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FINAL REPORT

PROJECT NO. I-292-80

The Conversion of Straw into a Concentrate-Like Feed

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ABSTRACT OF THE REPORT

The possibility of converting wheat straw into a highly-available concentrate-like feed for ruminants, by using the SO_2 mild treatment or the combined SO_2 +cellulase treatment, has been explored in this project. It was found in a preliminary study [1st annual report] that the optimal application range of SO_2 is 3-5 g per 100 g straw DM and the treatment should be continued for 72 h at 70°C . The SO_2 pretreated straw can be titrated by NH_4OH to reach the desirable pH for enzymic saccharification. Optimal straw DM content and T.virido cellulase application were found to be 20% and 20 FPU per g, respectively, to produce a product of 75% cell solubles and 25% residual cell walls, [1st and 2nd annual report]. The SO_2 treatment solubilized the cell wall of the straw reducing its content from 80 to 55-52% and increasing the in vitro digestibility of organic matter from 45 to 80%, and of total monosaccharides from 56 to 90%. To prove the general effectiveness of the mild SO_2 treatment, straws from several wheat cultivars including soft and hard, semi-dwarf and dwarf varieties were treated with SO_2 . The effect of treatment on cell wall composition and in vitro digestion has been confirmed and it is suggested that the SO_2 mild treatment is generally effective in increasing the degradability of wheat straw by rumen microorganisms. SO_2 treated straw has been fed to sheep in a preliminary digestion trial and was readily accepted by the animals, but the organic matter digestibility of the straw was increased to only 65%. A second in vivo experiment has been conducted with sheep cannulated in the rumen and at the duodenum and fed four diets: three straw based diets, untreated, SO_2 treated and SO_2 +cellulase treated, and a fourth, concentrated diet which served as a reference. The fermentability of the SO_2 +cellulase treatment was remarkably increased as evidenced from the rumen VFA profile and microbial activity. The digestibility of total monosaccharides was increased from 63% up to 90% by both treatments. The SO_2 treatment supplied the largest quantity of absorbable amino acids to the intestine. The SO_2 +cellulase treated straw did not show any nutritional advantage over the SO_2 treated straw. In terms of carbohydrate digestibility and fermentability the saccharified straw is very close to a concentrate feed but as compared with barley it contains 25% less carbohydrates. Eight straw and forages and their ammoniated or alkali-treated products were evaluated by laboratory procedures by the American partner, involving saponification and determination of optical density [OD] of alkaline extract. Saponification values appear to be a good measure of efficiency of treatment and are equally applicable to alkali and NH_3 treated materials. On the other hand, OD of extracts was better correlated with digestibility in untreated forages.

OBJECTIVES OF THE RESEARCH

In order to maintain the intensive level of production of the ruminant industry, there is an urgent need to find out local and cheap alternatives for the expensive and imported starchy feed. about 1,300,000 tons [DM] of cellulosic waste materials containing 60-70% carbohydrates, are being annually produced in our country. The conversion of the appropriate cellulosic sources by a chemical or a combined chemical+enzymatic treatment into a concentrate-like feed, might resolve the problem. We have previously shown that up to 60% of the organic matter of wheat straw can be converted into reducing sugars by a combined process that includes pretreatment with SO_2 under mild conditions and enzymatic hydrolysis with *T. virido* cellulase. When examined in an artificial rumen system, the saccharified straw manifested a digestion pattern, typical of a highly fermentable feed and comparable to a starchy mixture.

The objectives of the research were:

1. To examine and to find out the optimal set of conditions for the SO_2 treatment and the combined SO_2 +cellulase treatment.
2. To study the effect of treatments on the composition of cell wall constituents and to assess the fermentability and overall degradability of the treated straws by rumen microorganisms.
3. To assess the nutritional value of the SO_2 and SO_2 +cellulase treated wheat straw with sheep cannulated in the rumen and at the duodenum.

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COOPERATION

Dr Mary Mandels of Natick Massachusetts was supposed to be the original cooperator on this research. Unfortunately, her cooperation has been administratively prevented, the definite decision being given during the first year of the project. Therefore I had to find a new American cooperator, and was lucky to have the agreement of Prof. P.J. Van Soest of Cornell, Ithaca, N. Y. to join the research. Prof. Van Soest had begun his part of the research at the end of the second year and visited our lab twice during January and October 1983. During his visits we discussed analytical issues associated with CW fractionations, a field in which Prof. Van Soest is specialized. He also gave us, to the scientific and extension community, several excellent seminars.

The group of Prof. Van Soest was involved in studies concerning the plant cell wall chemistry and its surface properties as well as in developing laboratory methods for the evaluation of treated straw. Both subjects are of a major importance to the understanding of the phenomenon of microbial digestion of plant cell walls and to the precise and fast evaluation of treated straw. Present methods tend to overestimate the in vivo results. Therefore, the contribution and cooperation of Prof. Van Soest was very important for the project, and provided valuable information to the general field of lignocelluloses.

At the end of the 3rd year I have visited the lab of Prof. Van Soest at Cornell, and general issues of cooperation including the final report have been discussed.

BENEFIT TO AGRICULTURE

Straw contains about 60% carbohydrates and should be considered as a potential energy source for ruminants. However the existing and widely researched methods of alkali treatment [by NaOH or NH_3] do not offer any feasible option to the intensive ruminant industry. The main drawback of those methods is expressed in a negative associative effect on straw digestibility while fed together with concentrates. The SO_2 mild treatment presents a new approach which might open the way to involving treated straw into intensive ruminant rations. This appreciation is based on effects elicited by the SO_2 treatment, including:

1. Massive cell wall solubilization, increased digestibility and fermentability of carbohydrates, and consequently an increased intake of energy.
2. SO_2 treated wheat straw is an efficient energy contributor for the synthesis of microbial biomass in the rumen.

The present phase of the research was dedicated to verification of treatment conditions and to nutritional evaluation of the SO_2 and SO_2 +cellulase treated straws. A continuation into the production-performance phase is required to set the proper conditions for involving the SO_2 treated wheat straw into intensive ruminant diets.