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Effects of roughage source, amount, and particle size on behavior and gastrointestinal health of veal calves

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ABSTRACT

The European Union 1997 Directive, stipulating that veal calves should be fed a minimum of 50 to 250 g of fibrous feed from 8 to 20 wk of age, is vague. A fibrous feed ration maximum of 250 g has been implicated in welfare issues, namely the occurrence of abnormal oral behaviors and poor gastrointestinal health. Past research suggests that this amount is insufficient to prevent the development of abnormal oral behaviors and enabling good rumen development. Different sources and particle sizes of roughage could lead to very different welfare outcomes. In a 3 × 2 × 2 factorial design, 240 group-housed calves (10 ± 1 d; 46.1 ± 0.1 kg) were fed different roughage sources (straw, maize silage, or maize cob silage; the latter 2 were dried and provided no extra moisture compared with straw) in 2 amounts (250 or 500 g of dry matter per day), and 2 particle sizes (chopped or ground). Roughage was supplemented to milk replacer (MR) from 2 wk after arrival. In addition, 60 calves were fed 1 of 3 additional control treatments: MR only (n = 20), MR plus an iron supplement (n = 20), or MR plus ad libitum hay (n = 20). Oral behaviors were recorded using instantaneous scan sampling at 2-min intervals for 2 h in 3 periods per day, at 12 and 22 wk of age. Calves were slaughtered at 24 wk of age and rumen and abomasal health parameters were recorded. Limited provision of straw resulted in behavior comparable with that from unlimited provision of hay, with reduced tongue playing and oral manipulation of the environment, as well as increased chewing compared with diets with no roughage supplement. Straw prevented ruminal hairballs, but impaired rumen development and increased abomasal damage. A higher ration of roughage increased chewing (12 wk), decreased oral manipulation of the trough (12 and 22 wk) and the pen (22 wk), and increased rumen weight. However, more roughage led to increased abomasal damage for certain parameters. Longer feed particles had no obvious benefits for behavior, but decreased hairball prevalence. Overall, unlimited hay had the highest benefit for both behavior and gastrointestinal health. Adding iron to the MR did not alter behavior or gastrointestinal health compared with MR without iron supplement. This study demonstrated that different roughage sources, amounts, and particle sizes have different effects on veal calf behavior and gastrointestinal health, and hence on veal calf welfare.
Key words: veal calf, behavior, gastrointestinal health, roughage

INTRODUCTION

Surplus dairy calves are generally transported to fattening farms and reared under intensive conditions for the production of veal. To produce the pale-colored meat preferred by consumers, veal calves are fed a diet low in iron, which typically translates to low levels of solid feed relative to milk replacer (**MR**) and, in particular, low levels of roughage. The European Council 1997 Directive (EC, 1997) stipulates that veal calves should be fed a minimum of 50 to 250 g per day of fibrous feed from 8 to 20 wk of age. However, no clarification is made as to which source or particle size of fibers should be fed to veal calves. Moreover, it is unclear whether solid feed amounts stipulated in the European Union (**EU**) Directive refer to DM or fresh product. Previous research has demonstrated that these amounts are insufficient in preventing the development of abnormal oral behaviors in veal calves (Morisse et al., 1999; Mattiello et al., 2002; Webb et al., 2012). These behaviors are thought to mainly result from a frustrated drive to chew and ruminate on solid feed (Veissier et al., 1998). Abnormal oral behaviors in veal calves include tongue playing and rolling; excessive oral manipulation of trough, bucket, and pen structures; sham chewing; and grazing of the

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coat of other calves (Veissier et al., 1998; Morisse et al., 1999; Webb et al., 2012). Abnormal behaviors are generally considered to be an indication of chronic stress and poor welfare (Broom and Fraser, 2007). Abrasive and coarse feed sources, and longer feed particles may increase chewing and rumination, and consequently reduce abnormal oral behaviors in calves. For example, straw seems more effective than beet pulp in reducing abnormal oral behaviors (Mattiello et al., 2002). Moreover, larger amounts of solid feed, kept constant relative to metabolic weight, were shown to improve chewing and rumination (Webb et al., 2012).

The production of veal and especially the feeding strategies used have been implicated in several gastrointestinal health problems (e.g., abomasal damage, poor rumen development, and in some cases the development of hairballs in the rumen; Morisse et al., 1999; Brscic et al., 2011). In a cross-sectional European study, Brscic and colleagues (2011) showed that veal farms that fed more solid feed were associated with a higher prevalence of abomasal lesions. A link between the provision of solid feed and abomasal damage in veal calves was also confirmed experimentally, although MR provision itself can lead to abomasal damage in veal calves (Breukink et al., 1991; Mattiello et al., 2002). It remains unclear whether certain sources of solid feed may be a greater risk for abomasal damage. Straw, grains, straw pellets, and maize silage (**MS**) pellets have been associated with abomasal damage (Breukink et al., 1991; Mattiello et al., 2002; Brscic et al., 2011). Rumen development is affected by the fermentation value of the solid feed, with microbial digestion end products, namely VFA, enabling papillae growth (Flatt et al., 1958). In addition, the physical action of the coarse and abrasive solid feed on the rumen wall increases rumen capacity and muscularization (Harrison et al., 1960; Tamate et al., 1962) as well as reduces the incidence of a condition labeled plaque. Plaque involves a layer of particles and debris being stuck to ruminal papillae, which reduces VFA uptake (Haskins et al., 1969; Suárez et al., 2007). Therefore, different sources of solid feed, differing in fermentation value and physical structure, may have different effects on rumen development. Finally, low levels of solid feed in veal calf diets have been associated with ruminal hairball development, which may impair digestion (Morisse et al., 1999).

This study assessed how different sources, amounts, and particle sizes of roughage might affect the behavior and gastrointestinal health of Holstein-Friesian calves, to provide a basis for an animal-friendly feeding strategy. To quantify the effects of roughage supplementation on behavior and health, a control group fed only MR was included. Roughage supplementation usually involves higher iron intake. Therefore, an additional control group was fed MR only, with an iron supplement. This provided a control for potentially confounding effects of iron intake. Finally, a positive control was included in the design to provide a basis for high welfare in the current study. This group of calves was fed hay (**HY**) in unlimited quantities. Hay provides both structure and fermentable fiber and should minimize abnormal oral behaviors and enable optimal rumen development.

MATERIALS AND METHODS

The study was conducted at the experimental cattle farm of Wageningen University and Research Centre (Lelystad, the Netherlands). All procedures met the terms of the Dutch law for animal experiments, which complies with the ETS123 (Council of Europe 1985 and the 86/609/EEC Directive) and was approved by the Wageningen University and Research Centre Committee on Animal Care and Use.

Animals and Management

Two batches of 150 Holstein-Friesian bull calves (10 $\pm$ 1 d; 46.1 $\pm$ 0.1 kg) were studied in 2 successive experiments, each lasting for 6 mo. Each batch comprised 2 groups of 75 calves housed in separate barns. Each group within each batch comprised 1 pen per treatment. The calves were housed throughout the experiment in the same 3 $\times$ 3-m^2 pens with wooden slatted floors (5 calves per pen). During the first 6 wk after arrival, partitions (allowing visual and tactile contact between calves) were placed in each pen, separating individual animals to minimize cross-sucking and disease transmission. Partitions were removed at 6 wk and calves were group housed until slaughter at 24 wk. The temperature, ranging from 15 to 25°C, was controlled using mechanical ventilation and heating. Calves were given an antimicrobial treatment when they arrived at the experimental facilities (colistin for 10 d and oxytetracycline for 5 d). Blood samples were taken every 4 wk to monitor hemoglobin levels. Calves were injected with extra iron when required to ensure that average hemoglobin levels were above 4.5 mmol/L when slaughtered at 24 wk of age (Table 1). This is the minimum level stated in the EU legislation for veal calves.

All calves were bucket fed with MR twice per day at 0700 and 1600 h following a commercial scheme to produce veal (i.e., starting with 3 L/d, the milk allowance was increased linearly throughout the study to end at 17 L/d). During the first 6 wk, calves were fed starter MR and thereafter, fattening MR (Table 2). The powder-to-water ratio was, on average, 1:8 at the beginning and 1:5.8 at the end of the study. The treat-