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Effects of egg yolk inclusion, milk replacer feeding rate, and low-starch (pelleted) or high-starch (texturized) starter on Holstein calf performance through 4 months of age

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ABSTRACT

The objectives of this research were to evaluate milk replacer (MR) feeding rates, alternative protein and fat sources in MR, and calf starter starch concentration and their effects on calf performance to 4 mo of age. Male Holstein calves (42.6 ± 1.2 kg of body weight; n = 192) were assigned at 3 d of age to 1 of 8 treatments in a randomized complete block design with a 2 × 2 × 2 factorial arrangement of treatments. Factors tested from d 0 to 56 (nursery) were low or high MR feeding rates, 0 or 10% inclusion of spray-dried egg yolks in MR, and low- or high-starch calf starter. The low MR rate was 0.66 kg of dry matter (DM) fed for 39 d followed by 0.33 kg of DM for 3 d. The high MR rate was 0.87 kg of DM fed for 5 d, 1.08 kg of DM for 37 d, and 0.43 kg of DM for 7 d. The MR contained 27.5% crude protein and 19.6% fat (DM basis) and starters were 21.2% crude protein; low starch was a complete pellet with 10.2% starch, and high starch was textured using whole corn and oats with 43.3% starch. From d 56 to 112 (grower), calves were randomly assigned to pens (4 calves/pen) maintaining MR rate and starch content while stratifying yolk treatments within pen, resulting in a 2 × 2 factorial arrangement. Starter was blended with 5% chopped hay during the grower trial. Fecal scores and medical treatments were recorded daily. In the nursery trial, calves were weighed initially and weekly thereafter. Hip width and body condition score (BCS) were measured initially and every 2 wk thereafter. In the grower trial, body weight, hip width, and BCS were measured on d 56, 84, and 112. Data were analyzed as repeated measures with calf (nursery) or pen (grower) as the experimental unit. Calf average daily gain, hip width, and BCS change were greater for calves fed high versus low MR, 0 versus 10% yolk, and high versus low starch in the nursery. In the grower trial, calves fed low MR and high starch had the greatest average daily gain (1.09 vs. 0.87 kg/d) and hip width change (5.4 vs. 3.9 cm) compared with calves fed low MR and low starch with other treatments intermediate. From 0 to 112 d, calves fed high MR had 9% greater body weight gain and 4% greater hip width change than calves fed low MR, yet nutrient efficiency was similar despite 80% more MR intake than calves fed low MR. Additionally, calves fed high-starch starter achieved 18% greater body weight gain and 17% greater hip width than calves fed low starch starter overall, a more than 2-fold greater response than the effect of MR feeding rate.

Key words: calf, starch, egg, milk replacer

INTRODUCTION

Many have reported that as more milk or milk replacer (**MR**) is fed, preweaning ADG increases (Bar-Peled et al., 1997; Nocek and Braund, 1986). However, when the amount of milk or MR fed is more than approximately 0.7 kg of DM, postweaning ADG is typically less than when ≤0.7 kg of DM from milk or MR is fed (Hill et al., 2006a,b, 2007, 2010). Reduced postweaning ADG has been thought to be related to less dry feed intake before weaning, but preweaning MR intake has shown mixed effects on DMI immediately postweaning and after 56 d (Hill et al., 2007, 2010, 2013). Less postweaning ADG when feeding more milk or MR may be associated with lesser rumen development (Terré et al., 2007a,b; Suarez-Mena et al., 2011), leading to less digestion of dry feed at and after weaning (Terré et al., 2007a,b; Hill et al., 2010, 2016c; Chapman et al., 2016). Some data suggest calves fed large amounts of milk to achieve more ADG early in life may increase milk yield in the first lactation (Soberon et al., 2012). Other researchers have suggested calves fed more starter and less MR to achieve more balanced early life ADG may also increase potential for more milk in the first lactation (Bach and Ahedo, 2008; Heinrichs and Heinrichs, 2011; Bach, 2012; Gelsinger et al., 2016).

Milk proteins are expensive relative to other proteins due to increased demand for human use (Davis and

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Drackley, 1998) and the use of alternative, lower cost proteins are of interest for calf MR. Egg protein has been shown to have a comparable protein efficiency ratio to milk protein (Schaafsma, 2000), could have utility in MR, and offers a lower cost than milk proteins. However, the success of using egg protein in MR for calves has been mixed. Quigley (2002) reported a linear reduction in ADG for calves fed 10 and 20% spray-dried whole egg (**SDWE**) as a partial replacement for whey protein and animal fat, particularly from d 0 to 28 when no starter was fed. However, Touchette et al. (2003) found 5% SDWE inclusion in MR supported similar or improved ADG compared with all-milk protein, but 15% SDWE inclusion reduced ADG approximately 18% compared with lower inclusions of SDWE. It is unclear why SDWE reduces performance when partially replacing milk proteins, though it may be due to anti-nutritional factors present in egg protein (Quigley, 2002). Some of these factors may be avoided by using spray-dried egg yolk, a co-product of egg white separation for human consumption. Egg yolk is composed primarily of lipids, which make up approximately 61% of the total DM of the yolk and include palmitic acid, oleic acid, linoleic acid, and phosphotidylcholine (Quigley, 2002; USDA, 2015). Protein makes up approximately 35% of the yolk DM and includes lipoproteins and phosphoproteins (Byrne et al., 1989). Use of alternative proteins for MR fed to calves less than 3 wk of age is advised against by NRC (2001) due to difficulties in protein digestion. However, most of the research in neonatal calves where alternative proteins were fed in MR have been with low to moderate (0.44 to 0.73 kg of DM/d) MR feeding rates and formulas with less than 24% CP on a DM basis.

The use of low-starch co-products is prevalent in the US dairy calf feed market (Hill et al., 2012). Quality carbohydrates are required by the young calf because the rumen and other digestive systems are underdeveloped (NRC, 2001). Inclusion of low-starch ingredients in the diet of calves less than 4 mo of age has resulted in reductions in ADG and structural growth (Hill et al., 2008, 2012, 2016a; Suarez-Mena et al., 2011; Terré et al., 2013) likely stemming from low digestibility (Hill et al., 2016a) compared with high-starch feeds. However, these data were collected when feeding calves low to moderate MR feeding rates. Kosiorowska et al. (2011) did not observe interactions of whole milk feeding rate (3.2 vs. 6.4 kg/d) with calf starter starch content (35 vs. 11% starch on a DM basis) on the performance of male Holstein calves, but ADG was improved when milk allowance or starch content were high. It is unclear if the response would be similar when alternative proteins are used in MR.

Most studies evaluating preweaning nutrition in calves do not report performance beyond 1 to 2 wk postweaning. Additionally, even fewer studies have evaluated potential interactions between preweaning and postweaning nutrition on growth in dairy calves. Therefore, the objectives of this research were to evaluate spray-dried egg yolk as an alternative fat and protein source in MR, MR feeding rate, and starch concentration in the starter and their potential interactions on calf performance pre- and postweaning until 4 mo of age.

MATERIALS AND METHODS

All animals were cared for as described in the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (FASS, 2010). Calves were received in 4 blocks of 48 calves 5 wk apart. Calves were purchased from a commercial dairy farm and transported 3.5 h to the Nurture Research Center nursery in southwest Ohio. The nursery consisted of individual calf pens (1.2 m × 2.4 m) with a coarse rock, tile-drained base bedded with wheat straw in a naturally ventilated barn with curtain sides and no added heat. The nursery trial (d 0 to 56) was conducted from January to July where the average ambient temperature in the nursery was 10°C (range from −11 to 32°C) and the average relative humidity was 77% (range from 24 to 100%). The grower trial (d 56 to 112) was conducted from March to September with an average ambient temperature of 18°C (ranged from −1 to 26°C) and an average humidity of 80% (ranged from 24 to 100%).

In the nursery trial, 192 male Holstein calves initially 42.6 ± 1.16 kg of BW and 3 to 4 d of age were assigned to 1 of 8 treatments in a randomized complete block design with 2 × 2 × 2 factorial arrangement of treatments. Factors tested included 2 levels of spray-dried egg yolk inclusion (0 or 10% on as-fed basis; Ballas Egg Products Corp., Zanesville, OH), 2 levels of MR feeding rate, and 2 levels of starch concentration in calf starter (10 or 43% starch on DM basis). The low MR rate was 0.66 kg of DM fed in 2 equal meals twice daily (0630 and 1400 h) for 39 d followed by 0.33 kg of DM fed once daily (0630 h) for 3 d. The high MR rate was 0.87 kg of DM fed in 2 equal meals twice daily for 5 d, 1.08 kg of DM for 37 d, and 0.43 kg of DM fed once daily for 7 d. Milk replacers were formulated to contain 27% CP and 17% fat (DM basis; Table 1) and were diluted with water to 14% DM before feeding. Calf starters were formulated to provide 20% CP (DM basis; Table 2) and were either a complete pellet (10% starch) or textured with whole corn and whole oats (43% starch). Starter and water were offered for ad libitum intake throughout