Usage of the Penn State Forage Separator for evaluating particle size of TMRs

by

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TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENT	i
LIST OF TABLES	iii
INTRODUCTION	1
LITERATURE REVIEW	3
Penn State Shaker Box	3
Particle Length	5
Dry Matter Intake	7
Rumen Health	8
MATERIALS AND METHODS	11
RESULTS AND DISCUSSION	13
CONCLUSION	22
REFERENCES	24

LIST OF TABLES

TABLE	PAGE
1. Forage and TMR particle size recommendations.....	4
2. Holstein Sample 1 Results.....	13
3. Holstein Sample 2 Results.....	14
4. Holstein Sample 3 Results.....	15
5. Holstein Sample from middle of manger results.....	16
6. Jersey sample 1 results.....	17
7. Jersey sample 2 results.....	18
8. Jersey sample 3 results.....	19
9. Jersey sample from middle of manger results.....	20

INTRODUCTION

Nutrition accounts for 58% of the cost of production on the dairies (6). Feed prices have increased significantly while milk prices have plummeted. Even though cows are typically fed in groups, cows have individual daily nutrient requirments; whether she is lactating or is in the dry period. Along with this dairymen need to find ways to keep the dairies in business and survive in such hard economical times.

There are many problems dairies can face due to poor feeding and nutrition management. One of these is poor feedbunk management, including problems like not mixing feed properly, including particle size and variety. Particle size has many effects on the cow, and adequate forage particle length is necessary for proper rumen function. Acidosis, laminitis, and subacute rumen acidosis have become prevalent problems for commercial dairies (4). With this said, there is the need to make sure that no feed is wasted and the cows are not sorting their total mixed rations to get the full production of milk during each lactation, as well as maintaining proper rumen function. Dairymen are also having a hard time measuring particle size. Proper particle size distribution of feeds is an important part of ration formulation. Management of forage particle size starts with harvesting forages at the proper stage of maturity. Chopping the crop at the right length helps to achieve the desired particle length in a TMR. Measuring particle length of the forages is only a portion of the solution. Analyzing the TMR particle size is the main goal in measuring the

distribution of feed and forage particles that the cows are truly consuming. The Penn State Forage Particle Separator is a simple and effective “on farm” way to quantify chopping results. TMRs only work as well as the mixer does. In addition to analyzing forage and particle size, the particle separator can help monitor feed bunk sorting and can help in trouble shooting feeding, metabolic, or production problems on the dairy. There are either 3 or 4 boxes that have consecutively smaller sieves that the forages. TMRs are shaken, with smaller particles being dropped through to smaller sieves. The feeds remaining on top of each sieve and in the bottom pan are then compared against the total volume of the original sample. The main objective of the shaker box is to maximize the amount on the middle sieve at about 45-65% of the total material. Measuring the TMRs remaining in the bunk is key to evaluate sorting (3). This should be done several times throughout the day. The particle distribution size should not differ more than 3-5% from the original TMR. In this project, by using the Penn State shaker box, it can help determine what the cows on the dairy are actually consuming, if the particle sizes are adequate for rumen function, how to improve forage and TMR mixes for the herd, and improve management of overall nutrition.

LITERATURE REVIEW

Penn State Shaker Box

Development of Penn State Shaker Box

The Penn State forage particle Separator has become a very useful tool that quantitatively determines the particle size of forages and total mixed rations. Proper particle size distribution of feeds is an important part of ration formulation and nutrition management on dairies. Until recently it has been very difficult to measure the particle size on dairies (3). The Penn State forage particle size separator box consists of three or four boxes that are stacked on top of one another. The top box retains particles of feed or forage that are greater than three forth's of an inch. The middle box retains particles between five sixteenths and three forth's of an inch. The bottom box has a solid bottom and retains particles under five sixteenths of an inch. The American Society of Agricultural Engineers' (ASAE) for particle size analysis and distribution has been available for many years (3). This method of analysis is an intensive laboratory procedure that is impractical for farm use. The objective of developing the Penn State forage particle separator was to mimic the complex lab method, but with a simpler, on-farm method (3).

Using the Penn State Shaker Box

When using the separator you stack the three or four boxes on top of each in the correct order. The sieve with the largest holes on top, the medium-sized holes next, then the smallest holes and the solid pan on the bottom. Obtain a sample of approximately 3 pints of forage or TMR and put it in the top pan. On a flat surface, shake the sieves in a clock wise matter. Shake the sieves 5 times then rotate the separator box one-quarter turn. No vertical motion should be done during shaking. The shaking pattern for the particle size separator should also be from left to right and vice versa. This process should be repeated seven times, for a total of eight sets or 40 shakes. There is a recommended distribution of total feed particles by percentage in each of the four boxes (3). In the table below.

TABLE 1. Forage and TMR particle size recommendations (3).

Screen	**Pore Size (inches)**	**Particle Size (inches)**	**TMR (%)**
Upper Sieve	0.75	> 0.75	2 to 8
Middle Sieve	0.31	.31 to .75	30 to 50
Lower Sieve	0.05	.07 to .31	30 to 50
Bottom Pan		< 0.07	□20

Particle Length

Importance of Particle Length

Dairy cows require adequate particle size to maintain a healthy functional rumen. Reduced particle size has been shown to decrease the time spent chewing, therefore cause a trend toward decreased rumen pH. Particle size has become very hard to ensure because most commercial dairy rations contain high levels of concentrate and high quality silages that are often finely chopped (4). Feed particles that are too long are more likely to cause sorting in the ration and this destroys the diet making it different from the originally formulated one. Management of forage particle size starts with harvesting forages at the right stage of maturity (3). When chopping the crop at the proper length it produces forages that can be utilized to get the desired particle length in a TMR. Measuring the particle length of individual forages is recommended for achieving the proper TMR particle size. Evaluating the TMR helps to identify the distribution of feed and forage particles that the cow is actually consuming. Distribution equipment and mixing can reduce particle size of feeds and forages.

Effects of Fiber Length

Diets are highly fermentable in the rumen and aid to maximize milk production (3). Even so these high fermentable diets can also lead to many metabolic disorders. Subacute ruminal acidosis, displaced abomasums, milk fat depression, dry matter intake, and fiber digestion depression, are all disorders that can occur due to

poor particle size (3). Dietary fiber is critical in preventing these disorders. Effective fiber intake can affect chewing and saliva secretion. Fiber in long feed particles greater than one centimeter promotes chewing and saliva secretion (3). More chewing and saliva help neutralize the acids produced during ruminal digestion of feeds. Saliva acts as a buffer in the rumen to elevate the pH. The fiber that promotes chewing is physically effective (5).

Dry Matter Intake

Importance of TMR

Feeding a total mixed ration ideally results in rumen bacteria encountering the same mixture of ingredients and nutrients that aids the cow's rumen throughout the day. Consistency also helps improve rumen fermentation (5). Cows need to consume adequate amounts of long forages or fiber in their TMR so they can regurgitate the feed, chew their cud, and secrete saliva. Saliva helps buffer the rumen environment so that bacteria can efficiently digest forages. TMRs may also result in better intake by the cow and improve her milk production, health, and reproductive performance (3). Any minor inconsistencies and improperly followed guidelines of using the TMR can also then decrease milk production and increase health problems. When feeding a TMR it's important to monitor the amount of TMR consumed. Monitor dry matter or

moisture content of forages and other wet byproducts being fed, amount of each feed in a TMR batch, particle size of the TMR being feed, and consistency of the particle size of the TMR being mixed, delivered, and left in the feed bunk (3).

Importance of Fiber Intake

Cows require sufficient neutral detergent fiber (NDF) in their diets to maintain rumen function and to maximize milk yield (5). Dairy rations should generally contain at least 25% NDF. A large portion of dietary NDF should come from forages. Digestibility of NDF is an important part of forage quality because forage NDF varies in its degradability in the rumen (4).

Rumen Health

Rumen pH

Rumen pH fluctuates within a 24-hour period and is not constant. However, the rumen environment contains microbial populations that interact optimally within a pH range of 6.1 to 7.2 (2). Cows that are high producing fed high concentrate diets at greater than 45% of the ration generally have a ruminal pH that ranges from 6.6 before morning feeding to 5.3 or 5.0 during the intensive rumen fermentation phases and an average pH is usually 6.0-6.1 (2).

Displaced Abomasum

Displaced abomasum is a condition in which the abomasum becomes enlarged with fluid and/ or gas. The enlargement can be on the left or right and dorsally within the abdominal cavity. Right displacement (RDA) is usually accompanied by torsion which prevents digest passage and makes a critical condition which will require treatment immediately (6). The Left displacement (LDA) is usually associated with gas accumulation. The most common form in the USA is LDA. More than 79% of LDA are diagnosed within one month postpartum (6). The transition period is the major risk period in the etiology of LDA (6). Nutrition has been implicated as a major risk factor in the etiology of LDA. Feeding and management practices will be important for prevention. Lead feeding; which is the practice of increasing concentrates during the last two to three weeks prior to parturition has been a common practice on commercial dairies. Limiting evidence has been that this practice reduces postpartum disorders. As a part of management the feed bunk is another risk factor for LDA through feed consumption and actual nutrient densities of the consumed ration (6). Competition and insufficient bunk space may also limit feed intake. Low feed intake may lower ruminal fill providing a migration to the abomasum. Since LDA are at a greater risk during the early postpartum period due to physiologic and metabolic changes in the transition cow it is recommended that the concentrates should be fed at least three to four times daily (6).

Subacute ruminal acidosis (SARA)

Subacute ruminal acidosis has become a more common and economically important problem for dairy cattle (2). Clinical signs can be overlooked easily. Clinical signs include decreased dry matter intake, laminitis, rumenitis, liver abscesses, and pulmonary bacterial emboli. SARA usually is characterized by continuous depressed rumen pH between 5.2 and 5.6 (2). This is another disorder that can be caused by cheap/ poor quality feed; large intake of rapidly fermentable carbohydrates that result in accumulation of organic acids in the rumen. Four types of cattle are at risk of developing SARA: transition cows, high DMI cows, and those that are subject to a high degree of variability in their ration, meal patterns, and poorly formulated diets. The ideal ration should be formulated to perform in the rumen and is balanced between physically effective fiber and rumen fermentable carbohydrates which results in salivary flow and microbial volatile fatty acids. Increasing the forage amount in a ration also may increase rumination (2). Once again nutrition and feed bunk management affect rumen health. Free stall overcrowding, poor bedding, and even excessive parlor holding time may have an effect on feeding patterns and animal behavior. The diagnosis of SARA in a herd or group is by obtaining the measurement of the ruminal pH (2). There are many ways available for the collection of ruminal fluid for analysis. It is also important when collecting a sample, that it is collected from the same region of the rumen at each time due to various ruminal pH at different locations of the rumen (2).

Materials and Methods

In this project separate TMR samples were collected from the Jersey and Holstein herds at the dairy. These collections were used for the data and to be evaluated based on particle size. Three groups of samples were collected to evaluate the possible difference between Holstein and Jersey herd. These samples were evaluated using the Penn State forage particle separator. The sample was collected from the middle of the manger.

A second group of three samples were collected from the beginning, middle, and end of the manger. The results of the beginning, middle, and end of the feeding were collected in handfuls. For each container, five handfuls of TMR was collected. These samples were then placed one sample at a time in the top box of the shaker. The four plastic separator boxes were stacked on top of each other in the following order: sieve with the largest holes on top, the medium-sized holes next (middle sieve), then the smallest holes (bottom sieve), and the solid pan on the bottom. The shaker box was placed on a flat surface. Shaking the boxes in one direction five times then rotate the separator box one-quarter turn was the next step. This process was repeated seven times for a grand total of eight sets (40 shakes), rotating the separator after each set of five shakes. These procedures were done as recommended by the guidelines of

the Penn State Shaker box (3). After one complete set, the sample was then weighed and recorded. There were a total of twenty samples recorded. Nine collections of samples for the Jersey and Holstein herd had a beginning, middle, and end of the manger recorded. The sample collected and recorded from the middle of the manger for the Jersey and Holstein herd were done by students as a class assignment. This sample was chosen based on consistency relative to the other samples collected from the beginning, middle, and end.

RESULTS AND DISCUSSION

TMR meeting Penn State Guidelines

The following table shows the results for the first sample taken from the Holstein TMR of the beginning, middle, and end.

TABLE 2. Holstein Sample 1 Results.

Holstein Sample 1	**Beginning (wt, %)**		**Middle (wt, %)**		**End (wt, %)**	
Upper Sieve	4.25 oz.	23%	4.25 oz.	26%	4.125 oz.	21%
Middle Sieve	5.125 oz.	28%	4 oz.	24%	5.25 oz.	27%
Lower Sieve	6.25 oz.	34%	5.375 oz.	33%	6.25 oz.	32%
Bottom Pan	2.75 oz.	15%	2.875 oz.	17%	4 oz.	20%
Total for weight (oz)	18.375	100%	16.5	100%	19.625	100%

The upper sieve exceeds the 2-8% Penn State TMR guidelines. It is evident that the upper sieve has too much particles. The middle sieve ranges from 24-28% which is just below the 30-50% recommendations. The lower sieve is within the 30-50% recommended range. The lower sieve stayed within the lower end of the recommendation and is adequate. In the bottom pan the three sample collection were less than 20%.

The following table shows the result for the second sample taken from the Holstein TMR.

TABLE 3. Holstein Sample 2 Results.

Holstein Sample 2	**Beginning (wt, %)**		**Middle (wt, %)**		**End (wt, %)**	
Upper Sieve	3.625 oz.	21%	4.25 oz.	22%	2.875	19%
Middle Sieve	5.125 oz.	30%	5 oz.	26%	4.125 oz.	27%
Lower Sieve	5.875 oz.	34%	6.375 oz.	33%	5.125 oz.	34%
Bottom Pan	2.5 oz.	15%	3.5 oz.	19%	3.125 oz.	20%
Total for weight (oz)	17.125	100%	19.125	100%	15.25	100%

The upper sieve samples collected are above the 2-8% recommendations. All are above 19%. The middle sieve collections are close to the minimum recommendations of 30-50%. Only the beginning sample of the middle sieve meets the recommendations while the middle and end are about 3% below the minimum. All samples in the lower sieve meet the 30-50% guidelines. The samples in the lower sieve have been consistent in the first two samples.

In this table below it shows the results for the third and final collection of the beginning, middle, and end in the Holstein TMR.

TABLE 4. Holstein Sample 3 Results.

Holstein Sample 3	**Beginning (wt, %)**		**Middle (wt, %)**		**End (wt, %)**	
Upper Sieve	4.375 oz.	22%	4.25 oz.	22%	3.875	22%
Middle Sieve	5.625 oz.	28%	5.5 oz.	28%	4.875 oz.	27%
Lower Sieve	6.875 oz.	34%	6.25 oz.	32%	6 oz.	32%
Bottom Pan	3.25 oz.	16%	3.5 oz.	18%	3.5 oz.	19%
Total for weight (oz)	20.125	100%	19.5	100%	18.25	100%

The top sieve samples were all above the 2-8 % recommendations. The end sample was the lowest, being 19 %. In the middle sieve samples only the beginning met the 30-50 % recommendations at 30 %. The middle and end were below the minimum. The lower sieve samples were all above 30 % and met the requirements. The bottom pan samples were all below 20 % and met the recommendations.

In this table below it shows the results collected from the middle of the manger.

TABLE 5. Holstein Sample from Middle of Manger Results.

Holstein Sample Manger	**Middle (wt, %)**	
Upper Sieve	4.25 oz	22%
Middle Sieve	5 oz	26%
Lower Sieve	6.375 oz	33%
Bottom Pan	3.5 oz	19%
Total for weight (oz)	19.125	100%

In the upper sieve sample collected from the middle of the manger was above the 2-8 % recommendations by 20 %. The middle sieve sample didn't met the 30-50 % recommendations. it was below the minimum by 4 %. the lower sieve sample collected was above the minimum by 3 %. The bottom pan sample was below the 20 % recommendation.

In this table below it shows the results from the first sample taken from the Jeresey TMR of the beginning, middle, and end.

TABLE 6. Jersey Sample 1 Results.

Jersey Sample 1	Beginning (wt, %)		Middle (wt, %)		End (wt, %)	
Upper Sieve	4.125 oz.	24%	3.375 oz.	22%	2.625 oz.	21%
Middle Sieve	3.25 oz.	19%	3.25 oz.	22%	2.625 oz.	21%
Lower Sieve	6.625 oz.	38%	5.625 oz.	36%	4.75 oz.	38%
Bottom Pan	3.375 oz.	19%	3.125 oz.	20%	2.5 oz.	20%
Total for weight (oz)	17.375	100%	15.375	100%	12.5	100%

In the top sieve all of the samples collected were above 20 %. They all exceed the 2-8 % recommendations. The middle sieve samples are all below the 30-50 % recommendations by 19 %. The beginning sample was the lowest at 19 %. The lower sieve samples all meet the 30-50 % recommendations. They are all above the minimum recommendations. The bottom pan samples are all below 20%.

In the following table below it shows the results taken from the second sample of the Jersey TMR of the beginning, middle, and end.

TABLE 7. Jersey Sample 2 Results.

Jersey Sample 2	**Beginning (wt, %)**		**Middle (wt, %)**		**End (wt, %)**	
Upper Sieve	3.875 oz.	22%	3.5 oz.	23%	3.75 oz.	21%
Middle Sieve	3.5 oz.	20%	3.125 oz.	21%	3.875 oz.	22%
Lower Sieve	6.625 oz.	37%	5.5 oz.	36%	6.5 oz.	36%
Bottom Pan	3.75 oz.	21%	3 oz.	20%	3.75 oz.	21%
Total for weight (oz)	17.75	100%	15.125	100%	17.875	100%

In the upper sieve all of the sample exceed the 2-8 % recommendations. All are above 20 % and are excessive. The middle sieve samples do not meet the 30-50% recommendations. They are all below the minimum by atleast 8% . The lower sieve samples are all above the minimum recommendations of 30%. Only the middle bottom pan sample meets the recommendations. The beginning and end samples exceed the recommendatoins by 1 %.

In the table below it show the results from the third and final sample of the beginning, middle, and end collections of the Jersey TMR.

TABLE 8. Jersey Sample 3 Results.

Jersey Sample 3	**Beginning (wt, %)**		**Middle (wt, %)**		**End (wt, %)**	
Upper Sieve	4.625 oz.	23%	3.125 oz.	21%	3.75 oz.	23%
Middle Sieve	4.375 oz.	22%	3 oz.	21%	3.875 oz.	20%
Lower Sieve	7.125 oz.	35%	5.5 oz.	38%	6.5 oz.	37%
Bottom Pan	4 oz.	20%	2.875 oz.	20%	3.75 oz.	20%
Total for weight (oz)	20.125	100%	14.5	100%	18.75	100%

In the upper sieve all three samples exceed the 2-8 % recommendations. All are above 20 %. The middle sieve samples didn't meet the 30-50 % recommendations. They were all atleast 8 % below the minimum. In the lower sieve all samples met the recommendations. All were above the 30 % minimum by atleast 5 %. In the bottom pan all three samples met the 20 % recommendations.

In the following table below the sample was collected from the middle of the manger of the Jersey TMR.

TABLE 9. Jersey Sample from Middle of Manger Results.

Jersey Sample Manger	**Middle (wt, %)**	
Upper Sieve	3.5 oz	23%
Middle Sieve	3.125 oz	21%
Lower Sieve	5.5 oz	36%
Bottom Pan	3 oz	20%
Total for weight (oz)	15.125	100%

In the upper sieve the sample exceeds the 2-8 % recommendations. In the middle sieve the sample didn't meet the 30-50 % recommendations. It is below the minimum by 9%. In the lower sieve the sample meets the recommendations and is above the minimum by 6 %. In the bottom pan the sample meets the recommendations.

The Penn State Shaker Box recommendations were true to the value of how the samples should compare to the guidelines. All samples taken from the top sieve of the Jersey and Holstein herd were consistently high. The lower sieve samples from both herds were consistent in having the minimum requirements of 30%. In addition, the majority of all the samples were consistent with the recommendations for the bottom pan. The ration needs to be evaluated further to determine potential solutions

to reduce the amount of feed in the top sieve. Possible solutions are: 1) The ration needs to be adjusted. 2) The feed mixer needs to cut the larger particles finer. 3) Forages such as forage silage need to be more finely cut at harvest.

CONCLUSION

Particle size has many effects on the cow. Adequate forage particle length is necessary for proper rumen function. Dairymen are also having a hard time

measuring particle size. Proper particle size distribution of feeds is an important part of ration formulation. Management of forage particle size starts with harvesting forages at the proper stage of maturity. Chopping the crop at the right length helps to achieve the desired particle length in a TMR. Measuring particle length of the forages is only a portion of the solution. Analyzing the TMR particle size is the main goal in measuring the distribution of feed and forage particles that the cows are truly consuming.

The Penn State Shaker box aids dairymen in allowing them to see if their rations from the manger are consistent throughout each feeding. Making sure the rations are consistent is very important and can help resolve issues due to nutrition. The results from the samples collected, were all relatively consistent within the groups of the Jersey and Holstein herd. The lower sieves along with the bottom pan were within the Penn State Shaker box recommendations. The top sieve was consistent in all samples recorded. They exceeded the 2-8% recommendations. The middle sieve fluctuated in some samples, while a significant portion of them were below the 30-50% recommendations. With these results, the TMR can be looked over and changes to the ration can be made to get the right amount of particles in each sieve to meet the recommendations. Even though the Jersey and Holstein herds were compared it is evident that both of the formulated rations have too much particles in the top sieve. The rations for both herds need to be evaluated further to determine potential solutions to reduce the amount of feed on the top sieve. Possible solutions are: 1) The ration needs to be adjusted. 2) The feed mixer needs to cut the larger

particles finer. 3) Crops that are used for forage silage need to be more finely cut at harvest.

The Penn State Forage Particle Separator is a simple and effective “on farm” way to quantify chopping results. In addition to analyzing forage and particle size the particle separator can help monitor feed bunk sorting and can help in trouble shooting feeding, metabolic, or production problems on the dairy. This project is a great way to show how using the Penn State shaker box can help determine what cows are actually consuming, if the particle sizes are adequate for rumen function, how to improve forage and TMR intake for the herd, and improve management of overall nutrition.

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