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RESEARCH ARTICLE

IMPLICATION OF DIFFERENT NON-FIBROUS CARBOHYDRATE SOURCES ON INTAKE, NUTRIENTS DIGESTIBILITY AND PRODUCTION OF LACTATING-COWS IN EGYPT

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ABSTRACT

In this research, we aimed to study the implications of different carbohydrates sources on dry matter intake, nutrients digestibility and production, 9 lactating-cows (days in milk= 110±30 d; live weight=670 ± 40 kg) were allotted into3 groups (3 cows per each) for one month period. The treatments included different sources of non-fibrous carbohydrate (NFC), where its percentages are (44.38, 44.59 and 44.25% DM in basal diet treatment (B), beet pulp diet treatment (BP) and dried distillers' grains diet treatment (DD), respectively). Cows of group BP had a higher DMI, where DMI and NDF digestibility were improved. Ruminal pH was increased in group cows B and DD (6.63 and 6.64, respectively) compared with those that received BP group (6.26). The propionate percentage was decreased and pH increased in the BP group; whereas, a higher percentage of acetate and ratio of acetate: propionate were noticed with animals allotted to B treatment. Milk improved with BP group. Replacing NFC sources with different digestion coefficient, this change feed intake, ruminal bacterial population, and lactation performance. We could conclude that inclusion of different sources of NFC produce a better performance and productivity.

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INTRODUCTION

Carbohydrate is the main component of dairy feeds and rations. Carbohydrate is divided into non-fibrous carbohydrate (NFC) and neutral detergent fiber (NDF), both make up to 75% of rations. The NFC composed from neutral detergent soluble carbohydrate (NDSC), starch and sugars. Tafaj et al., 2007 and Varga, 2003 reported that carbohydrates balance in dairy cow diets affect by NDF amount and NFC, also NDF composition, NFC composition, and NDF:NFC ratio. However, NDF requirement percentage (27% - 37%), besides NFC content (45% - 35%) (NRC, 2001). The NFC value is reported as a single number, but its fractions are largely varies. The starch is deponent in NFC in maize (65-70%), while sugar in beet pulp ranges (12-40%) and NDSC (25%–44%). Dried distillers' grains with solubles (DDGS) is characterized by high crude protein (25- 32%, dry matter) and 47% NDF (Belyea et al. 2010). When DDGS is added in cows ration, it replaces soybean meal as a source of protein, besides it consider a source of energy as it replaces corn (Ranathunga et al. 2010).

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Janicek et al. (2008) limit addition of DDGS to 10% in ration due to high fat content, which disturb ruminal fiber digestion and the microbial population (Van Soest 1994) and reduce milk fat production. Anderson et al. (2006) recommended DDGS as it maintain high milk yield, furthermore, Janicek et al. (2008) feed up to 30% of the ration and found positive effect on milk yield and quality. In addition, Gehman and Kononoff (2010) observed a reduction of N excretion and efficient N utilization for milk production. NRC, (2001) and Larson (2003) documented that rapidly degradable starch effects on fiber fermentation, where a rate of replacing NFC by fiber of ration; starch digestion site; DMI and the physiological state; and processing methods of NFC sources, are the main cause of variation in the impact of the amount and nature of NFC on lactating-cows. However, the recommended amount of NFC for dairy cow rations is not clear. According NRC, (2001), the absence of clear recommendations is due to wide nutritional values in the sources of NFC, nutrient digestion, and the metabolism. Consequently, deep understanding of NFC types, digestibility and metabolism can improve animal productivity besides maintaining health. The NFC nature varies among feeds and diets. The impact of increasing or decreasing NFC was completely related to NDF (Grant, 1997 and Tafaj et al., 2007), so we could conclude that the content of NFC from different feeds gives a different action of NDF.

The physically effective NDF (peNDF) give focus on particle size, NDF amount, and effect of replacing forage fiber with NFC, that inform us about the effect of feed particles and chewing performance (Teimouri and Primohammadi 2009). Therefore, more information and studies of the values of NFC types in feeds help in the optimal utilization of feed ingredients, and formulate appropriate dairy rations that could improve performance. Whereas, ruminal acidosis is more common in dairy farms, the knowledge on the perfect level of soluble carbohydrate in diets of dairy cows is critical to make its control easer, besides the effective milk production from available energy. The main object of the current work was to study the impact of different feed carbohydrate, (wheat bran (B), beet pulp (BP) and DDGS (DD)) on DMI, digestibility of nutrients, chewing time and milk production.

MATERIALS AND METHODS

Cows and rations

The study was done at Khafagi Farm for milk production, Kafr El-Sheikh governorate, Egypt. The trial was conducted under the observation and according the regulation of Nutrition and Clinical Nutrition Dept. Faculty of Vet. Med. Soahg University. Nine mid-lactation Frisian dairy cows (BW = 670 ± 40 kg; DIM = 110 ± 30 d) were separated into three groups (3 per each). The experiment lasts 30-d periods (adaptation period, 14 d; samples collection periods, 14 d; and estimation of chewing activity period, 2 d). Diets composed from different sources of carbohydrate, (Table 1). Wheat bran, beet pulp and DDGs were prepared by miller with sieve 2-mm pores. Rations had the same composition (17.2% CP and 1.56 Mcal/kg of NEL) and same fiber characteristics (peNDF) (Table 2). Animals in different group were separated in different places. Diets were given ad-libitum twice per day for all groups, diets amount are adjusted (as-fed basis) with 10% remain as residue. Animals had free access to water and mineralized blocks along the experimental time.

Feed particle size and effective fiber

A Penn State feed particle separator was used to determine feed particle length and distribution (Kononoff, 2002). The NDF content on separator sieve layers were determined according to AOAC,(2002) and Van Soest et al., (1991). The physical effective factor (pef) of the diets was measured. Regarding to Kononoff, et al. (2003) the measure of pef was attributed to the amount of feed remain on the 1.18-m sieve and referred as pefm, while amount retained by 19- and 8-mm sieves referred as pef>8, and the amount remain by 19, 8, and 1.18-mm sieves refereed as pef>1.18, (Table 2).

Live weight, feed intake, and digestibility of nutrients

Live BW was estimated every week, while feed intake was estimated every day. Diets samples, residual feed and animal feces were collected every day for successive 7 days at morning milking, weighed. The samples kept after drying at 55°C /48 h and prepared with 1-mm screen mill, for the analysis of dry matter, protein, total lipids, ash, NDF, and ADF (AOAC, 2002) (Table 3). Non-fibrous carbohydrate was estimated by this equation: 100 - % CP +% NDF +% ash +% EE (NRC, 2001). Soluble sugars and starch were measured in diet samples (Table 3), while The NDSC was estimated as NFC (%) by this equation: (Sugar (%) + Starch (%), (Hall, et al., 1999). The feed intake and digestibility (% of DM) were estimated. Intake of peNDFs ($_{m}$, $_{>8}$ and $_{>1.18}$) were estimated for all groups.

Rumen characteristics

Fifty mL from ruminal liquor were collected 3 hours after the morning diets, with rumenocentesis approach. Fluid acidity was estimated after extraction as early as possible with a portable pH meter, and then samples were kept at −20°C. The ammonia nitrogen in rumen liquor was estimated (Inkjel, behrotest (Model S1, Behr Co. Germany). Acidification of ruminal liquors were done by addition of 2.5 mL HCl of 6-mol/L and then frozen for more analysis of VFAs and ammonia. Gas chromatography used for VFAs after centrifugation at 18,000 rpm /20 min (Merchen, et al., 1986).

Feeding and rumination times

Feeding and rumination activities were observed for animals in all groups over a day time (24-h) for 2 days and at day 23 to 24. These observations of activities were recorded at intervals of 5-min and continue for the entire interval. Total chewing time was calculated as the summation of both eating and rumination times (Teimouri and Primohammadi, 2009) (Table 4).

Milk yield

The daily milk production was recorded along the experiment time. On day 15 to 20, samples were taken every time of milking. A100 mL milk samples were used to determine milk fat %, protein%, and lactose% (AOAC, 2002).

Statistical analysis

The main impact of diets was analyzed by one-way analysis of variance with the procedure of Excel program (Microsoft Office, 2010). At observation of significant difference in the analysis, Bonferroni Correction (Bonferroni Post Hoc Test) was used to know statistical significance ($p<0.05$) among groups and means were separated.

RESULTS AND DISCUSSION

Feed composition, and physical character

The treatment diets are similar in chemical composition and physical character in all nutrients except for starch, sugar and NDSC percentages. The sugar concentrations were the same for B and DD groups and both were lesser than that reported with BP group (5.89, 5.81, and 6.24 %, respectively) while, the percentages of starch was higher with basal-diet followed by brewers dried-diet then beet pulp-diet came last (31.45, 28.77, and 27.01 % for B, DD, and BP groups, respectively). Besides, the percentage of NDSC was the higher at DD group followed by BP and B groups (11.6, 9.38 and 7.07%, respectively). Separation of feed particles, documented as percentage of total amount, feed particle remained on both 19, 8-mm sieves for the three rations were 10.33, 11.24 and 10.52; 21.40, 21.12, and 19.44 %; for B, BP and DD groups, respectively, while amount retained on 1.18-mm sieve differ, the DD group was higher than both B and BP groups (37.68, 35.14, 34.73 %, respectively).

Table 1. Feed ingredients and chemical analysis of rations containing non-fiber carbohydrates from different sources

Item	Groups		
	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
Ingredients, % of DM			
Alfalfa hay	25.05	25.01	26.04
Corn silage	15.05	14.83	15.33
Wheat bran	20.01	7.04	7.29
Soybean meal	3.06	3.05	00
Sunflower meal	3.06	3.05	3.43
Cotton seed meal	3.06	3.05	3.43
Corn grain	30.11	28.02	29.17
Beet pulp	00	15.00	00
DDGs	00	00	15.06
Vitamin-mineral supplement[1]	0.25	0.25	0.25
Urea	0.35	0.7	00
Chemical analysis, % of DM (Mean±SD)			
CP	17.26± 0.16	17.17±0.82	17.21±0.23
NDF	31.43±0.82	31.37±0.66	31.11±0.2
ADF	24.08±0.21	24.53±0.74	24.73±0.14
NFC	44.38±0.14	44.59±0.3	44.25±0.3
Starch	31.45±0.26[a]	27.01±0.19[c]	28.77±0.21[b]
Sugar	5.89±0.39	6.24±0.09	5.81±0.11
NDSC[2]	7.07±0.15[c]	11.60±0.2[a]	9.38±0.16[b]
EE	3.25±0.03[ab]	3.07±0.14[b]	3.44±0.13[a]
Ash	3.84±0.11b	4.26±0.14[a]	4.28±0.15[a]
NEl[3], Mcal/kg of DM	1.56±0.01	1.57±0.01	1.58±0.01

[a, b, c] The means with different subscripts within each row differ ($P < 0.05$).
[1]Vitamin-mineral supplement: Cover the dairy requirements of trace mineral and vitamins according to NRC, (2001).
[2] NDSC: Neutral detergent soluble carbohydrate.
[3] NEl was estimated according to NRC, (2001).

Table 2. Fiber physical characteristics of the rations containing non-fiber carbohydrates from different sources

Item	Groups		
	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
Particle size content (amount remain on each sieve) (% of DM) (Mean±SD)			
19 mm	10.33±0.34	11.24±0.29	10.52±0.38
8 mm	21.40±0.51[a]	21.12±0.22[a]	19.44±0.1[b]
1.18 mm	35.14±0.12[b]	34.73±0.16[b]	37.68±0.15[a]
Pan	33.20±0.1[a]	33.24±0.11[a]	32.42±0.05[b]
Physical effective factor			
Pef > 8 [1]	31.73±0.71[ab]	32.36±0.41 [a]	29.95±0.44 [b]
Pef > 1.18[2]	66.87±0.7	67.1±0.26	67.63±0.29
Physical effective NDF, % of DM [3]			
peNDF > 8	9.97±0.13 [a]	10.15±0.13 [a]	9.32±0.11 [b]
peNDF > 1.18	21.01±0.35	21.05±0.38	21.04±0.11

[a, b, c] The means with different subscripts within each row differ ($P < 0.05$).
[1, 2]pef>8 = physically effective factor, determined as % of DM retained on sieves layers of the standard Penn State particle separator.
[3]The peNDF was estimated by multiplying NDF content of each portion on each sieve on respective pef.

Table 3: Live body weight, intake, and nutrient digestibility of rations containing non-fiber carbohydrates from different sources

Item	Groups		
	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
		(Mean±SD)	
BW, kg	602.67±16.17	592.00±12.53	585.33±16.62
Intake, kg/d			
DM	21.3±0.26 [b]	22.03±0.15 [a]	20.17±0.23 [c]
NDF	6.69±0.24 [ab]	6.91±0.13 [a]	6.27±0.05 [b]
$peNDF_{>8}$[1]	2.12±0.03[b]	2.24±0.03[a]	1.88±0.04 [c]
$peNDF_{>1.18}$[2]	4.48±0.11[ab]	4.64± 0.08[a]	4.24± 0.05 [b]
CP	3.68±0.04[b]	3.78±0.03[a]	3.47±0.06[C]
NFC	9.45±0.14[a]	9.82±0.08[a]	8.92±0.1[b]
Starch	6.7± 0.14 [a]	5.95±0.05 [b]	5.8± 0.07 [b]
Sugar	1.25±0.07[ab]	1.38±0.02[a]	1.17±0.03[b]
NDSC[3]	1.5±0.07 [c]	2.5±0.12 [a]	1.95±0.08 [b]
EE	0.69±0.01	0.68±0.04	0.69±0.03
OM	20.52±0.4[a]	21.19±0.1[a]	19.36±0.19[b]
Digestibility, %			
DM	74.77 ±1.62 [ab]	75.81±0.5 [a]	74.09±0.47 [b]
NDF	69.4± 1.02 [a]	66.85± 0.62 [ab]	64.33±2.4 [b]
ADF	59.71 ± 1.36	54.44 ± 1.93	55.69± 1.85
CP	75.72±2.05	76.23±1.76	73.34±1.28
NFC	85.64±0.98 [b]	89.63±0.71 [a]	88.95±1.09 [a]
EE	67.85±1.47	68.73±0.42	67.87±1.31

[a, b, c]Means with different subscripts within each row differ ($P < 0.05$).
[1, 2]$peNDF_{>8}$ = physically effective NDF, determined as the proportion of DM retained on sieves of the standard Penn State particle separator.

The amount of pef (>8 and >1.18-mm sieves) and peNDF of the diets were different (Tables 1, 2). The lowest pef values of rations was pef>19-mm, although the pef>1.18 values were higher in all groups, this reflect the variation of peNDF values among groups. In the current study, peNDF>1.18 were around 21% DM, where Mertens (1997) recommended 21% to maintain optimal chewing activity where the rumen pH was higher than 6.0 and 20% to maintain milk fat percentage. The variances among groups were attributed to the impact of both peNDF content of rations and NFC composition, besides its sources. Starch amount of BP and DD groups was similar and lower than that recoded in the B group, but the NDSC significantly differ among groups. These data proved that amount of starch and soluble carbohydrates differ with different NFC sources. Our hypothesis was that feeding different carbohydrate sources, (NDF and NFC source), could change DMI, rumen characteristics, chewing activity, and milk yield and composition. In our work, milk yield and its fat percentage are more related to particle size (PS) on 8-mm than both 19-m and 1.18-mm sieves, where Esmaeili et al. (2016) and Kononoff, (2002) found that it is more related to 8-mm and 19-mm sieve. In the line of our results Yang and Beauchemin (2007) found same positive relation and documented that peNDF8 and the amount of particles 1 9mm were more important variables than peNDF 1.18.

DM intakes and apparent digestibility

Feed intake, NDF and peNDF>1.18 intake were different ($P < 0.05$), this reflect the difference in the intake of CP, NFC, and EE, among treatments. Changing NSCS sources increase feed intake at BP treatment, where reduced with DD treatment (Table 3). The NFC nature affects feed intake, and milk production and its quality. Increasing feed intake was recorded as a response for BP feeding. Intake of starch, sugars, and NDSC differed among the groups. Animals allotted to B and BP diets had better intake of starch compared with DD diet. Animals allotted to the DD diet had the lowest intake of both sugar and NDSC. Digestibility of DM, NDF, NFC, and EE differed among treatments. The better DM and NDF digestibility were recorded with treatment B (Table 3).

The intake of NDF, NFC and peNDF>1.18 differed than its pattern in the diets. Treatment BP, which had more NSDC intake, showed increased in DMI. These results have been supported by Poorkasegaran and Yansari et al., (2014). Replacing sugars and NDSC instead of starch has effects on intake where DMI was increased (Broderick et al., 2002) or not affected (Friggens et al., 1995). Also, raising of NDSC intake at the expense of starch may increase DMI (Allen et al., 2000), decrease (Broderick et al., 2002), or still as it (Leiva et aal., 2000). Variance in digestibility of fiber using different NFC sources may explain these results (Larson2003). Increased DMI in treatment BP could have been explained according to high NDSC and sugar content and compared with treatments B and DD. In our trial, DMI reflect the NFC intake by treatments, besides the VFA concentration where it is production has a positive relation with rate of fermentation of starch. Whereas, BP are higher intake followed by B and then came DD group (22.03, 21.3 and 20.17 respectively), and the NFC and sugar have the same pattern, the starch and NDSC have different pattern, also we could attribute this increase of DMI to higher level of VFA that also have the same order of DMI (115.43, 115.39 and 108.48 mol/L) (Table 5). Therefore, it looks like that VFAs metabolism in the body, reduce DMI in groups B and DD compared with BP. Leiva et al., (2000) explain the DMI reduction according to propionate content and metabolism in liver due to the reduction of hepatic propionate oxidation. Besides, ruminal pH affects intake of feed, where at lower pH, the VFAs were rapidly absorbed (Poorkasegaran and Yansari et al., 2014). In addition, replacing grain with high-fiber ingredients (BP and DDG), may result in energy content reduction or limit feed intake through the filling effects of the feeds (Poorkasegaran and Yansari et al., 2014). Ramierz et al., (2012) found an improvement of DMI in feeding DDG, that we did not observed in our experiment, besides they found improvement in NDF digestibility and no productive response, confirmed by our results. Schingoethe et al. (2009) observed that DDGS feeding to lactating cows not affects or increases milk yield. In our study, milk production still constant by the DDGS feeding, but when comparing milk yield on an iso-energetic basis (3.5% FCM), we observe decrease in milk yield.

Obviously, cows allotted to B and BP diets produced 3.6 kg more 3.5% FCM than allotted to DDGS diets. This response is due to a negative impact of DDGS on milk fat percentage It is believed that diets that are highly fermentable and also has a great amount of unsaturated fatty acids result in rumen conditions that favor bacterial bio-hydrogenation of fatty acids and formation of intermediates of conjugated linoleic acid (CLA) that ultimately inhibit milk fat production of mammary tissue (Shingfield and Griinari 2007; Bauman et al. 2008; Ramierz et al., 2012). However, we suspected a different response because of the previous work that record that addition of DDGS up to 30% of the diet had not any effect on milk fat % (Anderson et al. 2006; Schingoethe et al. 2009). Whereas, Abdelqader et al. (2009) and Hippen et al. (2010) found that DDGS are responsible for reductions in milk fat %. Baumgard et al. (2000) attributed the reduction of milk fat % to feeding DDGS that contains high levels of polyunsaturated fatty acids (PUFA), where these fatty acids when consumed in large amounts they are bio-hydrogenated by ruminal microfona, producing an intermediates such as trans-10, cis-12 CLA that responsible for the decrease expression of lipogenic enzymes, so decrease production of milk fat in mammary tissue.

Generally, Peterson et al. (2003) and Hippen et al. (2010) found that the addition of high amount of DDGS with highly fermentable feeds result in an increased rumen production of fatty acid isomers that inhibit production of milk fat. The milk protein content is not affected in all treatments, whereas Rius et al. (2010) and Mjoun et al. (2010) suggested the improvement of it to consuming more energy and peptide substrates that are available for mammary tissue. BP and DDG are NFC sources, and have same mean of NDF percentage as forages, whereas they have a small particle size. No-one can deny that, DMI is regulated by ruminal distension, so the substitution of BP or DD with forage resulted in higher DMI, but when substitute grain, DMI decreased (Tafaj et al., 2007 and NRC 2001). In this trial, the physical characteristics of the diets numerical different but not significant; therefore, the relative filling effects not differ. In group BB, the ruminal distension not affected DMI (Varga, 2003). Broderick et al. (2002) observed that the higher propionate concentration in the ruminal liquor will activate receptors for propionate in the ruminal region that may control satiety and feed intake, where propionate has hypophagic activity more than acetate, resulting in decrease feed intake.

Table 4. The observation of chewing activity of lactating-cows fed on rations containing non-fiber carbohydrates from different sources

Items	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
	(Mean±SD)		
Eating, min/d	261.67± 7.64 [ab]	280.0± 5 [a]	260.0± 5 [b]
Rumination, min/d	353.33 ±7.64 [a]	298.33± 3.79 [c]	320.0± 5 [b]
Total chewing activity, min/d	615.0 ±10 [a]	578.33± 8.62 [b]	580± 5 [b]
Chewing time per nutrients, min/kg			
Eating			
DMI	12.28±0.24	12.95±0.29	12.90±0.39
NDF	39.09±0.27	40.51±0.44	41.45±1.0
$peNDF_{>8}$[1]	123.24±2.13 [b]	125.2±2.54 [ab]	138.44±5.26 [a]
$peNDF_{>1.18}$[2]	58.46±0.30	60.38±0.8	61.29±1.72
NFC	27.68±0.46	28.51±0.75	29.14±0.75
Starch	39.06±0.49[b]	47.04±0.83 [a]	44.83±1.44 [a]
NDSC[3]	174.66±3.54 [a]	112.4±7.33 [c]	133.34±4.45 [b]
Rumination			
DMI	16.59±0.34 [a]	13.54±0.42 [b]	15.87±0.13 [a]
NDF	52.83±2.44 [a]	43.16±0.79 [b]	51.01±0.4 [a]
$peNDF_{>8}$	166.48±5.33[a]	133.41±3.85 [b]	170.31±1.27 [a]
$peNDF_{>1.18}$	78.98±2.95 [a]	64.34±1.37 [b]	75.42±0.28 [a]
NFC	37.38±0.85 [a]	30.37±1.03 [b]	35.86±0.18 [a]
Starch	52.75±1.39 [ab]	50.13±1.32 [b]	55.16±0.84 [a]
NDSC	236.11±13.98 [a]	119.77±8.38 [c]	164.12±5.5 [b]
Total chewing activity			
DMI	28.87±0.18 [a]	26.25±0.71 [b]	28.76±0.41 [a]
NDF	91.92±2.71 [a]	83.68±1.22 [b]	92.46±0.74 [a]
$peNDF_{>8}$	289.72±5.38[b]	258.61±6.38 [c]	308.75±6.53 [a]
$peNDF_{>1.18}$	137.44±2.88 [a]	124.72±2.16 [b]	136.71±1.58 [a]
NFC	65.06±0.44 [a]	58.88±1.78 [b]	64.99±0.6 [a]
Starch	91.81±0.9 [b]	97.17±2.16 [a]	99.99±1.9 [a]
NDSC	410.77±17.48 [a]	232.16±15.68 [c]	297.46±8.88 [b]

[a, b, c]Means with different subscripts within each row differ ($P < 0.05$).

[1,2] peNDF>8 = physically effective NDF, determined as % of DM retained on sieves layers of the standard Penn State particle separator.

[3]NDSC = Neutral detergent soluble carbohydrate.

Table 5: Ruminal liquor pH, ammonia and VFAs concentration of rations containing non-fiber carbohydrates from different sources

Item	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
	(Mean±SD)		
pH	6.63±0.01 [a]	6.26±0.01 [b]	6.64±0.01 [a]
NH_3-N, mg/dL (Ammonia nitrogen)	7.37±0.06 [a]	7.43± 0.14 [a]	6.59±0.15 [b]
VFA concentration			
Total, mmol/L	115.39±1.88 [a]	115.43±1.8 [a]	108.48±1.98 [b]
Acetate, mol/100 mol	61.07±0.94 [b]	64.77±0.75 [a]	61.32±0.85 [b]
Propionate, mol/100 mol	26.16±0.54 [a]	25.76±0.31 [a]	24.33±0.31 [b]
Butyrate, mol/100 mol	6.54±0.03 [a]	6.27±0.14 [c]	6.38±0.14 [b]
Isobutytate, mol/100 mol	2.17±0.07	2.44±0.11	2.35±0.08
Valerate, mol/100 mol	3.23±0.09 [b]	3.45±0.03 [a]	3.38±0.07 [ab]
Isovalerate, mol/100 mol	2.3±0.07	2.46±0.07	2.28±0.09
Acetate: propionate	2.35±0.07	2.51±0.08 [a]	2.5±0.08

[a, b, c]Means with different subscripts within each row differ ($P < 0.05$).

Table 6: the implication of rations containing non-fiber carbohydrates from different sources on milk production and its constituents of lactating-cows

Item	Basal-diet (B)	Beet pulp-diet (BP)	DDG-diet (DD)
	(Mean±SD)		
Milk production and milk constituents, (kg/d)			
Milk	22.97±0.51 [b]	23.87±0.32 [a]	22.77±0.39 [b]
3.5% FCM[1]	23.52±0.56 [a]	25.09±0.25 [a]	22.91±0.4 [b]
ECM[2]	23.68±0.65 [b]	25.15±0.29 [a]	23.22±0.48 [b]
Fat	0.84±0.02 [b]	0.91±0.01 [a]	0.81±0.02 [b]
Protein	0.77±0.03	0.81±0.02	0.78±0.02
Lactose	1.07±0.02	1.12±0.02	1.06±0.02
Total solid	2.68±0.07 [ab]	2.83±0.04 [a]	2.65±0.06 [b]
Milk composition, %			
Fat	3.65±0.02[b]	3.82±0.03 [a]	3.54± 0.05 [b]
Protein	3.37±0.06	3.38±0.07	3.41±0.06
Lactose	4.67±0.03	4.68±0.03	4.67±0.02
Total solid	11.68±0.04[b]	11.88±0.02[a]	11.62±0.12[b]

[a,b]Means with different subscripts within each row differ ($P < 0.05$).

[1]Formula for 3.5% fat-corrected milk (FCM): [(0.4324 × kg of milk) + (16.216 x kg of fat)].

[2]ECM = energy-corrected milk; value corrected for 3.5% fat and 3.2% true protein using formula from **NRC (2001)**: [(0.3246 × kg of milk) + (12.86 × kg of fat) + (7.04 × kg of true protein)].

Also, Poorkasegaran and Yansari et al. (2014) observed that propionate affect DMI as our result, but we suppose the propionate effect is concentration dependent not as general, (need more investigation), where we found B was higher DMI followed by BP then DD treatments, and the propionate concentration were 26.16, 25.76 and 24.33 mol/100, respectively. The addition of BP and DDG in the lactating-cow diet resulted in lowering digestibility of DM, and NDF, but increase digestibility of EE and NFC. In the current work, a lower digestibility of fiber in groups BP and DD was in line with decreasing chewing time, pH of ruminal fluid, and VFAs concentrations. The consumption of diets with high NFC has positive effects on fermentation and digestion. We could not neglect the influence of differences in digestible NDF. Valk et al. (1990) and Poorkasegaran and Yansari , et al. (2014) reported that lactating-cow allotted to corn based diet had a higher feed intake and consequently had a higher milk production than cows fed on BP, and this are opposite to our result of MDI but are in line with our result of digestibility, and chewing activity. The values DM digestibility is less than OM digestibility, because the amount of mineralized salt are not calculated with the DMI amount, thus in return increase the apparent loss of DMI.

Rumen liquor characteristics

Ruminal pH levels were decreased lactating- cows allotted to BP, where B and DD groups are higher (6.26, 6.63 and 6.64, respectively). Besides, the ammonia nitrogen concentration differs among groups ($P < 0.05$). The ammonia level was significantly decreased in B and DD groups than in BP group. Acetate amount were significantly varies among groups. The values of acetate and butyrate were decreased in B group, whereas BB group were the highest value (Table 5). High pectin or NDSC content of Beet pulp, consider the cause of relatively high amounts of acetate, so increase the acetate:propionate ratio but butyrate was lower than other CHO sources (Mansfield et al, 1994). Also, Lees et al. (1990) observed that lactating-cows allotted to BP were much higher values of acetate and butyrate, but propionate value was lower. Van Vuuren et al. (1993) report no variance in ruminal liquor pH or VFAs values in lactating-cows fed on carbohydrate sources. Different source of NFC or starch amount of lactating-cows ration has the ability to change the products concentration of rumen fermentation (Larson, 2003). Whereas, BP has high ruminal digestibility (Torrent etal., 1994), so support high levels of microbial protein production in rumen and milk yield, similar to the observation of corn based rations (Mansfield et al., 1994).

Milk production

The milk production was improved with BP treatment followed with the B and the DD groups come at last (23.87, 22.97 and 22.77Kg/day, respectively) (Table 6), also adding BP improves milk constituents such as fat and lactose percentages. Addition of BP may improve milk production (Huhtanen 1987), decrease (Valk et al., 1990), or still the same (Poorkasegaran and Yansari et al., 2014). This improvement could be attributed to feed intake which had the same order among groups. Besides, change pattern of fermentation in the rumen and VFAs values that implicate the hormonal status of the lactating-cow and alter production and constituents of milk due to the different CHO sources. The improvement of milkfat in treatments BP, consider a reflection to increase acetate, butyrate and propionate levels in the ruminal fluid. Also, the fat improvement in group BP was caused by the elevation of NDF intake, peNDF and total chewing activity in lactating-cow. In consistent with our result, milk fat improved in animals allotted to BP treatment, Poorkasegaran and Yansari , et al., 2014 and Mansfield et al. (1994) who attributed them to intake of fiber and acetate values that were higher in rumen liquor. Mansfield et al. (1994) observed decrease milk amount, but improve of milk fat and protein in lactating-cows allotted to BP based diet compared with the corn based diet. The milk protein increased with BP, but this finding was in contrast to Mansfield et al. (1994), but was supported by the results of Valk et al. (1990). Chester-Jones et al. (1991) and DePeters et al. (1991) observe reduction in CP intake, ammonia level, and protein digestibility for lactating-cows allotted to BP ration, compared with corn or barley rations. The utilization of the NPN need NDSC that is extensively fermented in the rumen, so may improve microbial protein synthesis. Total VFA concentration in treatments DD was decrease, where lower VFAs level is indicative for decrease fermentation of fiber in the rumen and consequently decrease milk protein production. Rooke et al. (1992), and Chcster-Jones et al. (1991) support our findings, whereas Larson, (2003) and Poorkasegaran and Yansari et al. (2014) not. We could assume that NFC sources and digestibility support microbial population, that supply intestine with microbial protein, and so the protein amount is affected with CHO and crude protein sources, and pH (Poorkasegaran and Yansari et al. 2014 and Valk et al. 1990).

In our current study, we observe an improvement of parameters related to fat of milk and its production with increasing TMR PS. Esmaeili et al. (2016) found a positive relation between milk fat percentage and milk yield that related to forage PS, also they observe that the improvement was inconsistent with chewing activity. In agreement with our results, Kononoff et al. (2003) observe increasing milk fat with constant chewing time, where it explained that to the acetate-to-propionate ratio and long chain trans fatty acids that control milk fat synthesis. Ramirez, et al. (2012) concluded that feeding DDGS lowered lower milk fat production, because of high ruminal fermentation of it and high amount of unsaturated fatty acids.

Conclusion

From the results of this trial, our conclusion is that DM intake, ruminal characteristics, chewing activity, and lactation performance affected by amount of NFC or soluble carbohydrate that have variant digestibility from different sources, besides we recommend the combination of all of treatment for better performance.

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