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Barley Straw Initiative

Project No. 11002 INT

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Value-Added Agriculture through Technology

Purpose

There is a demand for barley straw as an odor control mechanism; however, transportation issues limit the use of it as a marketable product. The purpose of the project is to explore whether barley straw can be pelleted, and if so, develop the pelleted product in a way that preserves the natural odor control enzymes and properties of the barley straw and allows for an effective, marketable odor control product that can be easily transported/stored and floats.

Goal

The Minnesota Barley Growers Association continues to receive phone calls from municipalities, airports, and industry seeking barley straw for multiple applications ranging from odor control to water clarity.

The transportation cost of a low density fiber prohibits market opportunities for barley straw in Minnesota. The Barley Straw Initiative focused on producing a barley straw pellet with various bulk densities to improve transportation economics. Secondly, if barley straw could be successfully pelleted at various densities, to evaluate fiber performance in forming a matt cover over a body of liquid. Third, evaluate the pelleted barley straw's ability to control odor as compared to utilizing ground barley straw only.

Preparation and Ingredients

Round bales of barley straw were obtained from Northwest Minnesota and supplied to AURI's Co-Product Pilot Lab facility in Waseca, Minnesota. The barley straw was processed on an Agri-Val bale shredder to obtain particle lengths of less than 6". The straw was then processed in two passes utilizing the 25 Hp Roskamp Champion hammer mill (Picture 1 & 2), operating at 3,600 rpm. The first pass was through a ½" diameter hole screen (#32) followed by a second pass through a 3/16 inch hole screen (#12), utilizing pneumatic air assist. The final pass was to obtain a fiber particle size appropriate for pelleting.

Picture 1 – Roskamp Champion Hammer Mill

Testing- Pellet Development and Durability

Pelleting research was conducted on a 60 Hp California Pellet Mill, Model 1112-4 (Picture 3), using two different pellet die compression ratios. Compression ratio is the effective die thickness divided by the diameter of the pellet produced. The pellet dies utilized were a ¼ inch diameter hole die with a 5:1 compression ratio (1.25 inches effective) and a ¼ inch diameter hole die with a 7:1 compression ratio (1.75 inches effective).

Picture 3 -1112-4 Model California Pellet Mill in AURI's Pilot Lab

Various volumes of steam were utilized in five pellet runs conducted. Steam was generated on an electric, high pressure, 5 Hp, Chromolox steam boiler at 65 psi.

Moisture additions ranging from 7.9% to 13.8% from steam were included in the test blends to aid in pellet quality and durability. *Note: The moisture addition of 13.8% is much greater than what is typically required. This was due to developing a high fiber pellet with various bulk densities and durability for research purposes. Initial barley straw moisture was 6.2%; this is extremely low for pelleting thus requiring increased additions of moisture.* An increase of 100 degrees Fahrenheit in pelleted material temperature is the minimum temperature increase desired.

Final information obtained included pellet durability and bulk density. Pellet durability testing was conducted on a Kansas State Pellet Durability Tester. This test involves cutting off a 500 gram sample, tumbling it for 10 minutes at 50 rpm. and sieving the test sample on a screen specific for the pellet diameter. Sieving conducted involved a Tyler #3.5 screen for sieving ¼ inch diameter pellets. Pellet durability is then calculated by dividing the remaining pellets after sieving by the initial starting weight, which was 500 grams.

Results of all pellet development and pellet durability are displayed in Table 1.

Table 1- Pellet Development Testing Results

Product	**Start Temp (pre-pellet)**	**Finish Temp (out of mill)**	**Amp Load** **(16 amp idle speed/65 amp full load)**	**Added Moisture (pre pellet) S=steam W= water**	**Dry Pellet Moisture**	**Pellet Durability**	**Pellet Density (lbs. Ft3)**	**Pellet Die Utilized** Hole diameter X compression ratio
Test **A** – Barley Straw ¼" X 5:1 - 1	64 F	182 F	28 Amps 8% feeder speed	12.8% S	11.8%	97%	38.1	¼" X 5:1
Test **B** – Barley Straw ¼" X 5:1 - 2	64 F	178 F	25 Amps 16% feeder speed	13.3% S	11.5%	95%	34.9	¼" X 5:1
Test **C** – Barley Straw ¼" X 5:1 - 3	64 F	188 F	36 Amps 20% feeder speed	7.9% S	10.5%	90%	30.8	¼" X 5:1
Test **D** – Barley Straw ¼" X 7:1	67 F	154 F	19 Amps 16% feeder speed	13.8% S	7.8%	84%	42.1	¼" X 7:1
Test **E** – Barley Straw ¼" X 7:1 - 3	67 F	148 F	26 Amps 10% feeder speed	10.6% S	7.7%	89%	42.1	¼" X 7:1

Five different pelleted barley straw samples were produced all having adequate pellet durability and density. The three pellet samples produced on the lower, 5:1 compression ratio pellet die, resulted in pellets with lower densities, although all three of these product samples had greater pellet durability than pellets produced on a 7:1 compression ratio die. The 7:1 compression ratio die produced a greater density pellet with a slightly less durable pellet. Typically, density and pellet durability coincide with each other; however, in this test we saw variability due to varying moisture levels used during pelleting.

The research mentioned above addressed the first and second goal of the initiative that included producing a barley pellet with varying bulk densities, yet adequate to optimize transportation. This generally requires a product with minimum densities of 12-17 pounds per cubic foot. The second goal was to develop pelleted barley straw with various densities and durabilities. This was achieved. Densities ranged from 30.8 to 42.1 pounds per cubic foot, which is a 26.8% difference in density. The significance of various densities and pellet durabilities is to identify the ability and rate of the pellet to breakdown in the presence of liquid, and form a mat covering.

The four barley straw examples utilized in the experiments are shown below (Picture 4). They include: loose barley straw ground on a ½" hole hammer mill screen, a low density pellet (30.8 lbs/ft^3), a mid density pellet (38.1 lbs/ft^3), and a high density pellet (42.1 lbs/ft^3).

Picture 4 – Barley straw and densified straw pellets utilized for testing

Top left – loose barley straw ground on ½" hole screen with hamermill
Top right – low bulk density barley straw pellet (30.8 lbs/ft^3)
Bottom left – mid bulk density barley straw pellet (38.1 lbs/ft^3)
Bottom right – high bulk density barley straw pellet (42.1 lbs/ft^3)

Testing- Pellet Performance on Odor Control

The third goal of the initiative was to evaluate the pelleted barley straw's ability to control odor as compared to utilizing ground barley straw only.

AURI conducted two tests involving liquid dairy manure and water with 300 milliliters of ammonia hydroxide added to approximately three gallons of water. The pails were filled with manure or water to a level six inches from the top of the pail. The goal of this test was to evaluate the pelleted barley straw's ability to control odor as compared to utilizing ground barley straw only.

A Qrae ammonia meter (Picture 5) with a pump was used to evaluate ammonia levels being emitted by the test containers. AURI utilized a Jerome meter (Picture 6) to also evaluate hydrogen sulfide control. ***Note: There was no hydrogen sulfide levels detected at a measurable level.***

Picture 5 – Qrae ammonia meter

Picture 6 – Jerome meter for hydrogen sulfide testing

Testing for ammonia control was conducted at multiple times beginning on day 1 and continuing until the day 32. During the initial testing, AURI utilized Dragger brand ammonia test tubes and pump to capture ammonia levels emitted from the top of the pail. Due to inconsistency in data and concern for accuracy, AURI began utilizing the Qrae ammonia meter at day 12 through day 32. To improve gathering an ammonia level at a steady state without the effect of surrounding wind currents and other factors, the test pails were covered with a lid equipped with a hose leading to the ammonia pump for five minutes until stable data was observed.

Following are the results and trends in barley straw performance on controlling ammonia:

Table 2 - Ammonia Control in Liquid Dairy Manure

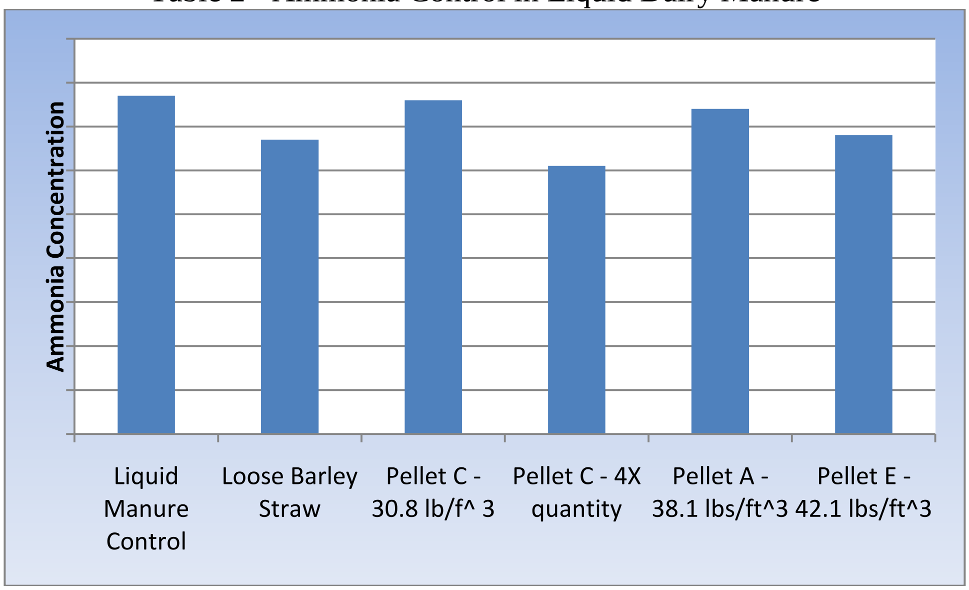
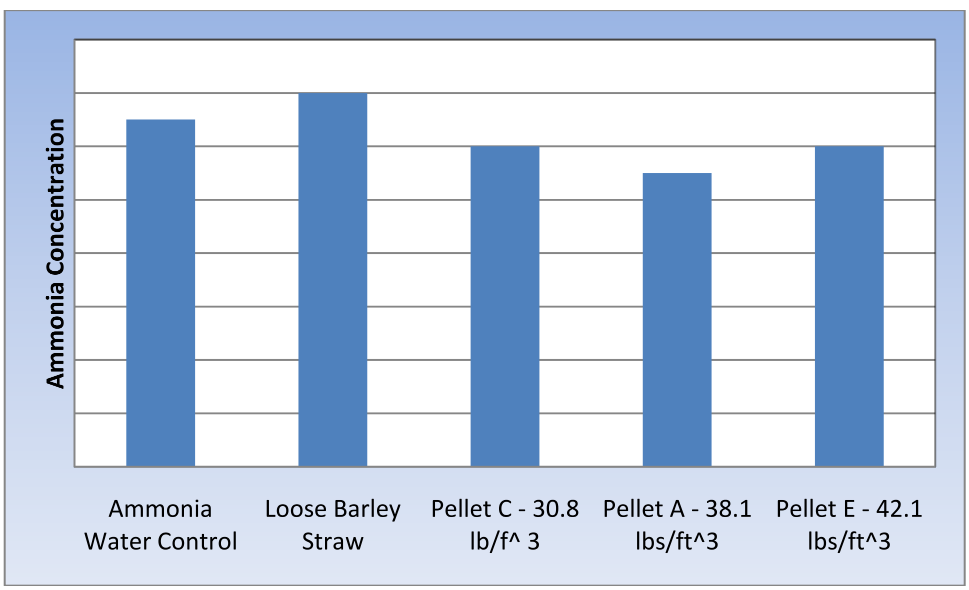


Table 3 - Ammonia Control in Water



Following are photos of the test pails taken at day 32 of the trial. The pelleted barley straw did expand and form a mat on the surface of the manure; although mat formation was not as uniform as the loose straw applied at the same mass. The pelleted straw expanded and sank when exposed to water as seen in Pictures 8 below.

Pictures 7 - Manure odor trial pictures at day 32

Control – Liquid Dairy Manure

Loose Ground Barley Straw (30 g)

Barley Test Pellet C (30g) – low density

Barley Test Pellet C (120 g) – low density

Barley Test Pellet A (30g) – mid density

Barley Test Pellet E (30 g) – high density

Pictures 8 - Water trials with 300 mls ammonia hydroxide added; trial pictures at day 32


Control – Water w/ 300 mls ammonia hydroxide


Loose Ground Barley Straw (30 g)


Barley Test Pellet C (30g) – low density


Barley Test Pellet A (30g) – mid density


Barley Test Pellet E (30 g) – high density

Conclusion

The Barley Straw Initiative focused on producing a barley straw pellet with various bulk densities to improve transportation economics. Testing conducted at the AURI Co-Product Pilot Lab facility demonstrated how *barley straw can be successfully pelleted and densities manipulated* based on pellet die utilization and the use of steam and moisture during the pelleting process. A greater compression ratio die resulted in greater bulk density. The addition of moisture and heat within a pelleting run utilizing the same die can also change product density and durability. Increased moisture typically results in a greater density pellet; however, pellet quality and density will plateau around 15% product moisture pre-pelleting.

AURI utilized three various barley straw pellet samples with densities consisting of 30.8, 38.1, and 42.1 pounds per cubic foot to evaluate the pelleted straw's ability to control odor as compared to utilizing ground barley straw only. Under the pilot lab condition previously stated, it was found that *pelleted barley straw controls ammonia release in liquid dairy manure and water* (with ammonia hydroxide added) as compared to the control samples with no surface application of a fiber.

When evaluating pelleted barley straw performance on liquid dairy manure, all pelleted barley samples did control ammonia release. There was not a significant difference in the control application, manure without barley straw added, as compared to the low density pellet application. The loose barley straw performed the best for controlling ammonia release utilizing the least amount of material. The low density pellet outperformed the loose barley straw, but only when applied at **four times the rate** of the loose straw.

It is important to note that actual ammonia levels are insignificant, as testing was conducted only to identify trends relative to the control. Variability in weather including wind, rain, temperature, and ultraviolet light may also have an effect on actual performance.

Identical test protocol used in the manure testing was followed using water with 300 milliliters of ammonia hydroxide added to three gallons of water. Testing conducted included a control pail, a pail with loose barley straw, and pails that contained the low, medium, and high density pellets. The mass of the loose and pelleted straw was 30 grams. The barley pellets rapidly deteriorated with the loose barley straw, and straw from the low density pellet remained suspended on the top of the pail as seen in Pictures 8. Ammonia level readings were much lower with the water trial. Conflicting data was collected indicating a greater level of ammonia being emitted from the loose barley straw test pail than from the control test pail with no straw added. All three pelleted barley straw test pails had slightly lower ammonia levels than the control pail with no added straw and the test pail with the loose barley straw.

The tests conducted at AURI indicate that pelleted barley straw will form a mat layer on manure and can control ammonia release from manure, but only when applied at a greater rate than loose straw (mass/area). Although there is an added cost per ton for processing and densifying barley straw and the need for an increased application rate, the efficiency gain in transportation may provide value-added opportunities for densifying barley straw for increasing market opportunity.