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A meta-analysis of the effects of feeding yeast culture produced by anaerobic fermentation of *Saccharomyces cerevisiae* on milk production of lactating dairy cows

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ABSTRACT

The purpose of this study was to use meta-analytic methods to estimate the effect of a commercially available yeast culture product on milk production and other production measures in lactating dairy cows using a meta-analysis of randomized controlled trials. Sixty-one research publications (published journal articles, published abstracts, and technical reports) were identified through a review of literature provided by the manufacturer and a search of published literature using 6 search engines. Thirty-six separate studies with 69 comparisons met the criteria for inclusion in the meta-analysis. The fixed-effect meta-analysis showed substantial heterogeneity for milk yield, energy-corrected milk, 3.5% fat-corrected milk, milk fat yield, and milk protein yield. Sub-group analysis of the data showed much less heterogeneity in peer-reviewed studies versus non-peer-reviewed abstracts and technical reports, and tended to show higher, but not significantly different, treatment effects. A random-effects meta-analysis showed estimated raw mean differences between treated and untreated cattle reported in peer-reviewed publications of 1.18 kg/d [95% confidence interval (CI): 0.55 to 1.81], 1.61 kg/d (95% CI: 0.92 to 2.29), and 1.65 kg/d (95% CI: 0.97 to 2.34) for milk yield, 3.5% fat-corrected milk, and energy-corrected milk, respectively. Milk fat yield and milk protein yield for peer-reviewed studies showed an increase in the raw mean difference of 0.06 kg/d (95% CI: 0.01 to 0.10) and 0.03 kg/d (95% CI: 0.00 to 0.05), respectively. Estimated raw mean dry matter intake of the peer-reviewed studies during early lactation (<70 d in milk) and not-early lactation were 0.62 kg/d (95% CI: 0.21 to 1.02) and a decrease of 0.78 kg/d (95% CI: −1.36 to −0.21), respectively. These findings provide strong evidence that this commercially available yeast culture product provides significant improvement in several important milk production outcomes as evaluated in production settings typical for commercial dairies in North America. Utilizing meta-analytic methods to study the complete breadth of information relating to a specific treatment by studying multiple overcomes of all eligible studies can reduce the uncertainty often seen in small individual studies designed without sufficient power to detect differences in treatments.

Key words: yeast culture, meta-analysis, lactating dairy cow

INTRODUCTION

Yeast products are commonly used around the world for inclusion in diets of production animals. It is thought that yeast products affect the rumen microbial population, causing changes in ruminal VFA production that result in increased milk production as well as an increase in milk fat (**FY**) and milk protein (**PY**) yields from lactating dairy cows (Erasmus et al., 1992; Putnam et al., 1997). Increased DMI has been observed in some studies (Dann et al., 2000) and decreased DMI in other studies (Schingoethe et al., 2004). Despite numerous peer-reviewed and non-peer-reviewed studies on the effects of feeding yeast products, the results of these studies in lactating dairy cows appear to be inconclusive. Some studies have identified significant effects on milk production (Harrison et al., 1988; Hippen et al., 2007; Lehloenya et al., 2008; Ramsing et al., 2009); others reported a trend in production (Williams et al., 1999; Dann et al., 2000; Wang et al., 2001) or no significant differences (Robinson, 1997; Schingoethe et al., 2004). Nutritionists, veterinarians, and dairy farmers need to know the efficacy of these yeast products on milk production measures to make appropriate decisions about the use of these products in their management systems.

One possible source of variability is that many trials may have lacked sufficient sample size and consequently

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statistical power to demonstrate differences in the production measures. Lack of statistical power can result in an increased risk of missing a true treatment effect and produce a false-negative trial result—a type II statistical error (Freiman et al., 1978; Egger et al., 2001). Meta-analysis has been proposed as a method to obtain useful summary estimates of effect, especially when numerous small studies have been conducted in different study locations by different researchers using different study designs that, when considered individually, may not provide conclusive evidence of effect (DerSimonian and Laird, 1986; Lean et al., 2009).

Another possible source of variation in response to supplementation of yeast product may be the type of yeast products that are used. Differences exist between active ingredients and putative modes of action of different products. Two main categories of yeast products are commercially available (AAFCO, 2011). Yeast cultures that are produced through yeast fermentation contain fermentation by-products and are not dependent on live yeast for their physiological effects. Rather, the fermentation products contain compounds that affect the growth of various types of rumen bacteria and protozoa (Wiedmeier et al., 1987; Harrison et al., 1988; Callaway and Martin, 1997). In contrast, active dry yeast products (AAFCO, 2011) are products that, by definition, must contain >15 billion live yeast cells/g. The effect is assumed dependent on the yeast cell being alive in the rumen to have a production effect (Dawson et al., 1990; Newbold et al., 1996). A recent meta-analysis by Desnoyers et al. (2009) provides an example of how lack of differentiation among these products is common in the peer-reviewed literature. The aim of the Desnoyers et al. (2009) meta-analysis was to estimate the effects of live yeast supplementation on intake, rumen fermentation, and milk production; however, the study mistakenly included 13 studies of yeast culture mislabeled as live yeast. Differences in both the manufacturing process of specific yeast products and the response of yeast products within different production systems of herds may further contribute to the variability of production responses.

The purpose of this study was to review critically all relevant research specific to only a single manufactured yeast culture product and to estimate the effect of the yeast culture product on milk yield (**MY**), FY, PY, ECM, and DMI of dairy cattle using meta-analytic methods. A secondary objective was to examine the differences in treatment effect and heterogeneity of various study designs (i.e., blinding and randomization) or other factors such as peer review that commonly lead to publication bias or heterogeneity of effect in other meta-analytic studies.

MATERIALS AND METHODS

All published and unpublished papers and reports that studied the effect of commercially available yeast culture products manufactured by Diamond V (Cedar Rapids, IA) that were conducted in lactating dairy cattle before 2011 were obtained from the manufacturer's records. A comprehensive search of English-language published literature was also performed by utilizing 6 search engines (PubMed, Google Scholar, Agricola, ScienceDirect, Scirus, and CAB), with the words "yeast," "cows," and "lactation," to identify other research papers and reports that may not have been provided by the manufacturer.

Inclusion Criteria

All published and unpublished studies in the English language were screened for inclusion in the meta-analysis using standardized criteria. To be included in the meta-analysis, studies must have evaluated at least one of the 3 yeast culture products (YC, XP, or XPC) sold by a single company (Diamond V). The 3 products are equivalent products in manufacturing except for the concentration. The study must have included a concurrent negative control group and randomized treatment assignments (Lean and Rabiee, 2011); must have been conducted in lactating dairy cows (not dry cows or in vitro studies); and must have used a parallel group design (i.e., not crossover). Additionally, studies must have reported results of at least one of the production outcomes of interest: MY, ECM, % milk fat (**F%**), FY, % milk protein (**P%**), PY, 3.5% FCM, ECM, or DMI, along with a measure of variance (standard error or standard deviation) or a *P*-value for comparison of effects between treatment and control groups.

Data Extraction

Data were collated from the eligible studies reporting the effect of yeast culture on production outcomes. In addition to outcome measures regarding milk production, the following data were extracted from the trials for sub-group analysis if the information was present: location of the study (state, country), source of the paper (peer-reviewed journal, conference abstract, or technical report), published in a peer-reviewed journal (yes or no), if an explicit statement about the randomization of treatments was included (yes or no), analytical control for confounders (yes or no), if the treatment application relative to calving date (yes, before calving vs. no), DIM at the start of the trial, stage of lactation for the study period (full lactation, <70 DIM, or ≥70