Effects of Yeast on Dairy Cow Performance, Ruminal Fermentation, Blood Components, and Milk Manufacturing Properties[1]

G. PIVA
Istituto di Scienze della Nutrizione
Facoltà di Agraria
Università Cattolica S.C.

S. BELLADONNA and G. FUSCONI
CERZOO, Centro Ricerche Zootecnia e Ambiente
S. Bonico

F. SICBALDI
Istituto di Chimica Agraria ed Ambientale
Facoltà di Agraria
Università Cattolica S.C.
29100 Piacenza, Italy

ABSTRACT

Effect of dietary yeast culture on milk production and composition, ruminal fermentation, blood parameters, and milk manufacturing properties of 24 midlactation Holstein-Friesian cows was determined in a 6-wk experiment. The control diet (DM) consisted of 30% corn silage, 22% alfalfa hay, and 48% concentrate. After a 2-wk preliminary period, cows were assigned in equal numbers to either 0 or 10 g/d of yeast culture for the remainder of the 4-wk study on the basis of age, DIM, and pretrial milk production. Production of milk (26.2 vs. 25.4 kg/d), FCM (23.6 vs. 21.6 kg/d), and milk fat (.90 vs. .78 kg/d) was increased significantly by dietary yeast culture. No differences were significant for milk composition. Molar proportion of acetate and acetate:propionate ratio in ruminal liquor tended to be higher in cows fed yeast culture. Total VFA concentration in ruminal fluid was not different between treatments. Manufacturing properties of milk and blood plasma components were not affected adversely by added dietary yeast culture.

(**Key words**: yeast culture, milk production, manufacturing properties, ruminal fermentation)

Abbreviation key: **YC** = yeast cultures.

INTRODUCTION

The use of yeast cultures (**YC**) in ruminant diets to improve performance has been reviewed recently (5, 21). Results of the addition of YC to rations of lactating dairy cows have varied. In some studies (9, 10, 21, 23, 24), YC increased milk production and milk fat percentage, but, in other studies (2, 8, 17) YC did not cause beneficial responses. Several factors affect the response of dairy cows to YC supplementation: stage of lactation, type of forage given, feeding strategy (TMR or forage and concentrate given separately), and forage: concentrate ratio (5, 7).

Various authors (6, 11, 16, 19, 21, 23) have reported that dietary YC causes a range of effects in the rumen, including increased pH, increased ruminal concentrations of VFA, decreased methane production, and increased total number of microorganisms and cellulolytic bacteria.

Data (1, 15, 25) suggest that creaming capacity and clotting properties are influenced by milk composition and ruminal fermentation, but, to our knowledge, no data are available on the effect of YC on milk manufacturing properties. Creaming capacity and clotting properties are very important parameters in cheese production, particularly in production

Received January 28, 1993.
Accepted May 6, 1993.
[1]Work supported by National Council of Research-Advances in Research for Innovations in Agricultural Systems (Richerche Avanzate per Innovazioni del Sistema Agricolo) Paper Number 1016.

TABLE 1. Ingredient and chemical composition of the TMR.

Composition	DM basis
	(%)
Ingredient	
Alfalfa hay	22.3
Corn silage	30.0
Corn flakes	10.4
Soybean meal	8.5
Soybean flakes	3.2
Corn gluten meal	3.3
Fish meal	1.1
Barley	6.0
Corn	6.6
Corn gluten feed	1.9
Wheat bran	1.5
Linseed meal	1.3
Beet molasses	1.1
Calcium carbonate	.3
Dicalcium phosphate	.8
Sodium chloride	.4
Vitamin and mineral premix[1]	.3
Chemical	
CP, %	17.6
ADF, %	21.1
NDF, %	33.5
NE_L,[2] Mcal/kg	1.73

[1]Containing per kilogram: 2,000,000 IU of vitamin A, 200,000 IU of vitamin D_3, 600 IU of vitamin E, 500 mg of vitamin B_1, 1 mg of vitamin B_{12}, 5000 mg of Fe, 200 mg of I, 3000 mg of Mn, 1870 mg of Cu, 10 mg of Se, and 5000 mg of Zn.

[2]Estimated from NRC (13).

of Parmesan cheese, a traditional product of the provinces of Parma and Reggio Emilia in Italy.

The objectives of this trial were to determine the effect of YC supplementation on 1) milk production and composition, 2) patterns of ruminal fermentation, 3) blood plasma components, and 4) ability of milk to be used for cheese making.

MATERIALS AND METHODS

Twenty-four Holstein-Friesian cows in mid-lactation were allocated equally to one of two treatments on the basis of DIM (105 ± 2 d) and mean daily 2-wk pretrial milk production (27.0 ± .8 kg/d). Treatments consisted of a TMR (Table 1) with or without the addition of 10 g/d of YC (Thepax Dry®; Dox-Al, Correzzana, Italy). The YC supplement was composed of selected strains of *Saccharomyces cerevisiae*; the growth medium (10×10^9 yeast cells/g) was devitalized by an osmotic treatment to have <1000 cfu/g in the final product). Cows were fed as a group once daily for ad libitum intake with free access to water. The experiment lasted for 6 wk. The first 2 wk of the experiment was a preliminary period during which cows were adapted to the control diet. Cows were housed in a free-stall barn in four pens of 6 cows each.

Amount of TMR delivered was measured with electronic scales on a mixer-feeder wagon. Orts from each group of cows were collected and weighed daily before the morning feeding throughout the 6-wk experimental period. Cows were weighed weekly. Milk production was recorded daily, and milk composition was analyzed twice weekly for fat, protein, and lactose contents using a milk analyzer (Milkoscan 133B; Foss Electric, Hillerød, Denmark). Data were used to calculate fat and protein production. Production of 4% FCM was calculated using the Institut National de la Recherche Agronomique (12) recommendations. The TMR was sampled weekly and analyzed for CP, ADF, and NDF according to Associazione Scientifica Produzione Animale (3).

Samples of ruminal digesta were taken weekly prior to the morning feeding via esophageal tube for analyses of pH, VFA, and ammonia. The pH was measured at each sampling via a Micro TT 2050 Titrator (Crison Instrument S. A., Alella, Spain). Samples were centrifuged at $10,000 \times g$ for 10 min, and then an aliquot (8 ml) of the supernatant fluid was pipetted into a 12-ml polyethylene tube, quickly frozen in liquid N, and stored at –20°C prior to analysis for ruminal VFA and ruminal ammonia. Concentrations of VFA were determined by gas chromatography (Varian 3700; Varian, Palo Alto, CA) using 4% CW 20 m Carbopack-B-DA packing (Supelco, Inc., Bellefonte, PA) in a 2-mm by 200-cm column. Chromatographs were adjusted for internal standard (trimethyl acetic acid) and were integrated for VFA concentrations by a Perkin-Elmer LC-100 Computing Integrator (Perkin-Elmer Corp., Norwich, CT). Ruminal ammonia concentrations were determined using an enzymatic kit (Boeringer-Mannheim, Mannheim, Germany).

Blood plasma was sampled weekly prior to morning feeding from the jugular vein into

TABLE 2. Effect of yeast culture (YC) on DMI, milk production, and milk composition.[1]

Item	Dietary treatments[2]			
	Control	YC	SE	$P <$
BW, kg	632	648	4.7	.65
DMI, kg/d	21.1	22.8	1.0	.74
Milk, kg/d	25.4	26.2	.1	.01
Milk fat, %	3.25	3.54	.14	.16
Milk protein, %	3.38	3.40	.04	.84
Fat production, kg/d	.78	.90	.04	.04
Protein production, kg/d	.83	.84	<.01	.19
4% FCM, kg/d	21.6	23.6	.7	.05

[1]Covariate-adjusted means.

[2]Twelve cows assigned to each treatment.

heparinized centrifuge tubes and centrifuged. Plasma was stored at –20°C until analysis for blood plasma components according to metabolic profile (4, 14).

Milk manufacturing properties were evaluated twice weekly; individual milk samples were analyzed for three Formagraph (Formagraph type 11700; Foss Electric) measures: coagulation time, curd firming rate, and curd firmness (1, 26). The samples also were evaluated for creaming capacity (25).

Data from the 4-wk experimental period were analyzed using one-way ANOVA with data from the 2-wk preliminary period as covariate. All data were analyzed using the SAS statistical package (18). The model used was

$$X = \mu + A + B + \text{error}$$

where

X = dependent variable,
μ = mean for the X parameter,
A = 2-wk preliminary period mean for the X parameter, and
B = treatment.

Effects were considered to be significantly different at $P < .05$, and covariate-adjusted means were reported for all parameters.

RESULTS AND DISCUSSION

Milk Production and Composition

The chemical composition of the TMR is given in Table 1. Protein, ADF, and NDF contents of the TMR met or slightly exceeded requirements (13) for cows at the production observed in this experiment.

Body weight and DMI were not significantly affected by the addition of YC to the TMR (Table 2). Similar results were reported in recent studies (2, 8, 10), but, in other investigations (7, 23, 24), supplemental YC increased DMI.

Cows fed YC produced more milk (26.2 vs. 25.4 kg/d; $P < .01$) and 4% FCM (23.6 vs. 21.6 kg/d) than cows fed the control diet (Table 2). In some studies (10, 21, 23, 24), supplemental YC increased milk production in early lactation, but, in other studies (2, 8, 17), no effect occurred in early or midlactation cows.

Milk composition was not significantly affected by diet; however, milk fat percentage was somewhat higher for cows receiving YC than for the unsupplemented cows (3.54 vs. 3.25%; $P = .16$). This probable increase in content of milk fat and the small but significant increase in milk production with YC increased fat production (.90 vs. .78 kg/d). Protein production was not affected by YC.

Changes in milk composition with added YC are in general agreement with those in previous work (9, 10, 21, 23, 24), which showed that dietary YC slightly increased milk fat; contrasting effects were recorded for milk protein, and effects tended to be positive (8, 10, 21). In our experiment, the high milk protein percentage (3.38%) for the control group could explain the lack of beneficial effect of YC on this parameter. The conditions under which the responses of dairy cows to YC are more pronounced are difficult to identify because the previous studies (5, 8, 9, 10, 21, 23,

TABLE 3. Effect of yeast culture (YC) on cheese-making ability.[1]

Item	Dietary treatments[2]			
	Control	YC	SE	$P <$
Creaming capacity, %	62.2	67.1	2.0	.10
Formagraph measures				
Coagulation time, min	15.0	16.7	.9	.30
Curd-firming rate, min	7.8	9.7	.6	.07
Curd firmness, mm	33.2	25.6	2.4	.06

[1]Covariate-adjusted means.

[2]Twelve cows assigned to each treatment.

24) were conducted under different management and dietary conditions. The effects of YC are markedly influenced by stage of lactation and feeding situations (5, 7). Williams and Newbold (22) suggested that YC appears to be more beneficial in high concentrate diets in early lactation. This benefit can be explained by the ability of YC to decrease ruminal lactic acid concentrations and to moderate ruminal pH.

Milk Manufacturing Properties

Creaming capacity and Formagraph measures are in Table 3. Creaming capacity tended to be higher (P = .10) in cows receiving YC, which can be beneficial to dairy processing, such as Parmesan cheese production, in which low milk fat creaming negatively affects the capacity of milk to produce cheese. Coagulation time was not affected significantly by treatment, curd firming rate tended to be higher (P = .10), and curd firmness tended to be lower (P = .10), with added YC. However, the classification of suitability for cheese making based on coagulation time, curd-firming rate, and curd firmness (26) did not vary between control and YC groups and was type A (optimal suitability for cheese making) for both groups.

Ruminal Fermentation

Ruminal pH, ammonia, and VFA patterns are in Table 4. Cows fed YC tended to have lower ruminal pH (P = .08) and somewhat lower ammonia concentrations. In some studies (5, 11), supplemental YC reduced ruminal pH and ammonia, but this result is not in agreement with other investigations (17, 23). Recently, Erasmus et al. (7) reported no differences in ruminal pH and ammonia when YC was added to dairy cattle diets.

Ruminal VFA patterns were not altered by addition of YC (Table 4); however, molar proportion of acetate (63.7 vs. 60.2) and

TABLE 4. Effect of yeast culture (YC) on ruminal fermentation characteristics.[1]

Item	Dietary treatments[2]			
	Control	YC	SE	$P <$
pH	7.20	7.08	.04	.08
NH_3 N, mg/dl	18.5	16.0	1.1	.20
Total VFA, mg/dl	480	509	24	.44
Acetate, mol/100 mol	60.2	63.7	1.5	.17
Propionate, mol/100 mol	24.3	23.3	1.0	.46
Butyrate, mol/100 mol	11.1	10.3	1.2	.66
Acetate:propionate	2.55	2.82	.12	.17

[1]Covariate-adjusted means.

[2]Twelve cows assigned to each treatment.

TABLE 5. Effect of yeast culture (YC) on blood plasma components.[1]

Item	Dietary treatments[2]			
	Control	YC	SE	$P <$
Glucose, mmol/L	3.95	4.20	.12	.18
Cholesterol, mmol/L	5.55	5.42	.12	.49
Urea, mmol/L	6.95	6.10	.59	.41
Ca, mmol/L	2.81	2.78	.06	.77
P, mmol/L	1.74	1.67	.13	.73
Mg, mmol/L	1.14	1.14	.02	.97
Na, mmol/L	153.4	151.4	1.2	.34
K, mmol/L	4.53	4.55	.12	.92
Cl, mmol/L	106.3	107.7	1.5	.56
Zn, mmol/L	13.3	15.2	.8	.14
Ceruloplasmin, μmol/L	2.57	2.90	.33	.50
Total protein, g/L	83.8	87.3	1.6	.15
Globulin, g/L	47.3	50.2	1.9	.33
Albumin, g/L	35.9	37.8	.8	.19
Bilirubin, μmol/L	2.93	2.99	.32	.91

[1]Covariate-adjusted means.

[2]Twelve cows assigned to each treatment.

acetate:propionate ratio (2.82 vs. 2.55) tended to be higher ($P = .17$) for cows consuming YC. Total VFA concentration did not differ between treatment groups.

Higher acetate concentration and acetate: propionate ratio for cows fed YC is in agreement with results from previous studies (16, 19); the effect can be related to an increase in the concentration of the cellulolytic bacteria in the rumen, as suggested by various authors (11, 19, 21), probably as a result of a provision by YC of growth factors for these microorganisms (19, 21). The data of other authors (11, 21, 23) indicate that YC reduces the acetate:propionate ratio. Variable effects of YC on ruminal VFA patterns may reflect differences between studies in time of sampling, feeding pattern, ration composition, and DMI.

Blood Plasma Components

No significant difference occurred in blood metabolites, electrolytes, or enzymes between control and YC groups (Table 5). Blood plasma glucose and Zn tended to be improved (4.20 vs. 3.95 mmol/L; $P = .18$ and 15.22 vs. 13.33 μmol/L; $P = .14$, respectively) by supplementation with YC.

Williams (20) reported that YC acts as a highly concentrated form of Zn in which the element is chelated to components in the yeast cell. A deficiency of Zn may impair conception rate, ovarian function, and disease resistence (20). Improvements in reproductive performance when dairy cows were fed YC (20) may be related to improved Zn status. Further research should be conducted to improve understanding of the effects of YC on Zn status of dairy cows and the possible mechanisms involved.

CONCLUSIONS

The addition of YC in the diet of midlactation Italian Holstein-Friesian cows was beneficial in improving production of milk, 4% FCM, and milk fat. Milk composition and ability of milk to be used for cheese making were unaffected.

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