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Supplementation of Energy and Protein for Beef Cattle, A Literature Review

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Introduction ─ Effects of Supplementation

On cattle production operations, a forage diet often will not provide the necessary nutrients to meet the demands of grazing cattle throughout the year. Therefore, supplementation may be necessary to aid in meeting the demands of production. Bowman and Sanson (1996) defined supplements as feedstuffs added to the base diet to provide nutrients required to support the desired level of production.

Research has shown that supplementation can be an aid in improving the weight performance of grazing cattle. Garces-Yepez et al. (1997) established that supplementation can improve performance when forage alone is not sufficient. They found that average daily gain was greater for growing cattle fed supplements of corn and soybean meal, wheat middlings, or soybean hulls than cattle fed no supplement, and cattle fed supplements lost less body condition than cattle not receiving supplement. Anderson et al. (1988) observed that grazing heifers supplemented with corn or whole soyhulls gained faster than unsupplemented heifers. In other work, supplementation has been shown to aid in improving the reproductive performance of grazing cattle. Houghton et al. (1990) found that when cows are thin at calving and prior to the breeding season, they should be provided a high-energy supplement following parturition to reduce postpartum interval (PPI) and improve pregnancy rate. The authors further suggested that moderate use of low-quality forages during gestation may be possible without a detrimental effect on reproductive efficiency when supplementation is utilized.

Protein and Energy Supplementation

There are numerous classes of supplements, but supplements can essentially be divided into two very broad categories: protein or energy supplements. Protein supplements are added to the basal diet to increase protein supply, and energy supplements are added to the basal diet to increase energy supply.

Energy supplements can be subdivided into two groups: nonstructural and structural carbohydrate supplements. When choosing an energy supplement, it is important to consider the effect the supplement will have on the basal diet. The type of carbohydrate has a major effect on the rate and extent of forage digestion (Bowman and Sanson 1996). Caton and Dhuyvetter (1997) noted that sources of highly degraded fiber such as wheat middlings, beet pulp, and corn gluten feed have generally not reduced forage intake as much as nonstructural carbohydrate-based supplements such as cereal grains. However, when feeding structural carbohydrate-based supplements, it is important to consider the possibility that the supplement may substitute for the basal diet. Substitution was defined by Bowman and Sanson (1996) as the change in forage intake in kg dry matter per kg supplement dry matter fed. Feeding nonstructural carbohydrates may lead to substrate substitution effects. Poppi and McLennan (1995, p. 285) stated: "Energy supply to the rumen can be most effective when there is a fast NH_3 production and a loss of protein. Sugar beet pulp is capable of capturing NH_3, and it is high in digestibility and low in protein. The slower degradation of the fiber may enable better synchrony between energy and NH_3 release. However, the high fiber can lead to substitution effects, and use of these feeds as supplements may be more suitable for basal diets that are low in fiber." Soluble carbohydrates such as starch or sugar may impede cellulose digestion due to factors such as lowered pH, competition between cellulolytic and non-cellulolytic bacteria for essential nutrients other than energy, or use of alternative energy sources by certain of the cellulolytic bacteria (Fahey and Berger, 1988). ∅rskov (1986) found that a small amount of grain (20 to 30% of the diet) produces little or no depression of intake and digestibility of roughages, but a higher level can depress intake to an extent that it is no longer a supplement, but becomes a substitute. In most cases, it is important to insure that the supplement complements the basal diet and does not substitute for it.

Protein Supplementation

Intake Response

Research has shown that protein supplementation may cause positive associative effects in some cases when added to a low-quality basal forage diet. A positive associative effect takes place when the supplement increases total intake or digestibility of the forage. A negative associative effect takes place when the supplement decreases total intake or digestibility of the forage so that the intake of digestible nutrients is less than would be expected from the forage and supplement separately (Bowman and Sanson, 1996). In work on dormant tallgrass prairie, DelCurto et al. (1990) determined that feeding cattle a supplement that was less than 0.6% body weight and containing at least 22% crude protein increased both intake and utilization of this low-quality forage

Performance Response

In certain studies, protein supplementation has been shown to have an effect on cattle weight. Church and Santos (1981) noted that energy consumption of cattle fed soybean meal protein was sufficient to meet or exceed maintenance requirements, but cattle fed liquid supplement did not consume enough digestible energy to maintain body weight. Hennessy et al. (1983) observed that supplementing with protein pellets enabled cattle to increase live weight and maintain body condition, whereas supplementation with sorghum grain pellets did not significantly affect live-weight change. Cochran et al. (1986) fed either cubed alfalfa hay or cottonseed meal-barley cake supplements to cattle grazing fall-winter range and found that the type of supplement did not influence weight. However, supplemented cows were able to gain weight and maintain body condition more effectively than non-supplemented cows.

Energy Supplementation

Intake Response

Intake and digestibility are often depressed when cattle consuming low-quality forages are supplemented with nonstructural carbohydrates such as cereal grains, but low-quality forage intake and utilization has been shown to increase when cattle have been supplemented with fibrous by-product feedstuffs that contain high levels of structural carbohydrates.

Some studies have shown an increase in intake when supplementing with structural carbohydrates. Sunvold et al. (1991) fed dormant bluestem-range forage to beef cattle and found that DM intake increased when steers were fed wheat middlings. However, it was noted that intake does not continue to increase beyond certain levels of supplementation.

Digestibility Response

Sanson (1993) found that average hay dry matter digestibility for lambs fed supplemental beet pulp was 3.7% greater than for lambs fed supplemental corn. It was concluded that the difference may have been a result of an improved ruminal environment for fiber digestion when beet pulp was fed, which was higher in digestible fiber. This finding concurs with work conducted by Poppi and McLennan (1995). However, other studies with corn as a supplement have shown a decrease in forage digestibility. Chase and Hibberd (1987) observed that digestibility of hemicellulose and cellulose decreased linearly as the amount of supplemental corn increased. Additionally, hay and fiber digestibility also decreased as the amount of supplemental corn increased. Supplementation with corn or other concentrate feeds can negatively affect fiber digestion.

Ruminal pH Response

Cellulolytic bacteria and rumen protozoa are affected by low pH brought about by feeding excess concentrates in the diet (Yokoyama and Johnson, 1988).

Performance Response

There have been mixed results regarding energy supplementation and weight gain. Oliveros et al. (1989) found that daily gain increased with corn or wet-corn-bran supplement when fed with a high-roughage, low-quality diet of corn cobs and alfalfa haylage. Anderson et al. (1988) observed that energy supplements tended to increase daily gain in steers grazing bromegrass (a higher quality feed) in the fall, with no difference between soybean hulls or corn. In addition, energy supplementation increased daily gain over the summer grazing period, with no difference among corn, ground soyhulls, or whole soyhulls. Marston et al. (1995) established that cows fed a soybean-hull-based energy supplement gained more body weight during gestation than cows fed a soybean-meal-based protein supplement. Most of the body weight gain occurred during the first two months of supplementation when both forage quality and weather conditions were favorable. Energy-supplemented cows lost less body condition score before calving than protein-supplemented cows, with this advantage continuing throughout the breeding season and until weaning. Cow weight loss from calving to the end of postpartum supplementation was similar for energy- and protein-supplemented cows.

Reproductive Response

Energy supplementation has been shown to improve reproductive performance. However, results appear to be dependent on the timing (pre or post-partum) of supplementation. Clanton and Zimmerman (1970) reported that the level of energy fed during the winter had a large effect on the interval between calving and first estrus, and that heifers fed high-energy rations returned to estrus 90 d sooner than heifers fed low-energy rations. Wiltbank et al. (1962) suggested that feeding supplements pre or post-partum affected different reproductive variables. The level of energy intake in mature cows pre-calving influenced the length of interval from calving to first estrus and the level of energy intake post-calving influenced the conception rate. Wiltbank et al. (1964) suggested that the postpartum level of energy intake is probably more critical than prepartum level when considering total reproductive performance. However, Marston et al. (1995) found that cows fed energy during gestation had greater pregnancy rates than cows fed protein, but the pregnancy rate was not influenced by postpartum supplementation.

Protein and Energy Supplementation

Intake Response

DelCurto et al. (1990) contrasted two levels of supplemental protein with two levels of supplemental energy and found that responses in forage utilization were variable. However, results indicated that increased supplemental protein appeared to be associated with increased forage intake and utilization, whereas increased supplemental energy was associated with depressed intake and utilization. Sunvold et al. (1991) mixed supplements consisting of 60% wheat middlings and various amounts of soybean meal and sorghum grain to provide 15, 20, or 25% crude protein. At the 15% crude protein level, forage intake increased only slightly over nonsupplemented steers. However, at the 20 and 25% crude protein levels forage intake increased. In this study, as crude protein levels increased the amount of sorghum grain supplemented decreased. Sanson et al. (1990) noted that supplementing low-quality forage with corn decreased forage intake, even when the protein requirement was met.

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