Combining Barley Malt Sprouts with Dried Distillers Grains Using Steam Pelleting

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Executive Summary
The nutrient profiles and relative low cost of by-products generated from the barley malting and corn ethanol industries make them attractive feed ingredients for beef and dairy producers. However, barley malt sprouts (BMS) and dried distillers grains (DDGs) pose challenges to feed manufacturers and livestock producers. These challenges have curtailed the marketability and use of BMS and DDGs, resulting in unrealized returns to the malting and ethanol industries as well as livestock producers.

Admittedly, BMS and DDGs are difficult to pellet by themselves. The Northern Crops Institute Feed Production Center provided diets for numerous studies researching the efficacy of BMS and DDGs in livestock feed. Some general conclusions drawn from these studies were when compared to ground barley, a BMS mix required two and a half times the amount of electrical energy to produce an equal amount of pellets; doubling the BMS mix content of a DDGs-based range cube produced an 11% increase in electrical energy demand, with a corresponding 7.7% increase in pellet quality. These prior experiences suggested that by using steam pelleting to combine BMS and DDGs, some of their negative attributes would cancel one another, resulting in a more user-friendly product.

The focus of this study was to observe the conditions necessary for production of "good" quality pellets when using commercially representative BMS and DDGs. BMS were from two sources. The first was a blended product containing barley malt sprouts, ground screenings and ground thin barley (this is a commercial product developed to reduce the difficulty of pelleting 100% BMS). The second was solely barley malt sprouts. DDGs were from a single source, having a nutrient content consistent with NRC values. In Trial 1 graded additions (10, 20 and 30%) of DDGs were combined with the BMS mix. Results for the 100% BMS mix from prior studies were included for comparison, (operating conditions were similar, but not equal). In Trial 2 the same graded additions of DDGs were used plus the 100% BMS product. With the exception of differences in conditioning temperature, adjusted to maintain pelleting, the operating conditions were the same in Trials 1 and 2.

Of particular interest were the changes observed in production rate measured as metric tons per hour (mt/hr), amperage, kilowatts (power demand) and energy demand measured as kilowatt hours per metric ton (kwh/mt), with the increasing levels of DDGs. Results in Trial 1 for the increasing DDGs contents showed a slight production rate decrease of 2%, a 7.1% decrease in amperage, a 16% average decrease for kilowatts, with a nonlinear decrease of 6.7 to 15.6% for kwh/mt. Contrasting the increasing DDGs content with the 100% BMS mix showed an average production rate increase of 64%, with amperage and kilowatts about the same, and a nonlinear average decrease of 40% for kwh/mt. Results in Trial 2 for the increasing DDGs contents compared to 100% BMS showed a maximum production rate increase of 25.7%, a maximum decrease of 40% for amperage and kilowatts, and a maximum decrease of 46.6% for kwh/mt.

For Trial 1 the decrease in kwh/mt yields a maximum savings of $0.33/mt and a minimum savings of $0.22/mt, or an average savings of $0.28/mt with electricity priced at $0.0289/kwh. There were corresponding decreases in pellet quality (Pellet Durability Index values) of 2.5%

and 0.4%. For Trial 2 the decrease in kwh/mt yields a maximum savings of $0.62/mt and a minimum savings of $0.14/mt, or an average savings of $0.38/mt using the same kwh cost. There were corresponding changes in pellet quality (Pellet Durability Index values) of a 3.5% decrease and an increase of 1.25%.

Adding DDGs to BMS improves pelleting characteristics, provides potentially significant cost savings, with manageable changes to pellet quality.

Trial 1

Prior work with a commercial maltster showed that by mixing BMS with ground screenings and ground thin barley a product was created that was easier to pellet than BMS alone and provided a quality nutrient profile. This BMS mix (in unpelleted form) was combined with graded levels (10, 20 and 30%) of DDGs having nutrient levels consistent with NRC values to see if pelleting characteristics could be improved with minimal change in pellet quality (measured as Pellet Durability Index).

The BMS mix was combined with the different levels of DDGs, allowed to mix for seven minutes, water was added at the rate of 5% weight, and mixed seven more minutes. In the pelleting process water acts as a lubricant and a solvent. Prior experiences with the BMS mix had shown that insufficient moisture could be condensed from steam in the pellet conditioning chamber, necessitating the water addition in the mixing step.

Pelleting trials were conducted using the same parameters except for conditioning temperature, which was adjusted to maintain pellet production. Pellet mill die speed was 1,200 ft/min (365.8 meters/min), feed rate to the conditioning chamber was constant (using setting 1), conditioning chamber retention time was approximately 30 sec. with a shaft rotation speed of 150 rpm. Data collection (for the main-drive motor) included amperage, volts, kilowatts, power factor and production rate. These were used to calculate the energy demand in kwh/ton.

Physical characteristics of the starting materials were recorded as bulk density and average particle size. The BMS mix was 9% more dense than the DDGs, and particle sizes were similar. Finished pellet characteristics were recorded as bulk density and Pellet Durability Index (PDI) values. Increasing levels of DDGs slightly decreased pellet bulk density and PDI value.

Of primary interest was the effect the graded additions of DDGs had on pellet mill performance and pellet quality. In Table 1, comparisons between #C1, #C2 and #C3 showed a 2% decrease in production rate (mt/hr), a 7.1% decrease for amperage, a 16% decrease for kilowatts and decreases in kwh/mt from 6.7 to 15.6%. Contrasting the values for graded DDGs content with the Sprout Mix showed a 64% average increase in production rate (mt/hr), amperage and kilowatts about the same, and a 40% average decrease in kwh/mt. The decrease in kwh/mt provides a maximum savings of $0.33/mt and a minimum savings of $0.22 with electricity priced at $0.0289/kwh. There were corresponding decreases in pellet quality (Pellet Durability Index values) of 2.5% and 0.4%. Combining DDGs with BMS mix did lower the cost of production and sacrificed very little pellet quality. However, the results were inconclusive. This may be due to inconsistency of the BMS mix. This product is produced using volumetric metering rather than mass (weight) addition, so variability in density of BMS, ground screenings and ground thin barley is unaccounted for.

Table 1. Trial 1 - Cargill BMS mix with DDGs

Product: 1/4" (6.4 mm) pellet

Pellet mill: CPM Hyflo, 50 hp (37.5 Kw) main drive motor
Die: 1/4" x 2 1/2" (6.4mm x 63.5mm), standard relief
performance ratio, 10:1

Base ingredients:
barley malt sprouts (Cargill mix) (51.8 kg/hl - 404 micron avg particle size)
DDG (47.5 kg/hl - 387 micron avg particle size)
Additive: 5% water (weight to weight)

Trial #C1 - 70% barley malt sprouts (Cargill mix), 30% DDG - Aug. 4, 2006
Trial #C2 - 80% barley malt sprouts (Cargill mix), 20% DDG - Aug. 9, 2006
Trial #C3 - 90% barley malt sprouts (Cargill mix), 10% DDG - Aug. 10, repeat Aug. 16, 2006
Grd Barley - Aug. 4, repeat Aug. 18, 2006: included as a reference
Sprout Mix is from prior work - Mar. 6, 2003

The same feeder input setting was used in trials #C1 - #C3 and Grd Barley:
pellet die peripheral speed, 1,200 ft/min (365.8 m/min)
conditioning chamber shaft speed 150 rpm - retention time approx. 30 sec
steam pressure - 30 psig (1.87 kg/cm²)

	Trial #C1	Trial #C2	Trial #C3	Sprout Mix	Grd Barley
Voltage	456.3	449.3	453.9	504.0	458.2
Amperage	32.5	36.5	35.1	27.5	31.3
Kw	22.6	27.2	25.4	26.0	22.91
Power Factor	0.92	0.94	0.93	0.95	0.92
Prod. Rate (MT/hr)	1.01	0.97	1.03	0.61	1.17
kwh/MT	22.2	26.3	23.8	33.75	18.8
Pellet Durability Index (%)	94.8	95.7	96.8	97.2	86.5
Pellet Bulk Density (kg/hl)	61.3	61.8	62.7	na	62.7

Trial 2

BMS (in unpelleted form) were combined with graded levels (10, 20 and 30%) of DDGs with nutrient levels consistent with NRC values to see if pelleting characteristics could be improved with minimal change in pellet quality (measured as Pellet Durability Index).

The BMS were combined with the different levels of DDGs, mixed for seven minutes, water was added at the rate of 10% weight, and mixed seven more minutes. Additionally, BMS required the use of a pelleting aid (Super-Lube®) to further reduce frictional force.

The pelleting trials were conducted using the same procedures and parameters as Trial 1. Data recorded from the main-drive motor was used to calculate kwh/ton. Physical characteristics of the starting materials showed that the BMS were 39% less dense than the DDGs and particle sizes were similar. Pellet characteristics showed that increasing levels of DDGs decreased pellet bulk density by 10% and decreased PDI value by 3.7%.

Of primary interest was the effect the graded additions of DDGs had on pellet mill performance and pellet quality. Increasing DDGs content compared to BMS showed a 25.7% increase in production rate (mt/hr), amperage and kilowatts showed decreases of about 40%, and a 46.6% decrease in kwh/ton. The decrease in kwh/mt provided a maximum savings of $0.62/mt and a minimum savings of $0.14/mt, electricity at $0.0289/kwh. The apparent inconsistency of PDI values between the BMS pellets and the BMS + 10% DDGs is due to the use of the pelleting aid, which is lipid based and has a negative impact on pellet quality.

Table 2. Trial 2 - Busch Ag. BMS with DDGs.

Product: 1/4" (6.4 mm) pellet

Pellet mill: CPM Hyflo, 50 hp (37.5 Kw) main drive motor
Die: 1/4" x 2 1/2" (6.4mm x 63.5mm), standard relief
performance ratio, 10:1

Base ingredients:
barley malt sprouts (Busch Ag) (34.1 kg/hl - 391 micron avg particle size)
DDG (47.5 kg/hl - 387 micron avg particle size)

Additive: 10% water (weight to weight)

Trial #B1 - 70% barley malt sprouts (Busch Ag, Moorhead, MN), 30% DDG - Aug. 21, 2006
Trial #B2 - 80% barley malt sprouts (Busch Ag, Moorhead, MN), 20% DDG - Aug. 24, 2006
Trial #B3 - 90% barley malt sprouts (Busch Ag, Moorhead, MN), 10% DDG - Aug. 24, 2006
Trial #B4 - 100% barley malt sprouts (busch Ag, Moorhead, MN), + 0.25% SuperLube® - Aug. 29, 2006
Grd Barley - Aug. 4, repeat Aug. 18, 2006: included as a reference

The same feeder input setting was used in all trials:
pellet die peripheral speed, 1,200 ft/min (365.8 m/min)
conditioning chamber shaft speed 150 rpm - retention time approx. 30 sec
steam pressure - 30 psig (1.87 kg/cm²)

	Trial #B1	Trial #B2	Trial #B3	Trial #B4	Grd Barley
Voltage	454.4	449.6	451.4	447.3	458.2
Amperage	28.3	35.2	43.0	47.2	31.3
Kw	21.02	26.88	32.14	34.78	22.91
Power Factor	0.93	0.95	0.93	0.93	0.92
Prod. Rate (MT/hr)	0.88	0.74	0.72	0.70	1.17
kwh/MT	24.6	33.4	41.4	46.1	18.8
Pellet Durability Index (%)	92.5	96.1	97.1	95.9	86.5
Pellet Bulk Density (kg/hl)	57.6	59.3	60.2	63.5	62.7

Conclusions

Adding DDGs to BMS improves overall pelleting characteristics and provides potentially significant energy cost savings, with manageable losses to pellet quality. Combining DDGs with BMS could be a win-win situation. Feed processors would realize decreased energy costs and also decreased machinery wear and lower maintenance costs (parts and labor). Livestock producers would receive a more user-friendly feed with a complimentary nutrient profile. The end result would be increased draw-down on the DDGs inventory. ■