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ORIGINAL ARTICLE

Investigation of Ruminants' Digestibility based on the Particle Size of Nutritional Materials

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ABSTRACT

The current study aims to investigate the effect of food particles on ruminants' digestibility. Among the ruminants, the size of the nutritional particles is regarded as one of the most significant factors for the digestibility and absorption of the nutritional materials. Also, the size of the nutritional materials has a significant effect on the chewing process which ultimately leads to the efficiency of nutritional materials metabolism. Moreover, the size of forage particles influence both the concentration of NDF and the food ration on PH related to rumen. Effective physical factors of fibers depend upon the amount of non-structural carbohydrates, the shape of particles, the breakability of particles, as well as the size of the particles. The fiber part of food causes the stimulation of chewing and production of saliva; hence, it creates a favorable environment for the growth of rumen micro-organisms. In addition, large-size nutritional materials cause slower level of speed in passing through reticulorumen; therefore, such reduction provide sufficient ground for rumen's filling up which ultimately leads to reduction in the amount consumable nutritional materials. Whenever soft alfalfa is utilized, digestibility in the rumen is reduced. As a result, alfalfa is transferred to the narrow intestine of the animal. This study aimed to investigate the ruminants' digestibility based on the particle size of nutritional materials.
Keywords: *Food particles, fibers, rumen, ruminants*

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INTRODUCTION

In order to prevent the occurrence of livestock metabolic abnormalities and to protect the ecological well-grounded conditions in the rumen, the food ration provided for the livestock should contain sufficient amount of alfalfa physically and qualitatively well-formed. Mertens [1] have defined the effective use of fiber or the so-called 'effective fiber' as, "the part of fiber source with regard to food ration which stimulates effective rumination and salivation". Grant et al. [2], also, defined effective fiber as, the number of alfalfa particles which are not able to pass through the sieve pores of 1 mm. A plethora of studies have shown that the particles remain on the sieve with pores 18/1 mm (Pennsylvania system) and pass more slowly than those particles which do not remain on the net [3,4]. The size of forage particles influence both the concentration of NDF and the food ration on pH related to rumen. Furthermore, Allen [5] reported that utilizing finely chopped forage instead of large-sized chopped forage results in the 5 percent reduction in the buffer salivation flow. Nevertheless, through increasing the amount of forage NDF in the food ration from 20 to 24 percent, the buffer salivation flow increased less than one percent. Besides, providing the livestock with the adequate NDF without considering the size of forage particles may lead to metabolic diseases [6]. It seems that the average size of the necessary dried particles of forage is about 3 mm for maintaining the PH of rumen, the chewing activity, as well as the fat percentage of milk [7]. The food rations which contain silage forage with particles less than 3mm may lead to reduction in the fat percentage of milk, the PH of rumen, and the chewing activity duration [2]. Evaluating the relationship between the length of particles and the total chewing duration through using the data from 10 experiments on dairy cows, Allen [5] concluded a 3 mm point which did not influence the increasing chewing point with reference to the other particles' length. Also, whenever the average length of forage particles is less than 3 mm, the NDF concentration within the food ration should increase about several units in terms of percentage. The rations which contain finely chopped forage and starch sources (e.g., barley or highly moisture corn) may need a higher level of NDF for maintaining the fat percentage in milk.

EFFECTIVE PHYSICAL FACTORS OF FIBERS

Effective physical factors of fibers depend upon the amount of non-structural carbohydrates [8], the shape of particles [9], the breakability of particles [10], as well as the size of the particles [11]. The current study aims to investigate the effect of food particles on ruminants' digestibility.

THE AVERAGE PARTICLE SIZE OF FORAGE AND TOTAL MIXED RATION (TMR) BY UTILIZING PENNSYLVANIA SYSTEM

Within the following table, Konnoff et al. [12] have collected the recommended particle size of forage and the mixed ration.

Table 1. Forage and TMR Particle Size Recommendations as Estimated by the Penn State Particle Size Separator.

	Type		
	Corn Silage	**Forage age**	**TMR**
Sieve Size	**%DM retained**		
>19.0 mm	5+/-3	15+/-5	5+/-3
19.0-8.0 mm	55+/-10	60+/-15	40+/-10
8.0-1.18 mm	40+/-10	30+/-10	40+/-10
<1.18 mm	<5	<5	</20
MPL (mm)[a,b]	8+/-2	10+/-2	5+/-2

[a]As estimated by the Penn State Particle Separator [12].
[b]MPL = geometric mean length as calculated by the ASAE [13].

The Effect of Food particle Size on Ruminal Fermentation

The fiber part of food causes the stimulation of chewing and production of saliva; hence, it creates a favorable environment for the growth of rumen micro-organisms. The rations that the lower fibers possess and the shorter particle size cause reduction in chewing, buffer secretion of saliva, PH of rumen, acetate production, as well as fat percentage of milk. The acidity level of rumen in ruminants is influenced by Lactic acid and other fatty acid production.

In their study on the effect of decreasing forage particle size on effective fiber values and ruminal fermentation, Kononoff et al. [12] concluded that cows which consumed shorter forage were able to eat much more than the other cows. Also, the high level of forage digestibility led to increased concentration of fatty acids in their rumen. Furthermore, Shaver et al. [7] reported that the decreasing in the forage particle size reduces chewing activity. Hence, when chewing activity is reduced, micro-organisms are increased and the ratio of Acetates to Propionates is decreased.

The Effect of Food particle Size on the Amount of Consumed Food and Chewing Process

In their study on the physical deficiency in the ration of ruminants, Cole and Mead [14] found that fibers with adequate size in cows' ration decrease the level of rumination, disrupt the belching operation, and reduce both consumable food and appetite. In addition, Krause [15] reported that decreasing the length of silage corn seeds in the ration increased the amount of dried consumable materials. Normally, food ration containing large-sized corn enjoy slower level of speed in passing through reticulorumen [16]. Moreover, Kennedy et al. [10] concluded that decreasing the length of forage particles in the ration increased the amount consumable food probably due to the increase in particle surface in contact with the microorganisms of the rumen; consequently, fermentation is increased. One of the most prominent factors, which are effective on the amount of ruminants' consumable food, is reticulorumen dilation in that the animal's needed energy is provided through filling up the rumen. Hence, large-size forage causes rumen's filling up since the speed of particles' passing in the rumen is controlled [5, 17]. Investigating the effects of alfalfa particle size and specific gravity on chewing activity, digestibility, and performance of Holstein dairy cows, Teimouri Yansari *et al* [18] demonstrated that decreasing in the alfalfa particle size causes reduction of time in ruminants' consumable food and the total chewing activity.

The Effect of Food particle Size on Digestibility

Teimouri Yansari et al. [18] illustrated that decreasing the alfalfa particle size did not have significant influence on the digestibility of dried material, organic matter, crude protein, non-fiber carbohydrate, as well as crude fat. Nonetheless, NDF digestibility and ashes were significantly reduced in that NDF digestibility in the entire digestive tract was attributed to the reduction in the persistence of forage within the network and to the network digestibility. On the other hand, Yang et al. [19] did not find any significant influence on NDF digestibility by decreasing the forage particle size. Decreasing the particle size results in an increase in both the digestibility level of edible materials and the bacterial contact level; consequently, such reduction causes an increase in the digestibility level.

Scrutinizing the size effects of 5 types of forage, Maulfair et al. [20] found that increasing the length of forage culminated in the reduction of both feces NDF concentration and indigestible NDF concentration. They investigated the effects of short, medium, long, as well as very long (1.46 mm, 5.10 mm, 5.32 mm, and 5.84 mm) forage. They, also, evaluated the appearance efficiency of nutritional materials and demonstrated that increasing the length of forage particles only resulted in digestibility reduction of dried matter and did not have any significant influence on the digestibility level of other nutritional materials within the ration. Furthermore, Zhao *et al* [21] reported that the digestibility level of nutritional materials (such as dried material, organic material, and starch) with regard to the digestibility tract of goats were not significantly influenced by the length of forage particles and the amount of crude fiber. Nevertheless, such materials had a significant impact on fiber digestibility level in colon and the entire digestive tract.

CONCLUSIONS

In fact, ruminants possess an effective sustainable system for maintaining the most amount of digestible energy which operates in terms of an increase in fresh nutritional materials and also an increase in passing of the previous nutritional particles. Such a sustainable system not only underscores chemical characteristics and concentration of nutritional materials, but also emphasizes on the importance of their physical attributes such as forage particle size. NRC's [23] reported that forage particle size up to .6 cm does not play a significant role on rumen digestibility. Whenever soft alfalfa is used, digestibility in the rumen is reduced. As a result, alfalfa is transferred to the narrow intestine of the animal. In this regard, since a part of the alfalfa contains fiber and such fiber in the narrow intestine does not enjoy sufficient bacteria as in the rumen, they are not digested and the digestibility level of the alfalfa is reduced within the intestine pipe.

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