

EFFECTS OF FORAGES AND TOTAL MIXED RATIONS PARTICLE SIZE ON PHYSICAL EFFECTIVENESS AND CHEWING ACTIVITY OF LACTATING COWS

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Abstract: In study are determined effects of four different mean lengths of corn silage, alfalfa haylage and total mixed ration (TMR) for lactating cows on physical effectiveness (pef), physically effective fiber content (peNDF) and total chewing activity. High correlations were found between mean particle length of forages and TMR and their physical effectiveness in lactating cows nutrition as also with physically effective fiber content. Significant effect of ration particle size on stimulating total chewing activity of lactating cows was determined.

Key words: cows, nutrition, physically effective fiber, chewing activity

Introduction

Using of NDF as chemical indicator of dietary fiber content, does not indicate on more subtle fibers' characteristics such as their importance for the kinetic of digestion and digesta passage, regarding to fibers' physical characteristics. Physical characteristics of fibers affect on animal health, ruminal fermentation and feed conversion efficiency, animal metabolism, milk fat content. Physical characteristics of rations for lactating cows are influenced by dietary forage to concentrate ratio, type of forages and concentrates, and mean particle size of feeds (*Stojanović et al. 2009*).

Balch (1971) proposed the chewing time per kg of dry matter (DM) as indicator of physical characteristics of forages, which was called index of roughage value. *Sudweeks et al. (1981)* measured required chewing time for forages and concentrate feeds, and developed indexing system where each feed were given appropriate value regarding to ability for stimulating chewing activity. Using of this index for anticipation of milk fat content, indicated on total chewing time required per kg of consumed DM as 21.4, 32.4 and 44.8 min. to maintain milk fat content at 3.2, 3.5 and 3.9 %. *Mertens (1997)* developed a system for physically

effectiveness factor (pef) determination used for calculating of feeds' physically effective fiber –peNDF content.

Traditionally, definition of fiber effectiveness refers to the ability of dietary fibers to maintain an optimal level of milk fat, and to ensure good health of dairy cows (Stojanović et al. 2002). Physically effective fiber-peNDF are associated with the physically characteristics of the fibers (primarily particle size) that affect on total chewing activity (total time of eating and ruminating), as also on two-phase nature of ruminal content (larger floating particles-ruminal mat and liquid content that includes smaller feed particles). Concept of peNDF is a quantification and integration of chemical and physical characteristics of fibers in a single measure or indicator (Stojanović et al. 2008).

System for determination of peNDF based on chemical and physical analyses consists of determination of feed or ration NDF content and portion of feed particles retained on 1.2 mm sieve (Mertens, 1997). Physically effectiveness factor-pef is equivalent to portion of particles larger than 1.2 mm, and content of physically effective fiber-peNDF is calculated by multiplying NDF feed or diet concentration with factor-pef.

Practical system for determination of peNDF intake of lactating cows is based on measuring of mass of feed particles retained by the 19, 8 and 1.2 mm sieves (system of sieves- Penn State Particle Separator - PSPS, Kononoff et al. (2003), and chemical analysis of NDF content of each fraction.

Study was conducted to analyze the effect of different particle size of forages and total mixed rations (TMR) for cows at early lactation, on physically effectiveness of feeds and diets, their physically effective fiber content, as also effect on stimulating of total chewing activity at lactating cows.

Materials and Methods

Study was conducted at four farms of dairy cows at PKB Corporation Belgrade. During one week, daily in three samples, using system of sieves (Penn State Particle Separator - PSPS) was determined mean particle size and mass of particles' fraction of corn silage, alfalfa haylage and TMR for cows at early lactation.

Two methods were applied for determination of peNDF content (Yang and Beauchemin, 2006): method based on determining a portion of sample DM retained by sieves of PSPS (physically effectiveness factor-pef), and average sample NDF content on DM base; method based on determining a portion of total sample NDF content retained by PSPS-sieves; obtained values are signed as peNDF_{3s} and peNDF_{3s_ndf}, respectively.

Average particle size of forages and TMR was determined using Particle Size Analysis method (Heinrichs and Kononoff, 2002). Total chewing activity (TCA,

intake and ruminating) for forages and TMRs was determined using model of *Mertens (1997)*: $TCA (\text{min/kg DM}) = 150 \times 0.01 \times \text{peNDF} (\%)$.

On the basis of obtained values for dietary DM intake, values for TCA (min/day) were determined, for each animal. The study was conducted on total of 403 Holstein cows, at four farms of PKB Corporation Belgrade (99, 109, 84 and 111 cows, respectively). Cows were at early lactation (10-60 days in milking), multiparous (2-5. lactation). Mixed part of ration was formulated to meet requirements for 24 kg of milk production, with 3.5% of milk fat and 3.1% of milk crude protein content. Cows were additionally fed concentrate and extruded soybean, according to milk yield. During the one week, distributed quantity of TMR and orts were recorded daily to calculate feed intake.

Table 1. TMR composition, kg of DM

Feeds	Groups-farms			
	I	II	III	IV
Corn silage	5.03	5.52	4.79	5.25
Alfalfa haylage	0.88	0.87	0.74	0.67
Alfalfa hay	3.38	3.89	3.87	3.33
Mixture for lactating cows, 18% CP	5.34	5.18	5.34	5.73
Extruded soybean meal	0.92	0.74	0.90	0.73
Beet pulp, dry	0.38	0.27	0.36	0.47
NaCl	0.04	0.04	0.04	0.04
NaHCO ₃	0.07	0.07	0.07	0.07

Tabular values for physically effectiveness of mixture and extruded soybean were taken, 0.3 and 0.4, respectively (*Mertens, 1997*).

Chemical analyses of average samples of feeds, TMRs and PSPS-fractions were done at Laboratory of Animal Nutrition, Faculty of Agriculture.

Obtained results were statistically analyzed using computer software STATISTICA v.6 (*StatSoft, 2003*). Parameters of descriptive statistic and correlations were determined, and ANOVA procedure, and Tuckey Honestly Significant Difference Test, were used to analyze significance of differences ($p < 0.05$ and $p < 0.01$).

Results and Discussion

High correlation was found between particle size of forages and TMR.

Table 2. Average particle size of forages and TMR, mm

Item	I	II	III	IV
Corn silage	9.31	8.79	8.46	7.51
Index	100	94.41	90.87	80.67
Alfalfa haylage	8.26	7.86	7.46	7.11
Index	100	95.16	90.31	86.08
TMR	8.05	7.11	6.95	5.26
Index	100	88.32	86.34	65.34

Table 3. Average NDF content of forages, TMR and PSPS-fractions, % DM

Item	I	II	III	IV
Corn silage	47.03	42.34	48.34	46.45
Fractions of particles				
> 19.0 mm	60.15	69.93	61.31	62.23
19.0 – 8.0 mm	48.00	56.75	45.66	46.53
8.0 – 1.2 mm	44.43	42.19	43.38	43.77
< 1.2 mm	29.77	28.86	27.33	28.02
Alfalfa haylage	45.83	46.21	43.63	43.56
Fractions of particles				
> 19.0 mm	53.99	50.27	57.02	51.40
19.0 – 8.0 mm	50.15	48.38	50.01	47.55
8.0 – 1.2 mm	43.00	42.32	44.36	42.51
< 1.18 mm	35.14	39.35	33.22	37.38
TMR	35.13	35.06	33.94	36.27
Fractions of particles				
> 19.0 mm	57.07	53.33	60.69	57.42
19.0 – 8.0 mm	37.38	35.72	35.09	38.28
8.0 – 1.2 mm	36.59	33.68	36.87	33.38
< 1.2 mm	24.78	27.14	24.86	21.78

Obtained values for physically effective fiber content of TMR indicate that lowering average particle size of forages decreases peNDF content, and decreases physical effectiveness of ration. Correlation between TMR average particle size and concentration of peNDF_{3s} was $r=0.97$, whereas for peNDF_{3s-ndf} was $r=0.73$.

Determined values for corn silage, indicate that correlation between particle size and peNDF content was even low negative $r=-0.06$ for peNDF_{3s}, and $r=-0.09$ for peNDF_{3s-ndf} content. This is a result of different NDF concentration of corn silages from different farms (42.34-48.34% DM). Obtained values for effect of alfalfa haylage average particle size on physically effective fiber content were $r=0.72$ for peNDF_{3s}, and $r=0.88$ for peNDF_{3s-ndf}.

Table 4. Physically effectiveness factor and peNDF content (%DM) of forages and TMR

Item	I	II	III	IV
Corn silage				
pef	0.98	0.98	0.97	0.97
peNDF _{3s}	46.14	41.62	47.08	45.20
peNDF _{3s-ndf}	46.46	41.95	47.59	45.68
Average	46.30	41.79	47.34	45.44
Alfalfa haylage				
pef	0.90	0.91	0.89	0.91
peNDF _{3s}	41.38	42.00	38.74	39.73
peNDF _{3s-ndf}	42.53	42.60	40.22	40.38
Average	41.96	42.3	39.48	40.06
TMR				
pef	0.96	0.93	0.93	0.84
peNDF _{3s}	33.55	32.54	31.63	30.39
peNDF _{3s-ndf}	34.14	33.14	32.36	32.58
Average	33.85	32.84	32.0	31.49

Determined values for peNDF content of forages and TMR were slightly higher, when second method was used.

Obtained results are consistent with earlier studies. Values for TMR physically effectiveness factors (pef) were within a narrow interval 0.93-0.94, whereas peNDF content ranged between 28.6-34.0%, and were not obtained differences in pef and peNDF contents, between rations based on alfalfa haylage with different chopping length (7.9 and 19.1 mm), (*Yang and Beauchemin, 2007*). *Yang and Beauchemin (2006)* compared results of measuring the distribution of PSPS-fractions of TMR particles (three different average particle size), and found values for pef were within the interval 0.89-0.85.

Table 5. Average values for total chewing activity of lactating cows

Feeds	I	II	III	IV
min/kg of consumed DM				
Corn silage	69.45	62.69	71.01	68.16
Index	100.0	90.27	102.25	98.14
Alfalfa haylage	62.94	63.45	59.22	60.09
Index	100.0	100.81	94.09	95.47
TMR	39.70	38.96	37.78	37.19
Index	100.0	98.14	95.16	93.68
min/day				
TMR	864.27 ^a	867.10 ^{ab}	825.83 ^c	822.84 ^d
Index	100.0	100.33	95.55	95.21

^{a,b,c,d} Means in the same row with different superscripts differ ($p < 0.01$)

Obtained results indicate on high correlation between chewing activity and particle size of alfalfa haylage ($r=0.80$). High correlation is determined between

TMR particle size and total chewing activity of lactating cows ($r=0.90$) expressed as min/kg of consumed DM, and slightly lower $r=0.75$ when expressed as min/day. There was no correlation between the average particle size of corn silage and total chewing activity of cows ($r=-0.08$), which is likely due to different content of peNDF and NDF of analyzed silages.

There was a significant effect ($p<0.01$) of decreasing TMR particle size on reduction of total chewing activity (min/day). The highest value for total chewing activity was determined at cows fed ration with the largest average particle size (8.05 mm, I-group), and the least at cows at the fourth group (particle size 5.26 mm).

Determined values for total chewing activity are consistent with earlier researching. Decreasing of forages' particle size (5.3 and 2.7 mm for alfalfa haylage, and 5.6 and 2.8 mm for corn silage), reduced chewing activity for consuming of ration (4.2 to 3.6 h/day, and from 11.0 to 9.9 min/kg DM), the chewing time for ruminating was also reduced (7.3 to 5.7 h/day, and 19.2 to 16.3 min/kg DM), (*Krause and Combs, 2003*). Reducing of cutting length of alfalfa haylage (22.3 to 4.8 mm) in ration for Holstein cows at early lactation, decreases total chewing time from 776.7 to 723.4 min/day, from 37.9 to 31.2 min/kg DM, as also from 120.8 to 99.7 min/kg of consumed NDF (*Kononoff and Heinrichs, 2003*). Total chewing time and ruminating time are in positive correlation with forages' content of peNDF and NDF (*Zebeli et al. 2006*). Higher TMR concentration of peNDF increases chewing activity, as also salivation, and prevents decreasing of ruminal pH, due to buffering effect of saliva and neutralization of large quantity of acids formed due to fermentation.

Conclusion

Using of PSPS-sieves system is an efficient and practical method for determination of physical effectiveness of forages and total mixed rations. It was obtained a significant correlation and effect of alfalfa haylage and TMR particle size on physically effective fiber content and total chewing activity of lactating cows. Reducing TMR average particle size decreases total chewing activity of lactating cows. There was not determined correlation between particle size of corn silage and physically effective fiber content, as also chewing activity, which is likely due to greater variation of NDF content at analyzed silages, and relatively small interval of variation of silages' average particle size.

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Uticaj stepena usitnjenosti kabastih hraniva i kompletnog obroka za krave u laktaciji na fizičku efektivnost i aktivnost žvakanja

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Rezime

U istraživanju je determinisan uticaj četiri različita stepena usitnjenosti silaže cele biljke kukuruza, senaže lucerke i kompletno mešanog obroka za krave u laktaciji, na fizičku efektivnost (pef), sadržaj fizički efektivnih vlakana (peNDF), i ukupnu aktivnost žvakanja. Utvrđena je visoka povezanost stepena usitnjenosti kabastih hraniva i kompletnog obroka sa njihovom fizičkom efektivnošću u ishrani krava, kao i sa sadržajem fizički efektivnih vlakana. Ustanovljen je statistički značajan efekat stepena usitnjenosti obroka na stimulisanje ukupne aktivnosti žvakanja kod krava u laktaciji.

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