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The Nutritive Value of Live Yeast Culture (*Saccharomyces cerevisiae*) and Its Effect on Milk Yield, Milk Composition and Some Blood Parameters of Dairy Cows

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ABSTRACT : This study was conducted to determine the nutritive value of live yeast culture (RumiSacc, *Saccharomyces cerevisiae*) and to investigate its effects on milk yield, milk composition and some blood parameters in lactating cows. Six multiparous Holstein cows were allocated to two groups of three cows and assigned randomly to one of two diets in a cross-over experiment. Daily 50 g RumiSacc was top dressed at the p.m. feeding for the treatment group. RumiSacc supplied a high protein and energy with high organic matter digestibility values (83.35%) determined by *in vitro* enzymatic analysis. Yeast culture supplementation significantly increased milk yield, tended to increase fat yield, protein yield and lactose yield of milk. Methylated fatty acid level of 18:3 (n-3) in milk fat was increased by yeast culture supplementation. The concentrations of methionine, phenyalanine, tyrosine, tryptophan and taurine were significantly increased with dietary inclusion of yeast culture. Live yeast culture supplementation did not affect other performance characteristics, milk quality characteristics and blood parameters. As a conclusion live yeast culture (RumiSacc, *Saccharomyces cerevisiae*) had high nutritive value and positive effects on milk production and some milk quality characteristics in lactating cows under field conditions. (**Key Words :** Live Yeast Culture, Milk Production, Milk Quality Characteristics, Blood Plasma Metabolites, Lactating Cow)

INTRODUCTION

Yeast and yeast products have been widely used in ruminant nutrition to manipulate rumen fermentation and improve animal performance. However, performance results of ruminants fed yeast and yeast products have been variable. These differences may depend on many factors such as diet composition, forage to concentrate ratio, type of forage fed, yeast dose, feeding strategy and stage of lactation. Several studies (Robinson and Garrett, 1999; Dann et al., 2000) have shown that live yeast and yeast culture supplementation may increase feed intake and milk production of dairy cows. Some researchers (Robinson and Garrett, 1999; Dann et al., 2000; Erasmus et al., 2005) have suggested that feeding yeast products may be most beneficial to dairy cows during late gestation and early lactation because of their effects on rumen fermentation and nutrient digestion. However, Swartz et al. (1994) reported that daily supplementation of two yeast culture preparations (*Saccharomyces cerevisiae*, at about 5×10^{10} cfu/d per cow) did not improve significantly the production parameters of lactating dairy cows under the nutritional management programs of the farms.

The use of yeast culture as a dietary supplement has been suggested as a useful tool to stabilize ruminal fermentation (Williams et al., 1991). Yeast culture products contain *Saccharomyces cerevisiae* fermentation metabolites (i.e., B vitamins, amino acids, organic acids) and may have a number of effects in the rumen including increased pH (Williams et al., 1991), altered volatile fatty acids concentrations (Williams et al., 1991), increased numbers of cellulolytic bacteria (Callaway and Martin, 1997) and

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increased rate or extent of ruminal fiber digestion (Callaway and Martin, 1997).

RumiSacc is a commercial live yeast culture. It contains live yeast and autolyzed yeast. Modified dried vinasse is included in this supplement as a protein supplement. Vinasse is a by-product from industrial production of baker's yeast, then it is modified and dried. It contains a readily degradable fraction of NPN in addition to amino acids, especially glutamic acid. Yalçın et al. (2010) reported that modified dried vinasse can be considered as a safe and an attractive alternative protein source for high quality protein supplements such as soybean meal. The objectives of this experiment were to determine the nutritive value of live yeast culture (*Saccharomyces cerevisiae*) containing modified dried vinasse and to evaluate its effects on performance, milk composition and some blood plasma metabolites of lactating cows.

MATERIALS AND METHODS

The animals used in this experiment were cared for in accordance with the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes.

Analysis of feeds and live yeast culture

Nutrient composition of live yeast culture (RumiSacc), feeds and orts were determined according to the AOAC (2000). Metabolizable energy values were estimated using the following equation (TSI, 1991):

ME (kcal/kg OM)
= 3,260+(0.455×CP)-(4.037×CF)+(3.517×EE)

where CP (crude protein), CF (crude fibre) and EE (ether extract) were expressed as g/kg OM (organic matter).

The levels of ADF (acid detergent fibre) and NDF (neutral detergent fibre) were analyzed by the method of Goering and Van Soest (1970). Mineral contents were determined using ICP-MS (Agilent 7500 ce model, serial no: JP51201902, Yamanashi-Ken, Japan). Free and total amino acids of live yeast culture were determined with modified OPA derivatization using the HPLC system of Agilent 1100 series (Agilent Technologies, Waldbronn, Germany). From these values contents of bound amino acids were also calculated. After alkaline hydrolysis of the sample of live yeast culture, fatty acids were methylated with BF_3 (AOCS, 1997). The obtained fatty acid methyl esters (FAME) were analyzed by gas chromatography (HP 6890, Agilent, USA) using a HP-88 column for FAME (100 m×250 μm×0.25 μm) (Agilent, USA).

Determination of digestibility and energy value of live yeast culture by *in vitro* enzymatic method

In enzymatic method, the enzymes of pepsin (Merck No: 7190), amylase (Sigma, A-3176), hemicellulase (Sigma, H-2125) and cellulase (Sigma, C-9422) were used (Aufrere, 1982; Castagna et al., 1984; De Boever et al., 1986). After determination of dry matter digestibility and organic matter digestibility of RumiSacc (Castagna et al., 1984), gross energy (ADAS, 1984), digestible energy (Sauvant et al., 1987), metabolizable energy (Sauvant et al., 1987) and net energy lactation (Aiple et al., 1996) were calculated as given below:

Gross energy (GE, MJ/kg DM)
= (0.0226×CP)+(0.0407×EE)
+(0.0192×CF)+(0.0177×nitrogen free extract)

where CP (crude protein), CF (crude fibre) and EE (ether extract) and nitrogen free extract were expressed as g/kg DM (dry matter).

Digestible energy (DE, kcal/kg DM)
= (GE×DOM)/100

where DOM (digestibility of organic matter) was expressed as %, GE was expressed as kcal/kg DM.

Metabolizable energy (ME, kcal/kg DM)
= ((86.82-(0.0099×CF)-(0.019×CP)×DE)/100

where CP and CF were expressed as g/kg OM, DE was expressed as kcal/kg DM.

Net energy for lactation (NEL, MJ/kg DM)
= -0.43+(0.0706×DOMD)+(0.102×EE)
+(0.030×nitrogen free extract)+(0.026×CP)

where DOMD (organic matter digestibility in DM), EE, CP and nitrogen free extract were expressed as % in DM.

Live yeast cells were counted in the samples of live yeast culture at the beginning and at the end of each period with BAM method (Tournas et al., 2001).

Animals, treatments and experimental design

Six multiparous Holstein cows, 90±35 days postpartum, were allocated to two groups of three cows according to calving date, lactation number and daily milk yield, and assigned randomly to one of two diets in a cross-over experiment. Cows were housed in individual tie stalls throughout the experiment. Fresh water was available at all times *ad libitum*. Experiment was consisted of two periods. Each period was 25 d in length, the last 7 d of each period was used for collection of samples.

The experimental diet consisted of concentrate (10 kg/d),

maize silage (26 kg/d), alfalfa hay (5 kg/d) and barley straw (2 kg/d). The diets were offered individually as total mixed rations in two equal proportions at 05:00 and 17:00 h in amounts sufficient to ensure about 5% refusals. Half of the cows were fed 50 g of live yeast culture (RumiSacc, *Saccharomyces cerevisiae*, Integro Food and Feed Manufacturing Company, İstanbul, Turkey) top-dressed at the p.m. feeding. RumiSacc consisted of live yeast and autolyzed yeast and modified dried vinasse (above 50%). Concentrate feeds were prepared in a commercial feed manufacturing factory as a pellet feed. The ingredients and chemical composition of the concentrate feed are presented in Table 1. Nutrient composition of forages are also given in Table 2.

Traits measured

The daily feed intake on a DM basis was determined by the difference between feed offered and orts. Orts were collected every day. Water was provided *ad libitum*. At the p.m. feeding, firstly the quarter part of total mixed diets were put in the feeders and 50 g live yeast culture was top dressed on the diets. Only after these feeds and the live yeast culture were completely consumed were the other parts of the diets given.

Table 1. The ingredients and chemical composition of the concentrate feeds

Ingredients (g/kg)	
Barley	189.18
DDGS	307.29
Wheat bran	374.37
Sunflower meal	69.54
Maize gluten	14.39
Bypass fat[1]	8.00
Limestone	24.29
Salt	4.94
Magnesium oxide	7.00
Vitamin-mineral premix[2]	1.00
Chemical composition (on dry matter basis)	
Dry matter (g/kg)	901.3
Crude protein (g/kg)	190.3
Ether extract (g/kg)	56.5
Crude fibre (g/kg)	72.8
Crude ash (g/kg)	77.8
Acid detergent fibre (g/kg)	119.5
Neutral detergent fibre (g/kg)	327.6
Metabolizable energy (MJ/kg)	12.58

[1] RumiFat R100: produced from high quality palm oil. It contains minimum 99.5% crude fat. Fatty acid composition: 71-73% C16:0, 4-6% C18:0, 16-18% C18:1, 3-5% C18:2.

[2] Supplied per kg of diet: vitamin A: 10,000,000 IU; vitamin D_3: 3,000,000 IU; vitamin E: 50 g; niacin: 100 g; biotin: 2 g; Mn: 50g; Fe: 30 g; Zn: 65 g; Cu: 10 g; I: 0.8 g; Co: 0.15 g; Se: 0.15 g.

Table 2. Nutrient composition of forages (g/kg, on dry matter basis)

	Maize silage	Alfalfa hay	Barley straw
Dry matter	254.0	931.1	945.9
Crude protein	97.6	143.6	17.7
Ether extract	20.0	16.8	10.8
Crude fibre	230.5	247.2	388.7
Crude ash	66.1	123.2	69.9
ADF	333.0	387.1	551.7
NDF	550.4	445.0	811.6

ADF = Acid detergent fibre; NDF = Neutral detergent fibre.

Cows were milked at 05.30 and 16.30 h daily by bucket-type milking system, and milk was weighed at each milking period. Feed conversion ratio was calculated by dividing the daily milk yield to daily dry matter intake. Milk samples were taken at each milking during the last 2 days of each period and analysed for fat, protein, lactose and minerals using a milk analyzer (LactoStar, Funke Gerber, Berlin, Germany) within 3 hours. Milk fat yield, milk protein yield and milk lactose yield were also calculated as kg/d. Five ml of the milk samples were treated with 5 ml of 25% (wt/vol) trichloroacetic acid for the determination of milk urea nitrogen (MUN). Samples were vortexed and allowed to stand for 30 min at room temperature before filtering through Whatman no.1 filter paper (Broderick and Reynal, 2009). Filtrates were used for MUN analysis by Abbott Aeroset Autoanalyzer (Abbott Laboratories, Illinois) using commercial Cobas BUN kits (ACN 427, Roche Diagnostics). Free amino acids of milk samples were analysed by using LC-MS/MS (Applied Biosystems of API-3200 model, serial no: AA14100B04, Foster city, CA). Fatty acid methyl esters were analysed by GC-MS (Shimadzu model of QP2010 PLUS, Serial no: C70504400636FA, Columbia, USA) using a Teknokroma TR-CN 100 column for FAME (60 m×250 μm×0.2 μm) (Teknokroma, Spain). Totals of saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA), poly unsaturated fatty acids (PUFA), short chain fatty acids (SCFA, <C14:0), medium chain fatty acids (MCFA, C14:0 to <C18:0), long chain fatty acids (LCFA, >C17), fatty acids originated from *de novo* synthesis (fatty acids<C16:0), fatty acids preformed fatty acids taken up by the mammary gland (fatty acids>C16:0) and the total of C16 (16:0 and 16:1 fatty acids that came from both *de novo* and preformed sources) were calculated.

Body condition score of cows was recorded by visual observation and manual assessment to score the dairy cows on a 1 to 5 scale on the first and last day of each experimental period (Edmonson et al., 1989).

Fecal samples were taken by rectal sampling from each individual cow at the last day of each period. pH of fecal samples was measured immediately using a portable digital

pH meter (Selecta, pH-2004, Spain). Then samples were dried for determination of dry matter using a forced-draught oven at 60°C for 48 h.

Blood samples were drawn from each individual cow via the vena subcutanea abdominis into tubes containing EDTA on the last day of each experimental period, about 4 h post morning feeding. Tubes were centrifuged at 3,220 g at room temperature for 10 minutes and then plasma was carefully harvested and analysed within two hours. Plasma total protein (ACN 678), albumin (ACN 413), urea nitrogen (ACN 427), cholesterol (ACN 433), triglyceride (ACN 781), glucose (ACN 525) and the activities of alanine amino transferase (ALT; ACN 685), aspartate amino transferase (AST; ACN 687) and creatine kinase (ACN 057) were determined by Abbott Aeroset Autoanalyzer (Abbott Laboratories, Illinois) using commercial Cobas kits (Roche Diagnostics).

Statistical analysis

Statistical analysis was done using SPSS programme (SPSS Inc., Chicago, IL, USA). Milk yield and milk composition, DM intake, body condition score and blood serum components were tested by analysis of variance with two factors (period and treatment) using the Minitab Statistical Package. Values were given as mean±standard error. All statements of significance were based on a probability of less than 0.05.

RESULTS AND DISCUSSION

The chemical composition of RumiSacc is presented in Table 3. RumiSacc is rich in protein (445.3 g/kg) whereas the levels of ether extract, crude ash and crude fibre were low. It contains 8.48 g/kg Ca, 7.35 g/kg K, 4.78 g/kg P and 3.16 g/kg Na. The major fatty acids of RumiSacc were oleic acid, linoleic acid and palmitic acid. Total of UFA was accounted for 66.99% (w/w) of total FAMEs. 60.56% of UFA is MUFA. The RumiSacc supplied a high metabolizable energy and net energy for lactation with high digestibility values as demonstrated by *in vitro* enzymatic analysis. It was shown that modified dried vinasse in RumiSacc had high and rapid ruminal degradation (within the first 4 h) of organic matter, and particularly of crude protein (Yalçın et al., 2010). As shown in Table 4, RumiSacc was mainly rich in glutamic acid which represented 30.8% of the total composition of α-amino

Table 3. Chemical composition of RumiSacc

Dry matter (g/kg)	923.7	Fatty acids (% of total fatty acid methyl esters)	
Crude protein (g/kg)	445.3	Lauric acid (12:0)	0.09
Ether extract (g/kg)	9.1	Myristic acid (14:0)	0.49
Crude ash (g/kg)	69.2	Myristoleic acid (14:1)	0.07
Crude fibre (g/kg)	80.1	Palmitic acid (16:0)	22.84
ADF (g/kg)	173.2	Palmitoleic acid (16:1)	6.18
NDF (g/kg)	209.1	Heptadecanoic acid (17:0)	0.12
ME[1] (MJ/kg)	11.62	Heptadesenoic acid (17:1)	0.14
Gross energy[2] (MJ/kg)	18.21	Stearic acid (18:0)	9.14
Digestible energy[2] (MJ/kg)	15.18	Oleic acid (18:1)	33.86
NEL[2] (MJ/kg)	7.41	Linoleic acid (18:2)	25.56
ME[2] (MJ/kg)	11.53	γ-linolenic acid (18:3, n6)	0.27
Dry matter digestibility[2] (%)	84.50	α-linolenic acid (18:3, n3)	0.59
Organic matter digestibility[2] (%)	83.35	Arachidic acid (20:0)	0.06
Minerals		Gadoleic acid (20:1, n9)	0.16
Calcium (g/kg)	8.48	Behenic acid (22:0)	0.19
Phosphorus (g/kg)	4.78	Erucic acid (22:1, n9)	0.16
Potassium (g/kg)	7.35	Lignoseric acid (24:0)	0.08
Sodium (g/kg)	3.16	∑SFA	33.01
Magnesium (g/kg)	1.89	∑MUFA	40.57
Cobalt (mg/kg)	0.28	∑PUFA	26.42
Copper (mg/kg)	3.71	∑UFA	66.99
Zinc (mg/kg)	17.89		
Manganese (mg/kg)	8.07	Live yeast cell (cfu/g)	1.3×10^8

ADF = Acid detergent fibre; NDF = Neutral detergent fibre; ME = Metabolizable energy; NEL = Net energy lactation; ∑SFA: Total of saturated fatty acids; ∑MUFA: Total of mono unsaturated fatty acids; ∑PUFA: Total of poly unsaturated fatty acids; ∑UFA. Total of unsaturated fatty acids

[1] Estimated using the analyzed crude nutrient values. [2] Estimated by *in vitro* enzymatic method.

acids incorporated into proteins, and also in aspartic acid (8.9%), leucine (6.9%), arginine (5.9%), lysine (5.6%) and alanine (5.4%) at a lesser extend. Glutamic acid, aspartic acid, phenylalanine, alanine and tryptophan were relatively abundant in a free form. Glutamic acid, the major component of milk protein, is a glucogenic amino acid.

Live yeast cells found in RumiSacc were about 1.3×10^8 cfu/g (Table 3). From Table 3 and Table 4 it can be seen that RumiSacc is highly nutritive for ruminants.

As shown in Table 5, the major finding in this study was that mean daily milk production was higher ($p<0.05$) in a yeast culture supplemented diet than in control cows (24.97 kg/d vs. 23.49 kg/d). Yeast culture provides soluble growth factors that stimulate growth of cellulolytic bacteria and cellulose digestion (Callaway and Martin, 1997). Significant increases in milk production associated with yeast supplementation, have previously been reported in dairy cows (Piva et al., 1993; Wohlt et al., 1998; Bruno et al., 2009). Milk response to feeding yeast culture usually ranges between 1 and 2 kg/d (Robinson and Garrett, 1999; Bruno et al., 2009). Kellems et al. (1990) reported that microbial additives such as yeast cultures had the greatest positive effect on cows in early lactation, increasing milk yield over that of control cows. Williams et al. (1991) found that yeast cultures had the greatest effect when diets contained 60% concentrate and 40% forage. Campanile et al. (2008) concluded that *Saccharomyces cerevisiae* supplementation increased organic matter digestibility thus allowing a higher energy availability for milk yield and reduced fat mobilization in buffalo cows. However, some researchers (Soder and Holden, 1999; Schingoethe et al., 2004; Bagheri et al., 2009) reported no beneficial effects in milk production from feeding yeast to lactating animals.

Table 4. Composition of the RumiSacc in α-amino-acids complexed into proteins (bound content) or in solution (free content) (g/kg)

α-amino-acid	Bound	Free
Aspartic acid	18.53	1.49
Glutamic acid	64.18	3.89
Asparagine	0.08	0.50
Serine	10.08	0.42
Threonine	9.23	0.02
Lysine	11.64	0.40
Arginine	12.18	0.70
Ornithine	0.30	0.03
Citrulline	0.17	0.02
Proline	3.64	0.01
Hydroxyproline	1.97	0.63
Glycine	10.72	0.20
Alanine	11.17	1.24
Valine	9.25	0.79
Leucine	14.29	0.33
Isoleucine	7.12	0.02
Cystine	0.88	0.31
Methionine	2.05	0.91
Sarcosine	0.20	0.02
Histidine	4.99	0.02
Phenylalanine	7.27	1.44
Tyrosine	5.46	0.36
Tryptophan	2.93	1.13

In the present study dry matter intake and feed

Table 5. The effects of live yeast culture supplementation on the performance and milk composition in dairy cattle

	Control group	Treatment group (RumiSacc)	p
Milk yield (kg/d)	23.49±1.83[b]	24.97±1.95[a]	0.038
Dry matter intake (DMI, kg/d)	20.49±0.36	20.84±0.25	0.119
Feed conversion ratio (kg milk/kg DMI)	1.15±0.08	1.20±0.08	0.155
Milk fat			
g/kg	29.63±1.17	31.41±1.62	0.313
yield (kg/d)	0.69±0.05	0.79±0.09	0.085
Milk protein			
g/kg	36.60±0.44	36.30±0.27	0.388
yield (kg/d)	0.86±0.07	0.91±0.07	0.101
Milk lactose			
g/kg	53.2±0.69	52.69±0.35	0.307
yield (kg/d)	1.25±0.10	1.31±0.11	0.120
Milk mineral matter			
g/kg	5.35±0.13	5.31±0.14	0.271
yield (kg/d)	0.13±0.01	0.13±0.01	0.101
Milk urea nitrogen (mg/100 ml)	14.31±0.50	14.42±0.56	0.298
Body condition score, average unit	3.25±0.09	3.17±0.08	0.492

Means within a row followed by different letters differ significantly ($p<0.05$).

efficiency values were not affected by yeast culture supplementation. In agreement with that, some studies with lactating animals found no response in dry matter intake (Arambel and Kent, 1990; Piva et al., 1993; Wohlt et al., 1998; Soder and Holden, 1999; Schingoethe et al., 2004; Bagheri et al., 2009) and feed efficiency (Bagheri et al., 2009; Moallem et al., 2009) by yeast culture supplementation. Harrison et al. (1988) explained this situation such that the addition of yeast cultures to the diets of lactating cows increased total concentrations of cellulolytic bacteria in the rumen, but this increase may have not affected total fiber digestion or dry matter intake. However, improvement in dry matter intake in treated animals (Erasmus et al., 1992; Dann et al., 2000; Stella et al., 2007) and improvement in feed efficiency (Erasmus et al., 1992; Schingoethe et al., 2004) in yeast culture supplemented lactating animals were reported.

Yeast culture supplementation did not affect body condition score in this study (Table 5). This is similar with the findings of some researchers (Soder and Holden, 1999; Dann et al., 2000; Schingoethe et al., 2004; Stella et al., 2007; Bagheri et al., 2009; Bruno et al., 2009). However, Giger-Reverdin et al. (1996) reported increased mobilization of body reserves in early lactating goats fed yeast.

In this study, milk composition was not affected significantly by yeast culture supplementation (Table 5). However, the average fat percentage was 6.1% higher in the yeast culture group than in the control. Fat yield ($p = 0.085$), protein yield ($p = 0.101$) and lactose yield ($p = 0.120$) from cows fed live yeast culture tended to be higher (14.5, 5.8 and 4.8%, respectively) compared with those from cows fed the control diet. The enhancement of fat yield was also observed in other researches (Piva et al., 1993; Putnam et al., 1997; Wohlt et al., 1998; Moallem et al., 2009) in response to yeast culture supplementation and might be attributable to the increased milk production and increased fiber fermentation in the yeast fed cows. Similarly some studies have shown that yeast culture had no beneficial effect on milk composition of dairy cows (Arambel and Kent, 1990; Swartz et al., 1994; Soder and Holden, 1999; Bagheri et al., 2009). Moallem et al. (2009) also observed no differences in milk protein percentage and milk protein yield. The meta-analysis of over 110 papers and 157 experiments (Desnoyers et al., 2009) showed that yeast supplementation increased milk yield without any significant effect on milk composition. Arambel and Kent (1990) suggested that ADF in the ration was probably sufficient to maintain milk fat synthesis, thereby negating any treatment effect. Similarly the findings of yield of milk fat, yield and percentages of protein and lactose in the study with lactating goats (Stella et al., 2007) were not affected with the usage of live yeast. Conversely, in some studies with dairy lactating goats fed live yeast, reduction in milk fat (Stella et al., 2007) and increase in milk fat (Giger-Reverdin et al., 1996) was observed. Moallem et al. (2009) reported that greater lactose percentage was observed in the live yeast group than in the control group ($p<0.02$).

Live yeast culture supplementation did not affect the percentages of milk urea N in this study and this result agrees with the other studies (Soder and Holden, 1999; Moallem et al., 2009).

The milk fatty acids from 4:0 to 14:0, as well as about 50% of C16, arise from *de novo* synthesis within the mammary gland. In contrast, the longer chain fatty acids such as 18:1 are supplied from circulating lipids and arise from either dietary sources or from depot lipids. Milk fat can be modified through nutritional management of dairy cows to provide more favourable fatty acids for consumers (Franklin et al., 1999). The effects of live yeast culture supplementation on milk methylated fatty acids are shown in Table 6. Dietary inclusion of live yeast culture significantly increased the levels of 18:3 (n-3). Total fatty acids with 16 carbon (16:0 and 16:1) originated from both *de novo* and preformed sources tended to increase ($p = 0.105$) and short chain fatty acids (<14:0) tended to decrease with yeast culture supplementation. Live yeast culture had no effect on other milk fatty acids. Similarly Longuski et al. (2009) observed that milk fatty acids were unaffected by yeast culture supplementation.

In this study, addition of live yeast culture to the diets of dairy cows increased the levels of methionine, phenyalanine, tyrosine, tryptophan and taurine in milk significantly (Table 7). This result is important in human nutrition. Erasmus et al. (1992) reported that yeast culture supplementation significantly ($p<0.05$) increased the flow of not only methionine, but also the flows of the other limiting amino acids. The increased flow of methionine and lysine observed in the study of Erasmus et al. (1992) may help to explain the 8.4% increase in milk production and 16.3% increase in milk protein observed by Günther (1989) in yeast culture supplemented cows. Erasmus et al. (1992) concluded that yeast culture may alter the duodenal amino acid profile which is of nutritional significance because yeast culture can therefore provide the nutritionist with a valuable tool to manipulate the duodenal amino acid profile. The contribution of lysine and methionine to total essential amino acids in duodenal digesta increased from 13.5 to 14.5% and from 4.6 to 5.8% of total essential amino acids, respectively, for cows fed yeast culture (Erasmus et al., 1992). Jenkins and McGuire (2006) suggested that the mammary gland has the capacity to alter the uptake of substrates from the arterial supply in response to changes in arterial amino acid concentrations, mammary blood flow, and metabolic activity to improve milk protein production.

Table 6. The effects of live yeast culture supplementation on milk fatty acids (% of total methyl esters of fatty acids) in dairy cattle

	Control group	Treatment group (RumiSacc)	p
8:0	1.57±0.12	1.46±0.09	0.206
10:0	3.46±0.16	3.10±0.18	0.073
12:0	3.76±0.08	3.60±0.17	0.361
13:0	0.09±0.01	0.08±0.01	0.546
14:0	12.36±0.21	12.00±0.53	0.345
14:1	1.70±0.26	1.85±0.15	0.537
15:0	1.34±0.16	1.36±0.15	0.918
15:1	0.13±0.02	0.16±0.02	0.249
16:0	35.86±0.51	36.76±0.36	0.084
16:1	2.61±0.26	2.63±0.19	0.876
17:0	0.74±0.04	0.80±0.06	0.342
17:1	0.23±0.04	0.27±0.03	0.180
18:0	10.57±0.51	10.03±0.13	0.408
18:1	20.64±0.58	20.92±0.41	0.748
18:2	3.61±0.11	3.55±0.12	0.586
18:3 (n-6)	0.05±0.01	0.05±0.01	0.579
18:3 (n-3)	0.40±0.02^{b}	0.48±0.01^{a}	0.035
20:0	0.17±0.01	0.17±0.01	0.916
20:1	0.10±0.01	0.10±0.01	1.000
20:2	0.04±0.01	0.04±0.01	0.820
20:3	0.03±0.01	0.03±0.01	1.000
20:4	0.23±0.01	0.23±0.01	0.851
20:5	0.04±0.01	0.04±0.01	0.499
22:0	0.11±0.01	0.10±0.01	0.158
22:6	0.12±0.01	0.14±0.01	0.176
23:0	0.05±0.01	0.04±0.01	0.566
24:0	0.04±0.01	0.04±0.01	0.573
∑SFA	70.10±0.57	69.53±0.71	0.500
∑MUFA	25.40±0.56	25.93±0.61	0.532
∑PUFA	4.51±0.11	4.55±0.12	0.716
16total	38.47±0.75	39.39±0.49	0.105
<16	24.39±0.17	23.61±0.79	0.319
>16	37.14±0.69	37.01±0.46	0.890
18 total	35.26±0.64	35.03±0.43	0.815
SCFA	8.87±0.31	8.24±0.41	0.090
MCFA	54.95±0.89	55.82±0.32	0.353
LCFA	36.18±0.65	35.94±0.45	0.809

∑SFA: Total of saturated fatty acids; ∑MUFA: Total of mono unsaturated fatty acids; ∑PUFA: Total of poly unsaturated fatty acids; SCFA = Short chain fatty acids (<14:0); MCFA = Medium chain fatty acids (14:0 to <18:0); LCFA = Long chain fatty acids (>17); FA<16:0 originated from *de novo* synthesis, FA>16:0 were preformed FA taken up by the mammary gland; 16 total: 16:0 and 16:1 FA came from both *de novo* and preformed sources.

Means within a row followed by different letters differ significantly ($p<0.05$).

Table 7. The effects of live yeast culture supplementation on the free amino acid composition of milk in dairy cattle (mg/100 ml)

	Control group	Treatment group (RumiSacc)	p
Aspartic acid	0.47±0.03	0.48±0.02	0.273
Glutamic acid	2.28±0.13	2.35±0.22	0.789
Serine	0.14±0.01	0.13±0.01	0.192
Threonine	0.16±0.01	0.19±0.02	0.139
Lysine	0.57±0.02	0.57±0.02	0.907
Arginine	0.16±0.01	0.17±0.01	0.427
Ornithine	0.16±0.02	0.18±0.02	0.106
Glycine	0.24±0.01	0.25±0.01	0.101
Alanine	0.56±0.03	0.57±0.03	0.422
Valine	0.35±0.05	0.35±0.04	0.762
Leucine	0.21±0.03	0.24±0.04	0.123
Isoleucine	0.09±0.01	0.10±0.01	0.330
Cystine	0.20±0.04	0.22±0.03	0.347
Methionine	0.11±0.01^{b}	0.14±0.01^{a}	0.027
Histidine	0.24±0.02	0.25±0.03	0.315
Phenyalanine	0.21±0.02^{b}	0.23±0.01^{a}	0.006
Tyrosine	0.18±0.02^{b}	0.20±0.02^{a}	0.031
Tryptophan	0.14±0.01^{b}	0.15±0.01^{a}	0.047
Taurine	0.28±0.02^{b}	0.29±0.02^{a}	0.016

Means within a row followed by different letters differ significantly ($p<0.05$).

However, Putnam et al. (1997) reported that flows of essential amino acids to the duodenum and the essential amino acid profiles of duodenal digesta and of mixed ruminal bacteria were not altered by yeast culture supplementation (10 g yeast culture/d). Kudrna et al. (2009) also observed some changes in milk amino acid concentrations and reported that dietary protected methionine supplementation in dairy cows marginally ($p<0.10$) increased methionine concentration in milk and increased significantly ($p<0.05$) the concentrations of threonine, alanine, valine, leucine, isoleucine, tyrosine, phenylalanine and lysine.

Plasma metabolites are frequently used to monitor the metabolic health status of dairy herds (Ametaj et al., 2009). All the blood parameters investigated were unaffected by live yeast culture supplementation (Table 8). Similarly Piva et al. (1993) reported that glucose, cholesterol, urea, total protein and albumin of blood plasma were not affected by supplementation with yeast culture. Putnam et al. (1997) observed that serum urea nitrogen and plasma glucose were not affected by daily 10 g yeast culture addition to the diets of lactating cows. Dry matter and pH of faeces were not affected from the yeast culture treatment in this study (Table 8). Similarly, Bagheri et al. (2009) reported that the levels of glucose and urea nitrogen in blood serum and fecal score

Table 8. The effects of live yeast culture supplementation on some blood plasma parameters, fecal pH and fecal dry matter in dairy cattle

	Control group	Treatment group (RumiSacc)	p
Protein (g/100 ml)	8.31±0.19	8.34±0.14	0.849
Albumin (g/100 ml)	3.85±0.10	3.87±0.11	0.626
Urea nitrogen (mg/100 ml)	16.45±0.66	16.57±0.81	0.828
Cholesterol (mg/100 ml)	228.17±16.52	237.50±15.91	0.302
Triglyceride (mg/100 ml)	9.17±0.73	8.17±0.69	0.055
Glucose (mg/100 ml)	51.33±0.10	52.17±0.73	0.292
ALT (U/L)	30.83±2.11	29.17±1.11	0.283
AST (U/L)	86.67±5.38	88.33±5.01	0.505
Creatine kinase (U/L)	184.17±17.06	199.50±25.15	0.211
Fecal dry matter (g/kg)	162.6±7.4	176.7±4.9	0.256
Fecal pH	6.86±0.06	6.84±0.06	0.657

ALT = Alanine aminotransferase; AST = Aspartate aminotransferase.

were not affected by live yeast supplementation (1.2×10^{10} cfu/d) of early lactation Holstein dairy cows.

The differences between some previous studies and the results in this study may be due to the stage of lactation, feeding strategy, environmental conditions, diet composition, type of forage, type and dose of yeast and type of yeast feeding. Some researchers (Arambel and Kent, 1990; Moallem et al., 2009) reported that yeast products might be more effective under stress rather than in the normal conditions.

CONCLUSIONS

Results from the present research show that RumiSacc is high in crude protein, glutamic acid, metabolizable energy and organic matter digestibility. Daily 50 g RumiSacc increased the milk production significantly. Yeast culture supplementation tended to increase fat, protein and lactose yield of milk. The levels of 18:3 (n3) in milk fat, methionine, phenyalanine, tyrosine, tryptophan and taurine in milk were increased significantly by yeast culture. Live yeast culture did not affect other performance characteristics, milk quality characteristics and blood parameters.

In conclusion, results obtained in this study demonstrate positive effects of live yeast culture on milk production and some milk quality characteristics of lactating cows under field condition.

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