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Escape protein supplementation for growing cattle grazing corn residues

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ESCAPE PROTEIN SUPPLEMENTATION FOR GROWING CATTLE

GRAZING CORN RESIDUES

by

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A DISSERTATION

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Metabolizable protein may limit the growing pattern of calves, therefore four trials were conducted to assess the importance of escape protein (EP) supplementation for calves grazing corn residues. Growing calves grazed non-irrigated and irrigated corn residue fields during the 1987 and 1988 fall-winter periods. Cattle were maintained on different methods of feeding, levels and sources of EP supplementation. Animal performance, diet composition and availability and chemical characteristics of several corn residue fractions collected throughout the grazing season were evaluated.

Animal daily gains were not affected by EP (P>.05) during the first 14-21 d of grazing. A positive response (P<.05) to EP supplementation was found the following 15 d. Residual grain was the highest quality plant part component and its daily rate of disappearance from the corn residue field was inversely related with the EP supplementation effect suggesting that corn provided enough metabolizable protein to meet the calf requirements. When two levels and qualities of alfalfa hay were used as sources of supplemental protein, calves still responded (P<.05) to EP supplementation implying that alfalfa was limiting in metabolizable protein.

Crude protein, EP, in vitro DM disappearance and grain content in extrusa samples, collected with esophageally-fistulated steers, decreased (P<.05) in a linear and(or) quadratic manner as the grazing season

progressed. Husk was the highest quality roughage fraction selected by the animals. Disappearance of the leaf blade fraction during the grazing period was associated with weathering damage as well as grazing effects. Stems, leaf sheaths and cobs were not usually selected; however, they may be consumed especially during high snow cover or during overgrazing conditions. Non-irrigated corn residue field parts had higher ($P<.05$) CP, EP and in vitro DM disappearance than irrigated fields and as a consequence, non-irrigated promoted higher ($p<.05$) animal gains than irrigated corn residue fields. Metabolizable protein needs of growing cattle were met when EP was provided. Metabolizable protein was not the first limiting nutrient during the first two weeks of the grazing season.

TITLE

Escape Protein Supplementation for Growing

Cattle Grazing Corn Residues

BY

Erasmo Gutierrez-Ornelas

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DEDICATION

I dedicate this dissertation to my parents, Mr. Erasmo Gutierrez-Cruz and Mrs. Ventura Ornelas de Gutierrez. Their love and hope were always extremely helpful to me during my program.

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TABLE OF CONTENTS

INTRODUCTION

Corn (*Zea mays L.*) is the most common grain produced on the American continent (North, Central and South America) to feed people and animals. About 200 million metric tons of corn are produced in the U.S.A. every year producing a tremendous amount of potentially available energy, as fiber by-products, that can be used in a ruminant feeding system. This energy can be partially recovered when ruminants are fed corn residues. Two approaches are generally used for corn residue utilization: a) feeding harvested, processed residue or, b) grazing corn residues. The first system is used for most of the corn-producing countries; however, corn residue grazing has been more successful in the U.S.A. In the Midwest, residual grain left in the corn residue field after harvest and weather conditions such as snow, wind etc. make a unique grazing system where cows or growing cattle can be wintered.

Crude protein supplementation is required in most corn residue grazing systems. The level of rumen-undegradable (escape) protein must be considered if growing animals are used and if high rates of gain are the objectives. With a corn residue grazing system, the quality of the diet changes rapidly and these changes should be known in order to design an appropriate supplementation program. Level and source of protein supplementation must be related with changes in quality of the diet consumed. During a winter corn residue grazing system, protein and maybe energy should be supplemented.

The objectives of this research were to evaluate the performance of calves grazing corn residues when rumen-undegradable protein was supplemented. Effect of protein supplementation relative to the time of

grazing season is discussed. Rumen-undegradable protein values are presented for different qualities of alfalfa (*Medicago sativa*) hay and plant parts of corn residue. Methods of escape protein supplementation, depending upon the diet quality of the grazing animal, are presented.

LITERATURE REVIEW

1. Corn residues in ruminant nutrition systems.

1.1. Importance and geographic distribution of corn residues.

Corn is the most widely produced grain crop in the U.S.A. (NRC, 1983) and in Central and South America (Kossila, 1985). Large amounts of fiber by-products are available at the end of the season that can be used to feed ruminants. Corn stover is the crop residue produced in the highest amount in the world (Kossila, 1985) and about 50% of its production takes place in North and Central America. Corn residues should be considered in the ruminant feeding system for three reasons: a) to avoid competition with people and non-ruminant animals for grain; b) to feed ruminants during seasonal feed shortages and; c) to make efficient use of the energy since energy contained in both grain and residue can be used.

In most of the areas, corn is used as a primary food energy source for people. A large amount of corn, produced in the U.S.A., is used to feed animals; however, 23% of the 1987 U.S.A. corn production was exported (USDA, 1988) and used as food in countries such as Mexico. Corn grain represents an important source of energy for people and domestic animals and greater competition between food and feed use is expected in the future (FAO, 1989).

Ruminants are likely to be affected by such competition since they are the most inefficient in converting grain into animal products (CAST, 1975). Animals have been affected already in countries like Mexico where feeding corn grain to animals is not permitted. By using corn stover for ruminants, animals became complementary rather than competitors and energy (from grain and residue) is used more efficiently.

Corn residues are generally available during fall and winter thus they help to meet the energy needs of ruminants during seasonal feed shortages. In addition, corn residues do not need to be harvested and stored since no use of land is made at that time. Also, once corn has been harvested, the nutritive value of the residue is not greatly affected by weather (Perry, 1973). When corn residues are collected from the field, their bulky characteristics and market value per unit of weight make transportation uneconomical (NRC,1983) and only local use is feasible.

More efficient energy use of corn by-products is possible since corn residue yield is at least twice that of grain (Kossila, 1984). If corn stover and grain have an energy value of 1.8 and 3.2 Mcal ME/kg respectively (NRC, 1984), 50% of the energy is wasted when residues are not utilized.

Fernandez-Rivera and Klopfenstein (1989b) reported rates of corn residue utilization of 30-50% during grazing. That amount may represent about 25% of the energy recovered and it could be even higher since in grazing situations cattle select the highest quality components of the field such as grain and husks.

Kossila (1985) showed that in 1981 North and Central America produced about 27% of the fibrous crop residues in the world (1.0 trillion of metric tons). United States, Canada and Mexico accounted for 96% of the total production. In these countries, 68.6% of the crop residues were derived from cereal crops (40% from maize), 20% from pulses (leguminous plants), 20% from sugar cane and the rest from other sources. Asia, South

America and Europe produced 54, 24 and 22%, respectively, as much corn residue as North and Central America. Kossila (1984) used different factors, according to the geographic area, to estimate residue production. For corn, the average value was 2.8 units of corn residue produced per unit of grain. The factor used by Kossila (1984) is considerably higher than factors such as 0.6 and 1.0 (Perry, 1973) or 0.8 and 0.9 for irrigated and non-irrigated fields, respectively, (Fernandez-Rivera and Klopfenstein, 1989b) under Nebraska conditions. Corn is more intensively produced in the U.S.A. than in other countries and the proportion of corn stover:grain is smaller than in the rest of the world. Using data from the USDA (1988), the world supply of corn residues has not changed since 1981 even though corn production has been reduced in countries like the U.S.A. and Mexico.

Harvesting, storage and transporting of corn residues increases their costs (Henderson, 1973) and their use may be uneconomical (NRC, 1983). Ruminants and crop residues should be located in the same area. Most of the time it is easier to move animals to the corn residue production area rather than transport the residue.

Illinois, Iowa and Nebraska produce about 50% of the U.S.A. corn production, therefore there is a potential to use corn residues. In the U.S.A., Nebraska is the third and fourth largest producer of corn and beef (cows and steers), respectively, consequently corn residues are important in winter feeding programs. Brazil, Argentina, Mexico and Canada are the next largest corn and beef producers in the American Continent (USDA, 1988); therefore they are in a good position to take advantage of corn residue utilization.

Economics have limited utilization of corn residues in ruminant feeding systems in developed counties where availability of cheaper and better feeding sources is present (Parra and Escobar, 1985). However, economic studies should be conducted in developing countries where ruminants may give those countries an opportunity to produce protein foods using by-products such as corn residues.

1.2. Importance of corn residues in Nebraska.

Use of corn residues in Nebraska is not new. Dowe (1953) recommended wintering of steers and stock cows with low-quality roughage and protein supplementation. Different ways of utilizing of corn residues have depended on the level of knowledge and technology throughout the years. For instance, grazing was the traditional way to use cornstalks by the 1970's but more efficient methods of utilizing corn residues have became available since that time.

Harvesting high moisture corn leaves a corn residue fraction with enough moisture to be conserved as a silage; therefore there was possible to harvest one kind of corn residue known as stalklage (Ayres, 1973). Husklage is another way to harvest corn residue. It is the forage discharged from the rear of a combine during harvesting corn. It consists of husks, cobs and some grain, and it is collected with a straw buncher pulled by the combine. Both products are kept, in most cases, as silage. Stalklage should be harvested immediately after combining because its moisture and nutritive value decline rapidly after grain harvesting (Roth et al., 1988). Collecting big round bales or large stackwagons of dry corn residues was reported by Richey et al. (1982). Less energy is

recovered in such a system because of the losses in DM and lower quality of the material collected.

If harvesting of high moisture corn is not practiced, grazing is still the best way to use corn residues. Clanton (1989) indicated that the use of corn residue for wintering beef cows has increased considerably in the last decade. More recently, grazing corn residues for growing calves has been successfully practiced by Klopfenstein et al. (1987) and Fernandez-Rivera et al. (1989a).

The different corn residue utilization systems have been economically analyzed by Lewis et al. (1988b). Lowest costs of gain were obtained when grazing corn residues. It is obvious that lower economic inputs are provided during grazing; however, a better quality diet may be selected by animals under the grazing system. Therefore, cattle may have higher gains and consequently reduced cost of gain when grazing residues compared to harvesting and feeding the residue. Calf daily gains above 0.3 kg were not recommended by Lewis et al. (1989a) if the cattle were going to summer grass at the end of the wintering phase.

Weather can be considered as the biggest single factor affecting animal performance on corn residue grazing systems in Nebraska. Snow cover is the most important weather factor (Ward, 1978). Clanton (1989) pointed out that muddy fields can limit the grazing ability of the animals. If cattle are allowed to graze in such an environment, forage will be trampled into the mud resulting in wasting of forage and poor animal performance.

Fernandez-Rivera et al. (1989b) developed a computer simulation model in order to consider the complex interactions among weather, forage,

soil, animals, and management that are taking place under a corn residue grazing system. Considering a 250-kg steer grazing corn residue and eating .80 kg of a protein supplement (52% CP), the model predicts daily gains of .46 kg with temperatures of -10^{o}C and no snow cover. That situation is typical in December; however, as temperature goes down and snow cover is present, calf daily gains could be as low as .11 kg with the same temperature and with 10 cm of snow cover. Negative gains (-.20 kg) are predicted at -30^{o}C with 20 cm snow cover. The last two predictions are good examples of environmental conditions in January and February in Nebraska. Fernandez-Rivera et al. (1989b) recommended further research in strategies for protein supplementation, protein energy interactions and role of residual grain in the corn residue grazing system in order to improve the precision of the model.

1.3. Feeding ruminants using corn residues.

Numerous approaches have been used over the past 50 years to utilize corn residues (Bagby and Widstrom, 1987). In addition, today large balers and mechanical stackers (developed for hay) are available to pick up plant residue directly from the field for transport to processing or storage sites (Richey et al., 1982). However, only about one-half of the available residue is really collected.

The most serious problem of using corn residues in ruminant feeding systems is their low quality (Klopfenstein, 1980). Therefore most of the use of low-quality corn residues has been restricted to ruminants on maintenance diets, such as gestating beef cows (Ward, 1978). Klopfenstein et al. (1987) has used corn residues successfully in growing calf diets;

however, inputs such as energy and protein supplementation are needed to promote animal growth.

Harvesting or grazing the corn residue is the first decision that must be made. Klopfenstein et al. (1987) described these options as the high and low input costs. The corn-harvest system in some developing countries consists of cutting the whole plant before the grain has completely dried. The plants are shocked and allowed to dry. Once the grain has dried, it is separated by hand from the whole plant and the corn residue can be fed. In the U.S.A., corn harvest is accomplished using combines. They leave the stalk and about 4.2% of grain production (Fernandez-Rivera and Klopfenstein, 1989b) in the field. Corn residue can be harvested in different ways such as big round bales and large stackwagon stacks (Richey et al. 1982) or as husklage or stalklage (Ayres, 1973). These different products can be processed later and fed to ruminants.

After harvesting, corn residues can be ground (if particle size is still to big) and(or) treated chemically to increase their nutritive value. Although different physical treatments have been reported (Walker, 1984), grinding seems the best physical treatment to improve nutritive value of lignocellulosic residues. Further processes could be performed in ground materials such as pelleting or cubing, but production costs should be carefully evaluated. Beardsley (1964) concluded that when grinding and pelleting an ordinary quality forage (alfalfa), feed intake may be increased by as much as 25%, daily gain by 100% and feed efficiency by 35%. He pointed out that digestibility of individual nutrients in forages may be altered slightly by changing the physical form but the net effect is small. Physical processes reduce crude fiber

digestibility since they produce fine material that may pass through the digestive tract too rapidly for maximum nutrient utilization. Blaxter and Graham (1956) noted that even though digestible and metabolizable energy were depressed after grinding and pelleting of the forage, net energy values were the same when fed on an equal intake basis. In such situations, less heat increment and methane production were observed which was related to a lower proportional production of acetic acid and a higher proportional production of propionic acid. In addition, some carbohydrates could have escaped the rumen and their utilization may be higher in the small intestine.

Distribution of cellulose within the cell wall and its structural relationship among the various cell wall constituents play an important role during the cellulose degradation (Cowling, 1975; Paterson, 1989). Cowling (1975) considered those factors likely to affect the accessibility of cellulose to chemical reagents, extracellular enzymes or other metabolic catalyst of cellulolytic organisms. Riquelme-Villagran (1988) pointed out that fiber diameter is very small compared to its length, and exposing the cut ends by grinding increases the surface area only by the cross section of the fibers. Regular milling techniques hammer or blade mills reduce particle size but the actual amount of cellulose exposed by these method is only slightly increased, because of the length-width relationship of fibers (Walker, 1984). High-energy grinding systems, such as vibratory ball milling, must be used in order to improve DM digestibility of cellulosic materials (Millet et al. 1975).

Another high input cost into harvested corn residues is their chemical

treatment. In most cases, chemical treatment is performed on ground, harvested residues, so chemical treatment adds other costs to the by-product. The specific method of treatment and its effect on the nutritive value of corn residues and other straws has been discussed in depth by Klopfenstein (1978; 1980), Klopfenstein and Owen (1981), Owen (1978), Sundstol and Owen (1984) and Oliveros (1987). In contrast with physical treatments, chemical treatments, such as sodium hydroxide (NaOH) and potassium hydroxide (KOH), increase DM digestibility of corn residues enhancing animal feed intake and performance. Ammonium hydroxide (NH_4OH) and calcium hydroxide [$Ca(OH)_2$] provide additional nutrients such as N and Ca during their treatment. Klopfenstein (1980) concluded that the modes of action of chemical treatment include: 1) solubilization of hemicellulose; 2) increasing the extent of cellulose and hemicellulose digestion and, 3) increasing the rate of cellulose and hemicellulose digestion possibly by swelling.

Walker (1984) hypothesized that chemical and physical treatments could be complementary in improving nutritive value of straws. Although it is partially true, grinding may reduce the positive effect of chemical treatments due to the faster rate of passage in finely ground roughages. When Carmona and Greenhalgh (1972) sprayed NaOH (5.5% of DM) on chopped and coarsely milled barley straw, similar OM, ADF and cellulose digestibilities were recorded for both the chopped and coarsely milled straw within either chemically untreated or treated straw. However, the increase in intake of untreated coarsely milled straw in comparison with the chopped straw was 35.5% whereas in chemically treated straw, intake was increased only 9.7% due to the physical treatment. Feed intake of

chopped straw was increased 35.5% and 80.5% due to further physical (coarsely milled) or chemical treatment, respectively. It was observed that chemical treatment promoted higher intakes than physical treatment. A similar response occurred with live weight gains (Pirie and Greenhalgh, 1977; Klopfenstein et al., 1990). Therefore, extra physical treatment may not be required when chemical treatment is applied.

Grazing corn residues using beef cattle has been recognized as a good management practice many years ago. Henderson (1973) and Klopfenstein et al. (1987) indicated that grazing is the most economical way to use the corn residues. Richey et al. (1982) harvested two-thirds of the available corn stover in the field when they set the harvest machine at about 7.5 cm above the ground surface. They pointed out that furrows may make it necessary to increase the cutting height and increase the losses of corn stover during harvesting. Although there are no data, it seems improbable that dropped ears left in the field could be recovered during the harvest of corn residues; therefore, grazing is the best and cheapest way to recover the grain left on the ground. Clanton (1989) related the nutritive value of corn residues with the amount of grain left in the field which may be affected by the number of dropped ears before harvest, weather conditions at harvest and harvesting procedures.

The need and method of integrating crop residues into beef cow management has been described by Ward (1978). The use of cool and warm season grasses along with winter grazing of crop residues can result in year-round grazing except for times of excessive snow cover during winter months. Klopfenstein (1983) used a similar approach but with growing