J. Dairy Sci. 98:1–14
http://dx.doi.org/10.3168/jds.2014-9045

Effects of whole-plant corn silage hybrid type on intake, digestion, ruminal fermentation, and lactation performance by dairy cows through a meta-analysis

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ABSTRACT

Understanding the effect of whole-plant corn silage (WPCS) hybrids in dairy cattle diets may allow for better decisions on hybrid selection by dairy producers, as well as indicate potential strategies for the seed corn industry with regard to WPCS hybrids. Therefore, the objective of this study was to perform a meta-analysis using literature data on the effects of WPCS hybrid type on intake, digestibility, rumen fermentation, and lactation performance by dairy cows. The meta-analysis was performed using a data set of 162 treatment means from 48 peer-reviewed articles published between 1995 and 2014. Hybrids were divided into 3 categories before analysis. Comparative analysis of WPCS hybrid types differing in stalk characteristics were in 4 categories: conventional, dual-purpose, isogenic, or low-normal fiber digestibility (CONS), brown midrib (BMR), hybrids with greater NDF but lower lignin (%NDF) contents or high in vitro NDF digestibility (HFD), and leafy (LFY). Hybrid types differing in kernel characteristics were in 4 categories: conventional or yellow dent (CONG), NutriDense (ND), high oil (HO), and waxy. Genetically modified (GM) hybrids were compared with their genetically similar non-biotech counterpart (ISO). Except for lower lignin content for BMR and lower starch content for HFD than CONS and LFY, silage nutrient composition was similar among hybrids of different stalk types. A 1.1 kg/d greater intake of DM and 1.5 and 0.05 kg/d greater milk and protein yields, respectively, were observed for BMR compared with CONS and LFY. Likewise, DMI and milk yield were greater for HFD than CONS, but the magnitude of the difference was smaller. Total-tract NDF digestibility was greater, but starch digestibility was reduced, for BMR and HFD compared with CONS or LFY. Silage nutrient composition was similar for hybrids of varied kernel characteristics, except for lower CP and EE content for CONG than ND and HO. Feeding HO WPCS to dairy cows decreased milk fat content and yield and protein content compared with the other kernel-type hybrids. Hybrids varying in kernel characteristics did not affect intake, milk production, or total-tract nutrient digestibilities by lactating dairy cows. Nutrient composition and lactation performance were similar between GM and ISO. Positive effects of BMR and HFD on intake and milk yield were observed for lactating dairy cows, but the reduced total-tract starch digestibility for these hybrids merits further study. Except for negative effects of HO on milk components, differences were minimal among corn silage hybrids differing in kernel type. Feeding GM WPCS did not affect lactation performance by dairy cows.

Key words: corn silage, hybrid, meta-analysis, dairy cow

INTRODUCTION

Whole-plant corn silage (**WPCS**) is the predominant forage used by the dairy industry in the United States (Johnson et al., 1999; Klopfenstein et al., 2013) with more than 2.5 million hectares of corn harvested as silage in 2013 (USDA-ERS, 2014). Shaver and Kaiser (2011) reported that forage comprises 50 to 60% of TMR DM in high-producing dairy herds with WPCS comprising 40 to 70% of the forage DM. Therefore, improvements in the nutritional quality of WPCS through hybrid selection can benefit dairy farmers through improved lactation performance or efficiency of feed utilization.

Traditionally, WPCS was produced by planting hybrids with high grain yield characteristics. Conventional or dual-purpose hybrids allow farmers the opportunity to harvest either corn grain or WPCS according to feed inventory needs. More recently, however, farmers are planting and harvesting more silage-specific hybrids with the aim of improved nutritional characteristics of WPCS to address the needs of high-producing dairy cows. Nutritional quality of WPCS can be improved through alterations in stalk or kernel characteristics. Stalk characteristics are usually modified with the aim of increasing the digestibility of fiber in WPCS. This

Received October 30, 2014.
Accepted December 23, 2014.
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has occurred primarily through reduction in the lignin fraction of NDF using brown midrib mutant lines (Jung et al., 2012). Leafy type hybrids, which have more leaves above the ear than other hybrids, are commonly used silage-specific hybrid by farmers and have the advantage of high whole-plant DM yields (Glenn, 2013). Although the stay-green characteristic (**SG**) delays the dry-down of stalks, which is beneficial for grain production (Thomas and Smart, 1993), it also exists in hybrids used for WPCS production in some areas (Arriola et al., 2012a,b). Grain characteristics are altered through modifications in nutrient or starch composition. Change in nutrient composition is usually related to greater CP and fat contents, such as NutriDense or high-oil hybrids, at the expense of starch content. Change in starch composition is related to the selection of hybrids with starch high in amylopectin versus amylose or hybrids with more floury type endosperm (Giuberti et al., 2014).

Genetically modified (**GM**) corn hybrids for insect resistance or herbicide tolerance (Clark and Ipharraguerre, 2001; Faust, 2002) are becoming more important for corn production. These hybrids represented 93% of planted corn in the United States (USDS-ERS, 2014) in 2014. The use of GM corn resulted in enhanced yields and reduced exposure to environmental risks (Shi et al., 2013), and thereby provided economic benefits for farmers in the United States (Hutchison et al., 2010; Nolan and Santos, 2012). Possibly GM corn may also be of benefit to dairy farmers that grow GM corn hybrids for silage production.

Although numerous reports on feeding trials with lactating dairy cows assessing the effects of various WPCS hybrid types can be found, attempts to quantify observed responses do not exist in the literature. A quantitative review may provide information for better decision making on hybrid selection by dairy producers and their nutritionists, as well as indicate potential strategies for the seed corn industry with regards to WPCS. Therefore, the objective of this study was to perform a meta-analysis using literature data on the effects of WPCS hybrid type on intake, digestibility, rumen fermentation, and lactation performance by dairy cows.

MATERIALS AND METHODS

To create a database to be used for the meta-analysis, a literature search was conducted using CAB, Google Scholar, PubMed, and ScienceDirect. The following key words were used: corn, maize, silage, hybrids, varieties, dairy cows, and dairy cattle. References included in the respective papers were also checked. The peer-reviewed articles included in the data set were with lactating dairy cows fed TMR and compared WPCS hybrid types. To avoid confounding factors within trials, only treatment means allowing for hybrid comparisons were used. For example, Kung et al. (2008) compared conventional corn silage harvested at normal cutting height, conventional corn silage harvested at higher cutting height, and BMR corn silage harvested at normal cutting height. The conventional corn silage harvested at higher cutting height was not used. This approach was also used in the following manuscripts: Tine et al. (2001), Moreira et al. (2003), Ebling and Kung (2004), and Akins and Shaver (2014). Despite the 5 to 10 percentage units greater WPCS (DM basis) in BMR diets compared with diets containing other hybrids, the following manuscripts were kept in the data set because this is representative of a common ration formulation practice by dairy nutritionists: Bal et al. (2000; experiment 2), Oba and Allen (2000a,b), Cherney et al. (2004), and Gehman et al. (2008). Subsequently, a data set comprised of 162 treatment means from 54 feeding trials reported in 48 peer-reviewed articles published 1995 through 2014 was used for the meta-analysis (Appendix Tables A1 and A2). Comparative analysis of WPCS hybrid types differing in stalk characteristics were in 4 categories: conventional, dual-purpose, isogenic, or low-normal fiber digestibility (**CONS**), brown midrib (**BMR**), hybrids with greater NDF but lower lignin (%NDF) contents or high in vitro NDF digestibility (**HFD**), and leafy (**LFY**). Hybrid types differing in kernel characteristics were in 4 categories: conventional or yellow dent (**CONG**), NutriDense (**ND**), high oil (**HO**), and waxy (**WX**). Genetically modified hybrids were compared with their genetically similar non-biotech counterpart (**ISO**). Four trials compared a GM hybrid against 2 commercial hybrids in addition to the genetically similar non-biotech counterpart (Grant et al., 2003; Ipharraguerre et al., 2003; Phipps et al., 2005; Castillo-Lopez et al., 2014), and one trial compared CON versus GM at both early and late maturity in 2 trials (Folmer et al., 2002). Thus, the larger sample size for CON than GM hybrids (21 versus 13, respectively). Trials with factorial arrangement of treatments were divided into 2 studies to avoid confounding factors. For example, Gehman et al. (2008) compared a dual-purpose versus a BMR WPCS in diet with or without monensin. In this case, the diets containing monensin were considered an experiment and without monensin another. This approach was used in 18 manuscripts (LaCount et al., 1995; Kuehn et al., 1999; Bal et al., 2000, experiments 1 and 3; Oba and Allen, 2000a,b; Weiss and Wyatt, 2000, 2002, 2006; Clark et al., 2002; Qiu et al., 2003; Fernandez et al., 2004; Taylor and