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Review Article

Moderated Starch Nutrition for a Sustainable Dairy Industry: A Refined Pragmatic Wisdom

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ABSTRACT

Introduction: Increased cow loss and treatment costs, and reduced longevity and sustainability in the world dairy industry may provide an insight into rethinking the starch feeding in dairy cows. The objective of this mini-review article was to underline the importance of moderated starch nutrition on the sustainable productivity and health of high-producing dairy cows. Increased milk production per cow through both genetic selection and nutritional programs may have led to decreased longevity and higher culling rates in commercial dairy farms. Starch is the primary energy source for lactating dairy cows, supplied mainly by cereal grains such as barley and corn. Feeding higher rates of starch, especially from barley grain with high rumen degradability can lead to health issues such as subacute rumen acidosis, causing economic losses. Reviewing the literature and large dairy herd observations, moderated starch feeding to modern dairy cows without major negative effects on milk yield and cow health should become a new pragmatic wisdom. It is suggested that the short and long-term effects of feeding varying amounts of different starch grains in high-merit dairy cows should be the focus of future research attention.

1. Introduction

Carbohydrates are the main source of energy for lactating dairy cows (about 70% of diet dry matter)[1]. Feeding energy-dense diets to support the energy requirements of high-producing dairy cows is a common nutritional strategy in many farms. However, greater starch loads in the rumen may lead to ruminal acidosis and subsequent health issues[2]. Hence, managing and moderating starch nutrition would be a logical practice to optimize dairy cow productivity and sustainability[2]. In addition, limited starch intake has been recommended to increase dry matter intake postpartum[2,3]. In this review article, a practical perspective was delineated to help optimize dairy profitability and sustainability.

1.1. Starch nutrition dynamics and strategies

Starch is the main component of cereal grains with different inherent features. Cereal grains are different in their starch content and degradability which can impact rumen physiology and animal performance[3]. Corn and barley grains are two main sources of starch in dairy diets. Corn grain contains about 70-75% starch and barley grain contains about 50-55%, reflecting their energy density[3,4]. Starch degradability from corn and barley grains is highly related to the proteinaceous matrix that surrounds starch granules[4]. Given that, corn grain has an extended protein matrix, its degradability is slower than barley grain[4]. Moreover, the processing method (warm vs. cold) has a significant influence on starch availability for the rumen microorganisms and volatile fatty acid (VFA) production[5]. Feeding higher amounts of starchy concentrates is a common practice in many dairy farms to meet the energy requirements of high-producing dairy cows. However, overfeeding starch may predispose cows to metabolic disorders such as rumen acidosis. Decreased dry matter intake (DMI) and milk production and compromised cow welfare via increased prevalence of laminitis are considered as the common consequence of excessive grain feeding in dairy cows[2,5]. Increased rates of cow loss and

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treatment costs, and reduced longevity and sustainability in the world dairy industry may provide an insight into rethinking the starch feeding in dairy cows[2].

Starch degradability has an important role in nutrient availability in the rumen and post-ruminal starch assimilation. In addition, the optimum level of starch in dairy cattle diets is closely related to dietary neutral detergent fiber (NDF), because both affect DMI, milk yield as well as rumen health[6]. Therefore, optimizing starch nutrition for dairy cows is an art that farm nutritionists should develop and practice. Recently, it was suggested that reduced-starch diets may have benefits for dairy cows[7]. Increased milk yield was reported in cows fed a lower starch diet (22.1%) vs. cows fed a higher starch diet (28.3%) in the fresh period from d 1 to 23 post-calving[7]. In another study, increasing dietary starch (DM basis) by replacing corn grain with beet pulp from 17.7% (low starch) to 24.6% (high starch) did not affect the performance of dairy cows on 118 d in milk[8]. Other studies have shown that feeding a higher-starch diet (26.2% DM basis) relative to a lower-starch diet (21.5% DM basis) in early lactation increased raw milk yield; however, energy-corrected milk yield was not different[9]. It is important to note that cows fed the higher-starch diet lost less body condition score (BCS) than those fed the lower-starch diet[7,9]. Greater non-esterified fatty acids and ß-hydroxybutyrate were reported for low-starch-fed cows, indicating greater body fat mobilization and BCS loss in such cows[10]. As such, high-starch-fed cows (27.2 %, DM basis) had reduced systemic inflammation and increased milk production than low-starch-fed cows (25.1 %, DM basis)[11]. Nonetheless, given that grains comprise up to 30-40% of dairy diets (DM basis), feeding higher starch may be risky, especially when rapidly fermentable cereals such as wheat and barley grains are fed[3]. Including a maximum of 35% grains (diet DM) even at high levels of production would be watchful[3]. From a pragmatic point of view, starch inclusion should not exceed 25-28% of diet DM[12].

1.2. Grain type and its relation to grain level

In addition to starch levels, the grain type has a key role in determining starch and NDF concentrations in dairy diets. Furthermore, milk production may be affected by using different grain sources in the diet. It seems that barley grain may provide a more synchronous release of energy and protein than corn grain[13]. It has been demonstrated that microbial nitrogen (N) flow to the duodenum was greater in barley-based diets than in oats-based diet[14]. However, such an advantage may disappear when the rumen pH is below the normal range (< 5.8-6.0) because of increased microbial maintenance requirements and wastage[13]. Increased endotoxin levels due to feeding higher levels of highly fermentable carbohydrates can lead to inflammatory responses, immune dysfunction, and reduced longevity. Such conditions may be exacerbated when barley grain is overprocessed[13]. Reduced rumen pH was observed for cows fed flatly rolled barley relative to those fed coarsely rolled barley[15]. The authors mentioned that starch digestibility had more correlation with rumen pH than with effective NDF intake. In a recent study investigating the effects of feeding wheat grain or corn grain on dairy cows' performance, a wheat-based diet negatively affected milk production[16]. Furthermore, the time period that the rumen pH remained below 6.0 was longer in the wheat-fed cows than in the corn-fed cows. In line with these results, Oba and Allen (2003) indicated that in corn-based diets, when high starch diets are fed to dairy cows (31%, DM basis), reducing starch fermentation rate by choosing a proper processing method such as dry grinding relative to moisturizing may increase milk yield. A recent large dairy herd study by the current authors demonstrated that decreasing dietary cereal grains from 39% to 34% of diet DM increased milk production (unpublished data; Aras-Dam Arsham, CO., Poldasht, Iran). Interestingly, the original diet had 82% barley grain and 18% corn grain (% of total grain); whereas the refined diet had 38% barley grain and 62% corn grain. In accordance with these farm outcomes, relatively replacing barley grain with corn grain and decreasing total dietary grains by feeding more protein may improve high-merit dairy cow performance.

2. Conclusion

Starch levels and sources in dairy diets play significant roles in determining cow health, productivity, and longevity. It seems that even at high production levels, starch is currently overfed to high-merit dairy cows. The higher starch levels, especially when readily fermentable grains such as barley and wheat are fed, may lead to chronic metabolic disorders such as subacute rumen acidosis, causing serious health and productive issues. It is recommended that starch levels should be controlled in dairy diets, particularly when grain types and processing methods are in favor of higher acid production in the rumen and subsequent health issues. Starch nutrition in high-merit dairy cows demands the development and practice of new pragmatic wisdom. Investigating the short- and long-term effects of feeding varying amounts of different starchy grains in high-merit dairy cows requires future research.

Declarations

Competing interests

There is no competing of interest.

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Availability of data and materials

Data from the study are available according to a reasonable request.

Authors' contributions

Akbar Nikkhah led the study and conceptualized, strategized, reviewed, edited, and prepared the final manuscript. The initial draft was developed and prepared by Masoud Alimirzaei. The final manuscript was checked by all authors.

Ethical considerations

The authors have made necessary ethical considerations (e.g., plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy).

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