The Effectiveness of Proteferm® as a Pellet Binder.

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Key Findings:

- **Proteferm added at 5 or 10% improved pellet durability compared with lignin.**
- **No steam is required to produce pellets when Proteferm is added.**

Summary

Two trials were conducted to determine the effectiveness of Proteferm® as a pellet binder for typical ruminant feed supplements. In trial one, Proteferm® was added to formulas at two levels, 5 & 10%, and compared with lignin sulfonate and a control diet without a pellet binder. All treatments were pelleted with and without additional steam conditioning. Adding Proteferm® produced pellets without steam, while formulas without Proteferm® could not be pelleted without additional steam conditioning. Pellets produced with either 5 or 10% added Proteferm® were 8% more durable than those produced with steam and lignin sulfonate. Pellets produced with no binder were intermediate in percent durability compared with lignin sulfonate and Proteferm®. Trial two consisted of two treatments, comparing Proteferm® with lignin sulfonate in high urea feed formulas. Both treatments resulted in very high quality pellets (98.1 and 98.7 PDI for lignin and Proteferm®, respectively). The propensity to 'clump' or sticking together of pellets was not objectively measured but observations were made. Both hot and cool pellets were less likely to clump with lignin sulfonate compared with Proteferm®.

Proteferm® can be used as an effective pellet binding agent to produce more durable, higher quality pellets while adding valuable nutrients to the feed formula and reducing or eliminating the need for steam conditioning. Feed

clumping problems associated with high urea formulas may be worsened with addition of 5% Proteferm. This tendency was not present in non-urea formulas.

Introduction

Liquid pellet binders have the potential to improve pellet quality and durability because of their cohesive properties. Earlier research has shown Proteferm® to be an effective pellet binding agent. This trial was conducted to compare Proteferm® to lignin sulfonate as a binding agent and to measure the degree of shrinkage due to moisture loss. Work by others has shown that moisture added to the mash, cold, as a conditioner is more bound compared with moisture added during steam conditioning which is more free to migrate.

Procedure

Trial one. The experiment was designed as a 2X4 factorial with four binder treatments (5 & 10% Proteferm®, lignin sulfonate, and control) and two levels of steam (with or without). The experiment was conducted using a laboratory sized, California Pellet Mill. The die bore size was 4.4 millimeters (.17 inches). The experimental formulas are given in Table 1.

Table 1. Composition of experimental formulas. Grams / 100 grams, as is basis.

	5% Proteferm	10% Proteferm	Lignin Sulfonate	Control
Soybean meal	70	65	73.75	75
Wheat midds	8.75	8.75	8.75	8.75
Calcium carbonate	5	5	5	5
Dicalcium phosphate	8.75	8.75	8.75	8.75
Salt	2.5	2.5	2.5	2.5
Proteferm®	5	10		
Lignin Sulfonate			1.25	
Dry matter	87.20	86.19	91.24	91.19
Crude Protein	34.30	34.05	34.28	34.55

Each treatment formula was replicated three times. Formulas were mixed in 25 lb. batches and the binding agents were added at the mill immediately prior to pelleting. Pelleting runs were alternated between treatments to eliminate any variation in pelleting quality by the machine due to time of day or length of use. Samples were taken of the feed mash prior to pelleting, of the hot pellets during pelleting, and of the pellets after they had reached ambient temperature (70^{o}F). Moisture content of the mash, hot pellet, and cool pellet samples was determined by drying in duplicate, approximately 35 grams in a 140^{o}F oven for 48 hours. Samples of cooled pellets were taken to Sure-Tech Laboratories in Fort Dodge, Iowa for analysis of pellet durability. Each sample was tested in duplicate using a number 4 mesh screen and following the standard procedure set forth by the American Society for Testing and Materials. Treatment means were compared using a two-tailed t test.

Trial two. Table 2 lists the ingredients used for each treatment. The same procedure was followed as in trial one. Both treatments were pelletized without additional steam conditioning and very good quality pellets were produced with very few fines.

Table 2. Composition of Experimental Formulas, Trial Two.
Grams / 100 grams, as is basis.

	Lignin sulfonate	5% Proteferm
Soybean meal	25.0	25.0
Wheat midds	31.9	27.5
Calcium carbonate	22.0	22.0
Dicalcium phosphate	4.85	5.5
Salt	5.0	5.0
Urea (46%)	10.0	10.0
Proteferm®		5.0
Lignin Sulfonate	1.25	
Dry matter	93.3	90.0
Crude Protein	45.6	46.8

Results

Trial One. The control and lignin sulfonate formulas would not form pellets without additional steam conditioning. Five percent Proteferm® with steam formed pellets similar in durability to those produced without steam (Table 3.). All Proteferm® treatments produced more durable pellets compared

Table 3. Pellet Durability Index Scores of Different Pellet Binder Treatments, Trial One. (%).

	5% Proteferm	SEM	10% Proteferm	SEM	Lignin Sulfonate	SEM	No Binder	SEM
No Steam	96.85[a]	.40	97.0[a]	.15	-		-	
Steam	97.41[a]	.32	-		89.78[b]	1.8	92.7[ab]	3.6

[ab]Means without common superscripts differ (P<.10).

with lignin sulfonate (P<.10). The control treatment resulted in pellets which were intermediate in durability compared with Proteferm® or lignin sulfonate. Ten percent Proteferm® and steam formed some pellets; however, the mill which was used for this experiment was unable to handle this mash as the die kept plugging up. No sample was taken because the small amount of pellets actually produced may not have been representative of the real characteristics of this formula. A larger sized mill with better rollers would not likely experience the same difficulty. Pellets produced with Proteferm® were far less variable in durability compared with lignin sulfonate or the control, as indicated by the standard errors.

Table 4 lists the dry matter content of each treatment at the mash, hot pellet, and cooled pellet stages. These measurements were made to evaluate the migration of moisture (shrinkage) within each treatment. The dry matter content of the mash for each Proteferm® treatment was taken after the addition of Proteferm® and the mash dry matter values for lignin sulfonate and control were measured before steam conditioning. There was no measureable loss of moisture for 5% Proteferm® without steam; however, 10% Proteferm® tended to lose some weight during cooling. Lignin sulfonate appeared to retain moisture from steam better than the control while the 5% Proteferm® with steam was intermediate compared with the other two Proteferm® treatments. Steam

conditioning added an average of 2.1% moisture to the control and lignin sulfonate treatments, but only .7% to the 5% Proteferm® treatment. This may have been due to the Proteferm® treatment being pelletized faster and spending less time in the conditioning 'barrel', although no measurements were made of this. Even though all measured shrinkages were reasonable and within generally accepted levels, the addition of 5% Proteferm® for use as a conditioning aid and pellet binder appears to reduce shrinkage.

Table 4. Effects of Pellet Binders Upon Dry Mater content and Weight Loss Due To Moisture Migration.

	No Steam		Steam Added		
Item	5% Prot.	10% Prot.	Control	Lig. Sulf.	5% Prot.
Mash, DM%	89.7	87.2	91.8	92.1	89.5
Hot Pellet, DM%	89.2	86.7	89.7	89.8	88.8
Cool Pellet, DM %	89.8	88.5	91.4	90.4	90.0
Shrinkage[a], %	0	1.25	1.69	0.60	0.54

[a]Shrinkage = weight loss due to moisture loss between time of conditioning (addition of Proteferm® or steam) and cooled pellet.

Results

Trial Two. Table 5 lists the durability of the pellets made with each treatment. The 5% Proteferm® treatment produced pellets which were statistically more durable (P=.001) than lignin sulfonate, but not different from a practical standpoint. The pellets were very uniform within both treatments and standard errors were low. It was observed that high urea pellets made with Proteferm® were 'stickier' and had a greater tendency to adhere to one another compared with those made using lignin sulfonate. Both formulas were 'sticky' after pelleting, due to the high level of urea used. Table 6 lists the dry matter content of the mash, hot pellet, and cool pellet for each treatment. There was no migration of moisture in either treatment.

Table 5. Pellet Durability Index Scores of Different Pellet Binder Treatments, Trial Two. (%).

	Lignin Sulfonate	SEM	5% Proteferm	SEM
No Steam	98.1[a]	.06	98.7[b]	.01

[ab]Means without common superscripts differ (P<.05).

Table 6. Dry Matter Content of Mash, Hot Pellets and Cool Pellets. (%).

	Lignin Sulfonate	Proteferm
Mash	93.4	91.7
Hot Pellet	92.4	91.0
Cool Pellet	93.4	91.4

Conclusion

Addition of Proteferm® to feed formulations at either 5% or 10% of the total formula, tended to increase pellet durability and reduce shrinkage of the final product due to moisture loss. In trial one, the control treatment produced pellets which were numerically higher, but not statistically different in durability compared with lignin sulfonate. This result was not expected and was probably due to experimental error (Type I). When the control treatment was attempted to be pelleted without steam, no feed agglomeration occurred. However, lignin sulfonate was able to form just a few pellets (less than 15%) without steam, indicating its adhesive properties compared with the control. Proteferm® should not be used in high urea formulas. Although pellet durability is very high, the likelihood of pellets clumping together is increased. There is no problem in low NPN formulas with stickiness of pellets made with Proteferm®. The 5% Proteferm® pellets were actually 'shinier' with a smoother, glossier outer coating compared with the control and lignin sulfonate pellets.

Discussion

Binding of particles in agglomerated feed pellets is a combination of solid-solid bonds between diet ingredient particles, capillary forces between water, air and solid material, adhesive and cohesive forces between ingredient particles and binders, and interactions between particles due to folding and plying. Solid-solid interactions consist mainly of crystallization and the bonds are established mainly during the cooling process. Interactions due to folding and plying occur particularly in fibrous ingredients where the particles are folded and plied around each other. Liquid binders such as Proteferm, play a role in capillary type binding as well as adhesive or cohesive forces. Pellets are porous and consist of three distinct phases, solid, liquid and air, which interact with each to form structural integrity. The liquid phase forms bonds between ingredient particles which are dependant upon the surface tension of the binding liquid and the radius of the feed particles. Pellets consisting of ingredients with smaller particle sizes are harder and more durable and liquids with higher surface tensions than water contribute to stronger bonds. Viscous materials such as Proteferm® tend to adhere ingredient particles together, thereby increasing solid-solid bonding interactions.