Evaluation of Carriers for Use in Supplemental Nutrient Premixes in Pet Food and Animal Feeds

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Introduction

To assure proper utilization and application of vitamin and mineral premixes, carriers play an important role. Carriers provide a delivery system for micronutrients that improve uniformity, dilution, and dispersability across the entire mix. The carriers are chosen based on their water-holding capacity, uniformity (physical and chemical), environmental safety, and lack of toxic compounds. Suitable carriers should also be abundant, a reasonable cost, locally available, and functional (Albareda et al., 2008). The process of choosing a carrier should start with an understanding of the premix function. The carrier should properly complement the "active" premix ingredients, and possess the following attributes, uniform particle size, uniform shape, bulk density consistent to prevent demixing, proper flowability, and resist electrostatic charges. The particle size of the carrier must match the other components in which it is mixed, and the carrier's density must be within the same order of magnitude as the other components. Rice hulls are the standard carrier for premixes in animal feed and pet food, but do not comply with the new trend for "grain-free" pet food. There are alternative carriers to rice hulls that are being used, but no data is available regarding their performance for this purpose. Therefore, our objectives were to evaluate alternative carriers relative to rice hulls for their utility to this purpose.

Materials & Methods

The ingredients evaluated were rice hulls (International Nutrition, Omaha, NE), soy hulls (International Nutrition, Omaha, NE), pea fiber (Lorschter Animal Nutrition Inc. Bern, KS), miscanthus grass (Renew Biomass, Springfield, MO), and corn cob meal (Fairview Mills Inc. Seneca, KS). The test carriers were evaluated by the following methods: angle of repose, particle size, Flodex, and microscopic images.

For particle size analysis, a Ro-Tap® (Ro-Tap II RX-94; Hogentogler & Company Inc.; Columbia, MD) machine was used with a stack of sieves placed largest to smallest according to size as follows: 1700, 1180, 850, 600, 425, 300, 212, 150, 106, 75, 53, microns and pan. A 100-gram sample plus 0.5 grams of flow agent was poured on top of the sieve stack in the Ro-Tap® machine and allowed to sift for 15 minutes. The weights of any remaining material in each sieve were recorded. To determine flowability, a Flodex™ (model no. 21-100-004, Hanson Research; Chatsworth, CA) machine was used. Fifty grams of sample was poured through funnel on top of the Flodex™ into a cup and allowed to sit for 30 minutes. The material was then released through sequential decreasing disc sizes until it no longer flowed. Once flow stopped, the smallest disc size that the material flowed through without stopping was recorded. For angle of repose, a device constructed from a Magnet Vibrating Feeder (Syntron® model F-TO; 115 volts, 60 hertz, .35 amps, FMC Corp. Material Handling Equipment Division; Homer City, PA) and Electric Controller (Syntron® model CSCR-18-1, 115 volts, 50/60 hertz, 5 amps, FMC Corp. Material Handling Equipment Division; Homer City, PA) was used at a controlled speed to move material onto a wooden platform. Once the material stopped piling on the platform, the feeder was stopped and the height and angle(°) of the pile was recorded. For microscopic images, a camera was attached to a 5X power microscope (Motic Microscope SMZ-168 series, model MOSMZ-168-BL; New York Microscope Co. Hicksville, NY) to take photos of 1 gram of each sample.

Table 1. Angle of repose standard flow properties compared to values calculated from testing.

Flow Property	Angle of Repose (degrees)
Excellent	25-30
Good	31-35
Fair – flow aid not needed	36-40
Passable – may hang up	41-45
Poor – must agitate, vibrate	46-55
Very poor	56-65
Very, very poor	>66

Figure 1. Rotational Tapping Particle Size Analysis machine (Ro-Tap II RX-94).

Results and Discussion

Table 2. Particle size distribution after sifting for 15 minutes (N = 3).

Material	Rice Hulls	Soy Hulls	Pea Fiber	Miscanthus Grass	Corn Cob Meal
Particle Size, Dgw (μm)*	366 ± 1.71[a]	320 ± 2.00[d]	352 ± 2.35[b]	134 ± 1.91[e]	332 ± 1.37[c]
Particles / gram	56088	199315	458363	2063267	32531
Surface Area (cm^2) / gram	143.2	180.3	185.6	418.2	143.9

[abcde] means within a row unlike letters differ ($p<0.05$).
*mean ± standard deviation

Table 3. Flodex™ results for all carriers (triplicate). The lowest disc size, flowability index, and special observations about flow and cone shape were recorded.

Carrier	Disc Size	Flowability Index	Special Notes
Rice Hulls	26	38.5[d]	flowed better when poured evenly (centered)
Soy Hulls	14	71.4[b]	thicker cone
Pea Fiber	22	45.5[c]	thick cone at 20, better at 22
Miscanthus	>34	N/A	did not flow through biggest disc we had available
Corn Cob Meal	5	200.0[a]	best flow, stops flowing halfway through 4

[abcd] means a column with unlike letters differ ($p<0.05$).

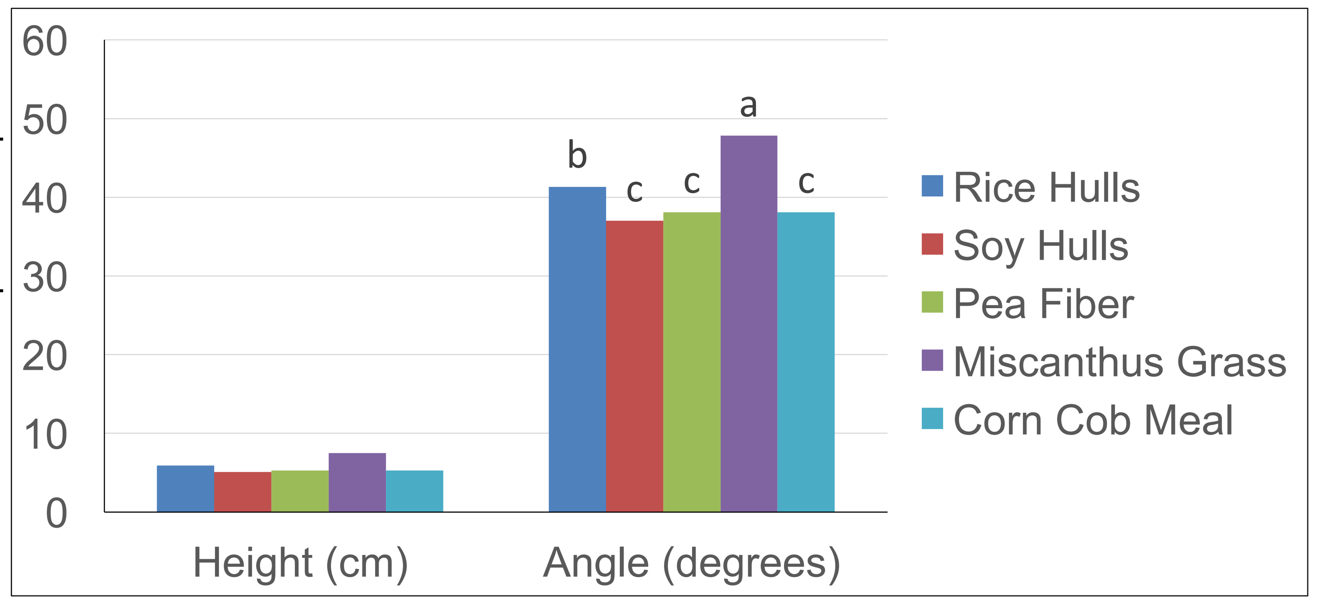

Figure 2. Angle of repose after cone formed, average height in cm and average angle calculated using the equation $\alpha = tan^{-1}(h/L)$, L = radius of platform = 6.75 cm ([abc] means within a measure unlike letters differ, $p<0.05$).

Figure 3. Microscopic images (5X) for rice hulls, soy hulls, pea fiber, miscanthus grass, and corn cob meal, respectively.

Ro-Tap® analysis for each treatment had a different average particle size (Table 2). Rice hulls had the largest ($p<0.05$) particle size at 366 ± 1.71 μm. Smaller particle size is ideal for uniformity between carrier and premix for easier attachment. Corn cob meal ranked in the middle with an average particle size of 332 ± 1.37 μm. A lower standard deviation is desired for proper mixing and less settling. Flodex™ results showed that all samples were different (Table 3). Miscanthus grass was excluded due to insufficient results. Corn cob meal was the best flowing carrier with the largest flowability index. The miscanthus grass did not flow through the largest disc size available. This is most likely due to the static within the material, restricting proper flowability. Angle of repose data shows that miscanthus grass and rice hulls differed from corn cob meal, pea fiber, and soy hulls. Corn cob meal, pea fiber, and soy hulls did not differ (Figure 2). Miscanthus grass angle of repose results were consistent with flodex results.

Conclusions

1. Rice hulls do not appear to be superior among the samples tested.
2. Based on these results, corn cob meal would be the best alternative, followed by soy hulls.
3. Miscanthus grass and pea fiber did not perform in this series of tests in a manner consistent with an ideal dry premix carrier. They may be more suitable for other applications.

References

- Albareda, Marta, Dulce N. Rodriguez-Navarro, Maria Camacho, and Francisco J. Temprano. "Alternatives to peat as a carrier for rhizobia inoculants: Solid and liquid formulations." *Soil Biology & Biochemistry* (2008): n. pag. Web.

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