatment were detected ($P = 0.01$) for serum concentration of CK. AÇAI-treated cows had lower concentrations on d 0, 4 and 10 than did SOY-treated cows.

Table II. Milk production, somatic cell count (SCC), fat, lactose and protein of cows fed with açai oil or soybean oil during the prepartum period: Assessments made within the transition period (4, 10 and 20 days postpartum).

Variables	Treatments[1]		SEM	*P*-value	
	AÇAI	SOY		Treatment	Treatment × day
Milk production (L)				0.01	0.01
d 4	29.22	25.26	2.23		
d 10	38.62[a]	30.96[b]	2.09		
d 20	40.13[a]	33.45[b]	2.23		
SCC (x10^3 /mL)				0.01	0.01
d 10	118.67	167.25	18.56		
d 20	112.60[b]	184.67[a]	21.44		
Fat (%)	3.32	3.28	0.10	0.74	0.81
Lactose (%)	4.61	4.67	0.15	0.62	0.50
Protein (%)	4.85	4.79	0.19	0.89	0.82

[1]**The treatments AÇAI and SOY represents 4% of açai or soybean oils in the concentrate, respectively.** [a-b]**Differs (*P* ≤ 0.05) between treatments each respective day.**

Serum oxidant/antioxidant status

The serum oxidant/antioxidant results are presented in Figure 1. Effects of treatment × day ($P \leq 0.03$), but not treatment ($P \geq 0.26$), were detected for serum levels of SOD, GPx, ROS. LPO and AÇAI-treated cows had greater concentrations of SOD and GPx on d 4, and lower levels of ROS on d 0 and 4, and LPO on d 0, than did SOY-treated cows. Effects of treatment × day ($P \leq 0.10$), but not treatment ($P \geq 0.38$), tended to be detected for serum levels of GST and ACAP. AÇAI-treated cows tended to have greater levels of GST on d 4, and ACAP on d 4 and 10, than did SOY-treated cows.

Feed intake

The feed intake during the prepartum was similar in both groups (95% vs. 93% of what was offered for AÇAI vs. SOY-treated cows, respectively). During the postpartum period, the cows consumed 100% of the concentrate supplied; however, because the cows were in a semi-extensive system, the intake was not possible to quantify.

DISCUSSION

The inclusion of açai oil in the feed of prepartum cows was demonstrated to be functional, benefiting health and consequently improving milk production. Functional oils are known to serve as basic nutrients and to produce metabolic and/or physiological effects (Anjo 2004). The search for natural compounds has been intensified, primarily as a consequence of the restriction of antibiotics as growth promoters. Alternative feeds are being explored, and some have been shown to have positive

Table III. Serum biochemistry variables of cows fed with açai oil or soybean oil during the prepartum period: analyzes made in the pre- and postpartum (20 days prepartum, day of partum, and 4, 10, 20 postpartum).

Variables[1]	Treatments[2]		SEM	*P*-value	
	AÇAI	SOY		Treatment	Treatment × day
Calcium (g/L)	8.41	8.27	0.19	0.17	0.87
Total Protein (g/dL)	7.91	7.58	0.13	0.09	0.31
Albumin (g/dL)	2.56	2.71	0.06	0.12	0.27
Globulin (g/dL)	5.38	4.91	0.15	0.05	0.39
Cholesterol (mg/dL)				0.43	0.05
d -20	69.12	74.14	5.65		
d 0	42.87[b]	59.62[a]	5.28		
d 4	52.83	53.86	5.65		
d 10	64.17	57.71	5.65		
d 20	80.17	69.17	6.10		
Triglycerides (mg/dL)	15.23	15.88	0.57	0.43	0.17
AST (U/L)				0.20	0.07
d -20	56.12	68.25	68.25		
d 0	60.10[b]	73.25[a]	73.25		
d 4	81.50[b]	99.62[a]	99.62		
d 10	79.33	68.29	68.29		
d 20	92.50	84.83	84.83		
GGT (U/L)	28.71	21.14	2.46	0.01	0.58
CK (U/L)				0.01	0.01
d -20	117.57	186.71	86.24		
d 0	90.87[b]	294.63[a]	80.67		
d 4	313.29[b]	889.00[a]	80.67		
d 10	152.00[b]	406.86[a]	86.24		
d 20	292.33	235.50	93.15		

[1]Aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT) and creatine kinase (CK). [2]The treatments AÇAI and SOY represents 4% of açai or soybean oil in the concentrate, respectively. [a-b]Differs ($P \leq 0.05$) or tend to differ ($P \leq 0.05$) between treatments each respective.

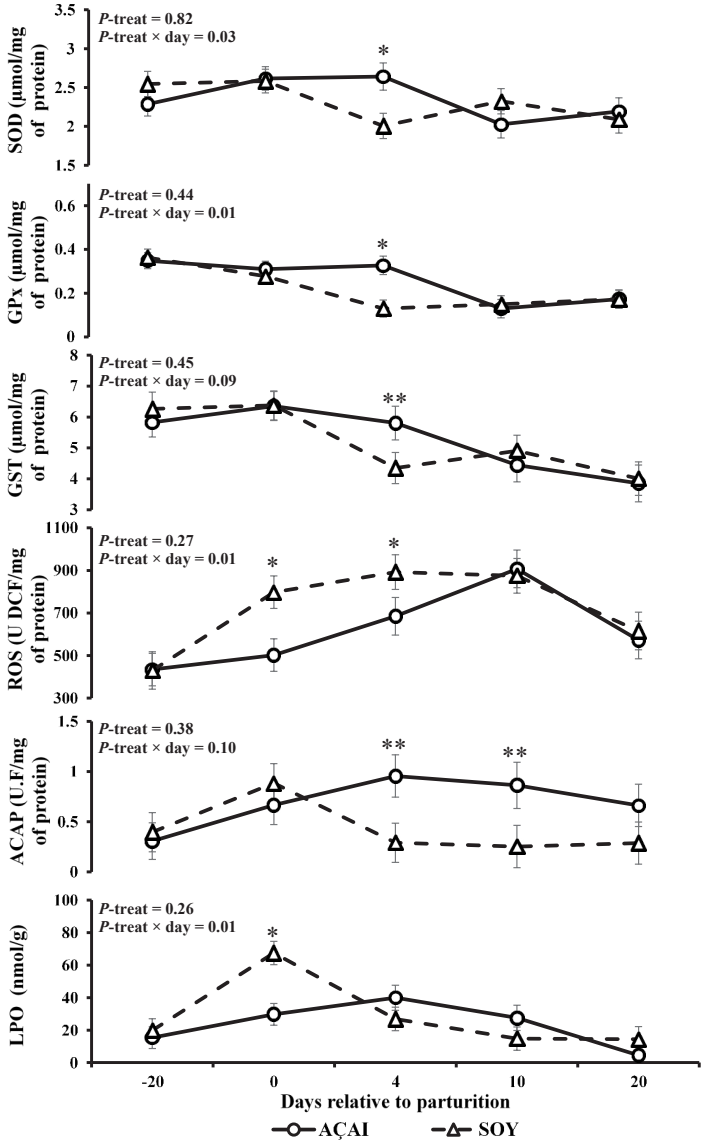

Figure 1. Serum levels of superoxide dismutase (SOD), glutathione peroxidase (GPx), glutathione transferase (GST), reactive oxygen species (ROS) total antioxidant capacity against peroxyl radicals (ACAP) and lipoperoxidation (LPO) of cows fed with açai oil or soybean oil during the prepartum period: analyzes made in the pre- and postpartum (20 days prepartum, day of partum, and 4, 10, 20 postpartum). The treatments AÇAI and SOY represents 4% of açai or soybean oil in the diet, respectively. Differs (*; $P \leq 0.05$) or tends to differ (**; $P \leq 0.10$) between treatments each respective day. Vertical bars represent the SEM.

outcomes in terms of production and health, as observed in the current study. According to Benchaar (2006), functional oils regulate ruminal fermentation, thereby improving the use of nutrients, subsequently improving the dairy performance of cows. Açai oil is richer in unsaturated fatty acids (UFA) as verified in this study (açai oil (total UFA - 87.3%) and soybean oil (total UFA - 80.1%)), and the increased uptake of long chain fatty acids by the mammary gland inhibits the synthesis of short- and medium-chain fatty acids. This process decreases the need for glucose in this synthetic process, while providing NADPH through the pentose cycle, thereby generating greater availability of glucose for increased milk production (Palmquist & Jenkins 1980).

In the current study, serum cholesterol levels at calving were greater for cows assigned to the açai group. Increased adipose tissue mobilization to meet energy demands is a major factor responsible for increased serum cholesterol levels (Aeberhard et al. 2001). In other words, decreased cholesterol levels may be related to the low levels of fat mobilization in these animals because, during the same period,

there were decreased activity of AST, an enzyme that increases its activity in a situation of high energy demand, mainly by muscles. However, we must not forget that the liver is the organ responsible for identifying the nutritional needs of all body tissues by adjusting its metabolism to meet demand (Drackley et al. 2005). Therefore, because açai oil supplementation did not increase AST levels, we believe that there were no hepatocellular lesions, something that usually occurs as a result of excess metabolic lipid mobilization (Grande & Santos 2008). This suggest that the dose we used was not hepatotoxic for cows. Supplementation of 2% of açai pulp in the diet in hypercholesterolemic rats improved the lipid profile, reducing total cholesterol, LDL and non-HDL levels (Souza et al. 2010). In addition to AST, there was also lower CK activity on the day of calving and on d 4. This result is positive for cow health, because CK and AST levels usually increase at calving because of muscular effort and high energy demand (Bouhroum 2013). Nockels et al. (1996) found decreased CK levels in cows receiving vitamin E supplementation. Therefore, considering that acai oil and vitamin E have potent antioxidant action, we suggest that CK levels in cows can be modulated by the antioxidant status, and this can minimize negative outcomes such as puerperal hypocalcemia and endometritis (Sattler & Fürll 2004). Important information in this study was the increase of globulins, possibly related to increased immunoglobulin levels, important for maintaining the health of the animal and mammary glands. According to Martí et al. (2013), mammary gland health is important for good milk production and quality, as observed in the current study when the cows ate diets containing 4% acai oil.

Cows in the prepartum period have high nutritional demands that often cause greater cellular respiration. High tissue utilization of oxygen increases the production of reactive oxygen species to levels greater than those able to be neutralized by endogenous antioxidants, thereby causing oxidative stress (Sordillo 2013). In this study, there was decreased oxidative reactions in cows in the AÇAI group and increased total antioxidant capacity in the blood, resulting in reduction of lipoperoxidation and ROS. This result confirms our hypothesis that açai contains high levels of antioxidants, because its phytochemical compounds are polyphenols of the flavonoid class, including anthocyanins and pro-anthocyanins (De Brito et al. 2007, Novello et al. 2015). According to the literature, these are important components of the defense system that combats oxidative stress (Schauss et al. 2006). Lower levels of ROS in the serum of cows that consumed açai suggested that the oil is a bifunctional antioxidant reacting directly or indirectly on ROS.

In the current study, we found that feed supplemented with açai oil stimulated the activity of SOD, GPx and GST, antioxidant enzymes responsible for regulation of redox balance and cellular protection. According to the literature, the enzymatic defense system comprises the first endogenous defense against ROS, preventing their interaction with cellular targets (Rover Júnior et al. 2001). SOD and GPx together prevent and control the formation of free radicals involved in oxidative damage. Souza et al. (2010) investigated the antioxidant potential of açai pulp in rats fed a standard or high cholesterol diet and found that mice consuming açai pulp had improved antioxidant status. Da Costa-Guerra et al. (2011) also used 2% of açai pulp to supplement diabetic rats, and showed increases in the activity of enzymes such as glutathione and SOD, as well as decreases in lipid peroxidation, suggesting favorable responses to oxidative stress. Little is known about the use of açai oil for ruminants;

however, these first results are positive and may stimulate future research to understand the mechanisms involved.

The use of açai oil in the diets of dairy cows is a novel strategy; the use of fats in livestock diet is not new. Açai oil is a by-product rich in oleic acid that is still little-used. In Brazil, the production and industrialization of açai fruit has grown in the last decade; therefore, the need arises to provide appropriate destinations for its waste. Knowing that the oil in the sheep diet (Santos et al. 2019) has an antioxidant effect, we hypothesized that the intake of açai oil would improve health, thereby minimizing the negative effects of the transition period, a critical moment in the life of the dairy cow, which would have a positive impact on lactation. More studies of açai oil in the feed of lactating cows are needed to determine whether the benefits on milk production and quality are direct effects of consumption of the by-product, or whether they are indirect, as suggested in our study.

CONCLUSION

Açai oil added in prepartum cow feed stimulates the antioxidant system, reducing serum lipid peroxidation and free radical levels. Lower activity of muscle injury biomarker enzymes (AST and CK) on the day of partum was observed, a consequence of the lower oxidative imbalance and inflammatory response in cows that consumed açai oil. The consumption of acai oil by cows also increased serum levels of globulins, corresponding to an improvement in the immune response in a critical period of the life of these animals. Although the açai diet was only offered during the prepartum period, this group of cows had greater milk yields and lower somatic cell counts during of analyses in the transition period, and these are some of the primary variables in terms of milk quality analysis. These findings suggest that the addition of 4% açai oil in dairy cow's diet may be an effective strategy to improve dairy cow health during the transition period, consequently allowing these animals to have greater milk production, as well as better quality milk (less SCC) in the first 20 days of lactation compared to cows that consumed soybean oil.

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REFERENCES

AMADO LL, GARCIA ML, RAMOS PB, FREITAS F, ZAFALON B, FERREIRA JLR, YUNES JS & MONSERRAT JM. 2009. A method to measure total antioxidant capacity against peroxyl radicals in aquatic organisms: Application to evaluate microcystins toxicity. Sci Total Environ 407: 2115-2123.

AEBERHARD K, BRUCKMAIER RM & BLUM JW. 2001. Metabolic, enzymatic and endocrine status in high-yielding dairy cows–part 2. J Vet Med Series A 48: 111-127.

ANJO DFC. 2004. Alimentos funcionais em angiologia e cirurgia vascular. J Vascular Bras 3: 145-154.

AOAC INTERNATIONAL. 1990. Association of Official Analytical Chemistry. Official methods of analysis. 15th ed., Virginia: Association of Analytical Chemist, 287 p.

BENCHAAR C, PETIT HV, BERTHIAUME R, WHYTE TD & CHOUINARD PY. 2006. Effects of addition of essential oils and monensin premix on digestion, ruminal fermentation, milk production, and milk composition in dairy cows. J Dairy Sci 89: 4352-4364.

BEUTLER E. 1984. Superoxide dismutase. In: Beutler E (Ed), Red Cell Metabolism. A Manual of Biochemical Methods. Grune & Stratton, Philadelphia, PA, 83-85.

BOUHROUM N. 2013. Relationship among body condition score, some biochemical parameters and uterine involution in dairy cow. Int J Biosc 3: 1-6.

DA COSTA-GUERRA JF, MAGALHÃES CL, COSTA DC, SILVA ME & PEDROSA ML. 2011. Dietary açai modulates ROS production by neutrophils and gene expression of liver antioxidant enzymes in rats. J Clin Biochem Nutr 49: 188-194.

DE BRITO ES, ARAUJO MCP, ALVES RE & CARKEET C. 2007. Anthocyanins present in selected tropical fruits: acerola, jambolão, jussara, and guajiru. J Agric Food Chem 55: 9389-9394.

CALDEIRA RM, BELO AT, SANTOS CC, VAZQUES MI & PORTUGAL AV. 2007. The effect of body condition score on blood metabolites and hormonal profiles in ewes. Small Rum Res 68: 233-241.

CUNNINGHAM JG & KLEIN BG. 2004. Tratado de Fisiologia Veterinária (3ª edição). Ed. Guanabara Koogan, São Paulo, 596 p.

DRACKLEY JK. 1999. Biology of dairy cows during the transition period: The final frontier? J Dairy Sci 82: 2259-2273.

DRACKLEY JK, DANN HM, DOUGLAS N, GURETZKY NAJ, LITHERLAND NB, UNDERWOOD JP & LOOR JJ. 2005. Physiological and pathological adaptations in dairy cows that may increase susceptibility to periparturient diseases and disorders. Italian J Anim Sci 4: 323-344.

GOFF JP & HORST RL. 1997. Physiological changes at parturition and their relationship to metabolic disorders. J Dairy Sci 80: 1260-1268.

GRANDE PA & SANTOS GT. 2008. O uso do perfil metabólico na nutrição de vacas leiteiras. Núcleo Pluridisciplinar de Pesquisa e Estudo da cadeia Produtiva do Leite. Disponível em file:///C:/Users/aleks/Downloads/perfilmetabolico-vacas%20(3).pdf.

HABIG WH, PABST MJ & JAKOBY WB. 1974. Glutathione S-transferases. The first enzymatic step in mercapturic acid formation. J Biol Chem 249: 7130-7139.

HARTMAN L & LAGO RCA. 1973. Rapid preparation of fatty acids methyl esters. Lab Pract 22: 475-476.

HERMES-LIMA M, CASTILHO RF, MEINICKE AR & VERCESI AE. 1995. Characteristics of Fe(II)ATP complex-induced damage to the rat liver mitochondria. Mol Cell Biochem 145: 53-60.

HOMMA AKO, NOGUEIRA OL, MENEZES AJEA, CARVALHO JEU & NICOLI CML. 2006. Açai: novos desafios e tendências. Amazônia: Ciênc Desenvol 1: 7-23.

LEBEL CP, ISCHIROPOULOS H & BONDY SC. 1992. Evaluation of the probe 2',7'dichlorofluorescin as an indicator of reactive oxygen species formation and oxidative stress. Chem Res Toxicol 5(2): 227-231.

LEBLANC S. 2010. Monitoring the metabolic health of dairy cattle in the transition period. J Reproduc Develop 56: S29-S35.

MARTÍ DOA, DÍAZ JR, MOLINA MP & PERIS C. 2013. Quantification of milk yield and composition changes as affected by subclinical mastitis during the current lactation in sheep. J Dairy Sci 96: 7698-7708.

MULLIGAN FJ & DOHERTY ML. 2008. Production of diseases of the cow in transition. Vet J 176: 3-9.

NOCKELS CF, ODDE KG & CRAIG AM. 1996. Vitamin E supplementation and stress affect tissue alpha-tocopherol content of beef heifers. J Anim Sci 74: 672-677.

NOVELLO AA, CONCEICAO LL, DIAS MMS, CARDOSO LM, CASTRO CA, RICCI-SILVA ME, LEITE JPV & PELUZIO MCG. 2015. Chemical characterization, antioxidant and antiatherogenic activity of anthocyanin-rich extract from *Euterpe edulis* Mart. in mice. J Food Nutr Res 54: 101-112.

PALMQUIST DL & JENKINS TC. 1980. Fat in lactation rations: review. J Dairy Sci 63: 1-14.

PEREIRA NS, MONTE AFG, DOS REIS AF, MORAIS PC & SALES MJA. 2010. Luminescence and energy transfer from açai oil in polystyrene matrix. Opt Mat 32: 1134-1138.

ROVER JÚNIOR L, HOEHR NF, VELLASCO AP & KUBOTA LT. 2001. Sistema antioxidante envolvendo o ciclo metabólico da glutationa associado a métodos eletroanalíticos na avaliação do estresse oxidativo. Quím Nova 24: 112-119.

SANTOS DS, KLAUCK V, ALBA DF, CAMPIGOTTO G, VEDOVATTO M & DA SILVA AS. 2019. Benefits of the inclusion of açai oil in the diet of dairy sheep in heat stress on health and milk production and quality. J Therm Biol 84: 250-258.

SATTLER T & FÜRLL M. 2004. Creatine kinase and aspartate aminotransferase in cows as indicators for endometritis. J Vet Med A Physiol Pathol Clin Med 51: 132-137.

SCHAUSS AG, WU X, PRIOR RL, OU B, HUANG D, OWENS J, AGARWAL A, JENSEN GS, HART AN & SHANBROM E. 2006. Antioxidant capacity and other bioactivities of the freeze-dried Amazonian palm berry, Euterpe oleraceae mart. (acai). J Agric Food Chem 54: 8604-8610.

SILVA DJ & QUEIROZ AC. 2002. Food Analysis: Chemical and Biological Methods. 3rd ed., Viçosa, MG: UFV.

SORDILLO LM. 2013. Selenium-dependent regulation of oxidative stress and immunity in periparturient dairy cattle. Vet Med Int 2013: 154045.

SOUZA MO, SILVA M, SILVA ME, OLIVEIRA RDE P & PEDROSA ML. 2010. Diet supplementation with acai (*Euterpe oleracea* Mart.) pulp improves biomarkers of oxidative stress and the serum lipid profile in rats. Nutrition 26: 804-810.

WENDEL A. 1981. Glutathione peroxidase. Methods Enzymol 77: 325-333.

WITTWER F. 2000. Marcadores bioquímicos no controle de problemas metabólicos nutricionais em gado leiteiro. In:

González FHD (Ed). Perfil metabólico em ruminantes: seu uso em nutrição e doenças nutricionais. Porto Alegre: UFRGS, p. 53-62.

YUYAMA LKO, AGUIAR JPL, SILVA FILHO DF & YUYAMA K. 2011. Caracterização físico-química do suco de açai de Euterpe precatoria Mart. oriundo de diferentes ecossistemas amazônicos. Acta Amazon 41: 545-552.

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Santos DS, Klauck V and Da Silva A.S. contributed to the design and implementation of the research, to the analysis of the results. Vedovatto M helped in the elaboration of the project and its execution and financing. Bordignon B, Theisen C, Reis JH, Gebert RR and Alba DF participated in the execution of the experiment and collection of samples and data. Souza CF and Baldissera MD did the laboratory analysis. All authors discussed the results and contributed to the final manuscript.