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Araştırma Makalesi

The Effects of Different Forage Types on Feed Values and Digestibilities in Some Brassica Fodder Crops

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Abstract

This study was conducted to explore the effects of different forage types (fresh, hay and silage) on the chemical composition, forage quality and *in vitro* true digestibility (IVTD) of fodder turnip (*Brassica rapa*), fodder mustard (*Brassica nigra*) and canola (*Brassica napus L.*). Ankom Daisy incubator was used to determine the IVTD and forages were incubated for 48 hours. According to the findings of this study, canola silage and mustard silage have the highest ether extract (EE) content, while mustard silage has the highest crude protein (CP) content ($P<0.001$). It was found that, among the samples, turnip silage has the highest value in terms of neutral detergent fiber (NDF) content; mustard grass, turnip grass and canola hay have higher values in terms of lignin content while mustard silage has the lowest lignin content. As a result, it was concluded that grass, hay and silage obtained from Brassica fodder crops could be used as alternative forage souces. However, use of Brassica silages is recommended in ruminant nutrition.

Key words: Canola, fodder mustard, fodder turnip, silage, hay

Bazı Brassica Grubu Yem Bitkilerinin Yem Değeri ve Sindirilebilirlikleri Üzerine Farklı Kaba Yem Tipinin Etkileri

Öz

Bu çalışma, Brassica grubu yem bitkilerinden yemlik şalgam (*Brassica rapa*), yemlik hardal (*Brassica nigra*) ve kanola (*Brassica napus L.*) bitkilerinde farklı kaba yem tiplerinin (taze ot, kuru ot ve silaj) besin madde içerikleri, kaba yem kaliteleri ve *in vitro* gerçek sindirilebilirlikleri (IVGS) üzerine etkilerinin belirlenmesi amacıyla yürütülmüştür. IVGS'nin belirlenmesinde Ankom Daisy inkübatör kullanılmış ve yemler 48 saat süre ile inkübasyona bırakılmıştır. Elde edilen veriler tek yönlü varyans analizi kullanılarak analiz edilmiştir. Çalışma bulgularına göre; yemler arasında ham yağ (HY) içeriği bakımından en yüksek değerleri kanola silajları ve hardal silajları gösterirken, ham protein (HP) içeriği bakımından en yüksek değeri ise hardal silajları göstermiştir ($P<0.001$). Yemlerde NDF içeriği bakımından en yüksek değeri şalgam silajı, lignin içerikleri bakımından en düşük değeri hardal silajı, en yüksek değerleri ise hardal taze otu, şalgam taze otu ve kanola kuru otlarının gösterdiği saptanmıştır. Sonuç olarak, çalışmada kullanılan Brassica grubu yem bitkilerinin taze ot, kuru ot ve silajlarının alternatif kaba yem kaynağı olarak kullanılabileceği kanaatine varılmıştır. Ancak, bu konuda kapsamlı *in vivo* çalışmaların yapılması ve ruminant beslemede brassica silajlarının kullanılması önerilmektedir.

Anahtar kelimeler: Kanola, yemlik hardal, yemlik şalgam, silaj, kuru ot

Introduction

Insufficient of quality forages is one of the leading problems in ruminant nutrition. It is necessary to increase the forage production and also to find alternative forage sources. It is believed that the use of Brassica fodder crops in animal nutrition will contribute to closing forages gap, given their potential as an alternative forage source. Resistant to unfavorable conditions (hail, drought, etc.) and commonly preferred as a secondary crop (crop rotation), Brassica fodder crops are known to be appetizing for ruminants with their green leaves, roots along and their silages (Kilic, 2009; Kilic and Erisek, 2019). In addition, these fodder crops have high nutritional values and can be grazed to animals. Brassica fodder crops have high digestibility but they must be consumed in limited quantities. It is estimated that their crop yield per decare ranges between four and 10 ton depending on the harvest period and cultivation frequency and they can be harvested in 2.5 to 3 months after cultivation. Consequently, it is believed that they are ideal forage alternatives (Hall and Jung, 2008).

Forages are stored using several methods. One of the most common practices is drying of forages and their silage in order to be used when there is need for forage in the future. It is important to explore the nutritional values of fresh, silage and hay forms of Brassica fodder crops as an alternative forage and to define the best conservation method to be used. Besides, the use of Brassica forage crops is also recommended in order to reduce the methane production in ruminants (Kilic and Erisek, 2019).

The aim of this study was to investigate the impact of different forage types (grass, hay and silage) on the chemical composition, forage quality and *in vitro* true digestibility of fodder turnip, fodder mustard and canola. This study is theorized with the assumption that silages of Brassica fodder crops, which are not common fodder crops and are found to have a number of negative effects on the ruminants when fed as fresh, will increase the nutritional value and digestibility when compared to their fresh and hay forms.

Materials and Methods

Feed supply and silage making: Fodder turnip (*Brassica rapa*-Polybra), fodder mustard (*Brassica nigra*-Black mustard) and canola (*Brassica napus L.*-Bristol) obtained from private firms were sown at the Research and Application Farm (140 m altitude,41° 21′ latitude (N) and 36° 15′ longitude (E)) of The Ondokuz Mayis University (3 parcels of 50 m2) in winter. The forages harvested at the beginning of May. The dry matter contents of harvested forages were 21.46%, 20.50% and 22.75% respectively. A portion of the each brassica was stored as fresh material and the remaining was chopped to about 2 cm, wilted for a one night and then were packed 5 replicate into mini silos produced from PVC materials (Filya, 2001). The all silos were opened after 60 days.

Determining nutrient compositions of Brassica's: The fresh material and ensilaged forms of Brassica's were dried in a forced-air oven at 65 °C for 48 hours and then ground to 1mm mesh size. The ground samples were analyzed for Kjeldahl N and CP was calculated by multiplying N by 6.25. Dry matter (DM) and ash were determined according to AOAC (1998). The neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and crude fiber (CF) analysis were done according to the method of Van Soest et al. (1991) using ANKOM 2000 semi-automated fiber analyzer (Ankom Technology). The ether extract (EE) was determined using ANKOM XT15 analyzer (AOCS 2005 Am-5-04). The contents of organic material (OM), nitrogen free extract (NFE), cellulose and hemicellulose of brassica forages were determined by calculation.

Determination of in vitro true digestibilities of Brassica's: The rumen content was obtained from 3 healthy, two years old, Sakiz x Karayaka rams (about 40 kg) slaughtered at a private slaughterhouse and then mixed. Rumen fluid was taken under CO2, strained through two layers of cheesecloth and placed in a thermos at 39 °C, with 2 handful rumen content. Rumen content was transported to the laboratory within 15-20 minutes. The Ankom DaisyII incubator (filter bag system) makes *in vitro* digestibility study easy and efficient because it uses an equipment which was designed with four rotating digestion jar and maintains constant (uniform heat: 39.5 °C) (Van Soest et al. 1991; Ankom Technology, 2005). Daisy incubator instrument contains 4 cylinder incubators which 1 cylinder need 1600 ml buffer solution and 400 ml rumen fluid as inoculums and 25 piece filter bags could be placed inside the each cylinder with solution. The cylinder was bubbled with CO_2 immediately before closed with lid of cylinder well and placed into incubator box for 48h incubation keep in 38 °C. After incubation, filter bags was cleaned under water flow and dried at the oven for 3h at 105 °C. The bags were analyzed for NDF digestibility with semi-automated ANKOM 2000 fibre analyzer. *In vitro* true digestibilities of the samples were estimated as follows;

In vitro true digestibility (IVTD), % =100 – ((W3-(W1xC1))*100)/W2

Where: W1: Weight of filter bag F57, W2: Weight of dry sample (NDF), W3: Final weight after NDF analysis, C1: The bag without sample was prepared also for correction.

Determination of pH, total volatile fatty acids and amonnia nitrogen (NH3-N) of rumen fluid: The rumen pH values were determined in rumen fluid samples by using digital pH-meter (Hanna Instruments 1332) in three replicates. The volatile fatty acids and NH3-N analysis were done by steam distillation according to Markham (1942) in 3 replicates.

Determination of forage quality: The relative feed values (RFV) of brassica forages were calculated as follows (Rohweder et al. 1978);

Dry matter digestibility (DMD, %)= 88.9-(0.779 x ADF%)

Dry matter intake (DMI, live weight, %)= 120/(NDF%)

Relative feed value (RFV,%)= (DMD x DMI)/1.29

Statistical Analysis: One-way ANOVA was used in the evaluation of the data. One Sample Kolmogorov Smirnov and normality hypothesis tests were used in order to test the compliance of the data for variance analysis and it was found that the data had a normal distribution (P>0.05). Levene Homogeneity of Variances test was used to test the homogeneity of the variances and it was found that the variances were homogeneous (P>0.05). Duncan's multiple range test was used for the comparison of mean values. Correlation coefficients and significance tests were calculated using Pearson's correlation analysis to determine the relationship between variables.

Results and Discussion

Chemical compositions of the Brassica fodders: The chemical composition of the fodder crops used in the experiment were presented in Table 1. Accordingly, turnip silage had lowest ash content than the other silages while the other silages had no significant differences among each other. Fresh material consistently had lower ash content when compared to silage and hay (P <0.001). Considering all the forage types, the highest ash content was determined in canola hay (P<0.001). Canola silage and mustard silage had highest values for the ether extract (EE) content.

Fodder mustard had higher crude protein (CP) content when compared to turnip and canola forages (P<0.001). The mustard fodder silage, on the other hand, had higher CP content when compared to its other fodder types (hay and grass) (P <0.001). Decomposition of soluble hydrocarbons during silage fermentation may account for such an increase in the CP content.

Table 1. Nutrient compositions of different Brassica forage types, %

Tipi	DM	Ash	EE	CP	CF	NFE	NDF	ADF	ADL	HCel	Cel
Canola silage	24.32	11.10± 0.06b	3.34± 0.14a	10.32± 0.24d	35.68± 0.37e	39.58± 0.95b	50.61± 0.30c	44.78± 0.08c	9.14± 0.01cd	5.84± 0.38	35.64± 0.07c
Mustard silage	23.43	11.38± 0.12b	3.36± 0.30a	14.60± 0.25a	46.78± 1.14ab	24.14± 1.19f	48.25± 0.60c	41.10± 1.13e	6.77± 0.31e	7.15± 1.73	34.33± 0.82cd
Turnip silage	22.11	10.12± 0.05c	1.90± 0.48b	7.76± 0.18e	44.63± 0.49bc	35.39± 0.02c	61.16± 1.01a	53.05± 0.96a	10.24± 0.83cd	8.11± 0.05	42.81± 0.13a
Canola frseh	22.75	8.19± 0.09e	2.16± 0.04ab	9.60± 0.24d	35.20± 1.49e	44.83± 1.04a	50.31± 1.08c	41.93± 0.09de	10.91± 0.40c	8.37± 1.17	31.03± 0.49e
Mustard fresh	20.50	9.05± 0.04d	2.26± 0.54ab	12.02± 0.27c	33.76± 1.49e	43.29± 0.55a	50.42± 1.39c	43.84± 0.09cd	15.61± 0.35a	6.58± 1.30	28.23± 0.44f
Turnip fresh	21.46	8.96± 0.03d	1.65± 0.33b	8.06± 0.14e	39.86± 2.00d	41.80± 1.52ab	50.57± 0.08c	43.90± 1.13cd	14.63± 0.94ab	6.67± 1.05	29.27± 0.19f
Canola hay	93.20	12.02± 0.02a	1.63± 0.34b	9.68± 0.13d	49.00± 1.01a	28.19± 0.82e	54.67± 0.49b	47.13± 0.11b	13.64± 0.88b	7.54± 0.38	33.49± 0.77d
Mustard hay	93.69	11.19± 0.25b	1.19± 0.57b	13.30± 0.37b	43.08± 1.48bcd	31.66± 1.18d	50.34± 0.96c	43.70± 0.66cd	8.86± 0.20d	6.63± 0.31	34.84± 0.46cd
Turnip hay	94.17	9.27± 0.09d	1.48± 0.37b	10.00± 0.21d	40.74± 0.30cd	39.05± 0.49b	56.39± 0.60b	48.23± 0.00b	10.95± 0.07c	8.15± 0.61	37.29± 0.07b
Sig.		**<0.001**	**0.024**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.575	**<0.001**

DM: Dry matter, EE: Ether extract, CP: Crude protein, CF: Crude fibre, NFE: nitrogen free extracts, NDF: nötr detergent fibre, ADF: acid detergent fibre, ADL: acid detergent lignin, HCel:hemicellulose, Cel: cellulose . a,b,c…: Means in the same column with different letters indicate significance. a,b,c….: Means with different supercripts in the same column are significantly different.

It is known that 10% CP content is required for the regular ruminant microbial activities at a minimum (Norton, 2003), and the CP contents were found in the ranges between 7.76 and 14.60%; 8.06 and 12.02% and 9.68 and 13.30% for silage, grass and hay obtained from Brassica fodder crops, respectively. Accordingly, fodder turnip silage and fresh had the lowest CP content and were found lower the specified limits. In addition, a diet which involves these fodders only may disrupt rumen microbial activity. The CP content (16.82%) reported by Canbolat et al (2013) is higher than the ones found in this study. Findings of this study (9.68%) are closer to the amount that would not disrupt the continued microbial activity. Nevertheless, the CP values obtained in this study were in compliance with the report of Hall and Jung (2008) who suggested a CP range of 8-10% for canola and fodder turnip hay.

Canola hay and mustard silage had highest values for the cellulose content (P<0.001). In terms of the NDF content, an indicator of fodder consumption, and the ADF value, a measure of digestibility, fodder turnips showed the highest values (P <0.001). This result suggests that turnip silage, as the only dietary ingredient, may have an adverse effect on the fodder consumption and digestibility. It was found that, mustard silage had lowest lignin content which is the indigestible part of the feed, while mustard fresh, turnip fresh and canola hay had highest lignin content (P<0.001). In the light of these data, it can be said that silage is more advantageous than other forage types (fresh and hay) and that structural elements of the cell wall are partially broken down during silage fermentation.

Canbolat (2013) reported that the nutritional content of canola changes during different vegetative periods, and that its DM (19%-33.70%), OM (93.56%-96.13%), CP (6.93%-21.12%), ash (3.87%-6.44%), EE (2.21%-9.66%), NDF (36.08%-77.16%), ADF (23.48%-56.75%) and ADL contents are adversely affected as the crops mature and when the harvest is delayed. In another study, Canbolat et al (2013) reported EE (5.16%), ash (6.22%), NDF (45.65%), ADF (37.79%) and ADL (12.66%) contents for canola, similar to those they have published previously. However, the EE contents obtained in this study were lower than that of literature; while the other nutritional values showed similarities with the ones in the literature.

Chaudhry (1998) reported that mustard hay has 45% of CF . This finding is similar to the value obtained for mustard hay in this study, while a lower CF is the case for mustard fresh. This can be explained by the early harvest of the crops.

Westwood and Mulcock (2012) investigated 5 species of Brassica including fodder turnip and canola, and reported ranges between 13.4 and 17.5% for DM content; 14.0 and 23.0% for CP content; 12.9 and 13.9% for ADF content and 12.4 and 16.1% for NDF content of a number of leafy turnip species (30 species in total); and suggested that the CP content is decreased as the harvest is delayed. Researchers reported a nutritional content of canola species (rape) between 13.8 and 14.9%; CP between 9.1and13.2% DM, ADF between 16.7-26.0% DM and NDF between 18.9 and 30.5% DM, EE between 2.5 and 3.2% DM, ash between 8.5 and 10.3% DM. The DM, CP, ADF, NDF, EE and ash contents were reported for the other Brassica forages (Swede) in ranges between 9.5 and 11.5%, 12.9 and 14.5% DM, 13.2 and 15.0% DM, 14.4 and 16.6% DM, 1.6 and 2.1% DM and 5.8 and 6.4% DM, respectively, and for Oleracea species in ranges between 14.7 and 20.6%, 6.3 and 13.8% DM, 21.3 and 26.9% DM, 24.6 and 32.0% DM, 1.5 and 2.7% DM and 6.2and 8.5% DM, respectively. In general, among the values obtained in this study, DM content was lower, while CP contents were higher and ADF and NDF contents were lower than the values reported in the literature, which is an indicator of early harvest. Nevertheless, it has also been demonstrated that different nutrient contents may be present in different species and that the leaf-stem ratio varies considerably.

Vaithiyanathan et al (2003) investigated the use of mustard hay as sheep feed and reported that feed quality improves with the addition of 2-4% urea. In addition, the study found 94.8% DM for mustard hay and reported 11.9% CP, 49.6% NDF, 34.1% ADF , 15.5% HCel, 23.2% Cel, and 6.5% ADL content on the basis of dry matter. A comparison of these data with the data obtained in this study for mustard hay shows that DM (93.69%) and NDF (50.34%) contents are similar; CP (13.30%), ADF (43.70%), Cel (34.84%) and the ADL (8.86%) contents are lower than the findings of this study, while HCel (6.63%) content is higher than the findings of this study. These differences may account for the differences in species studied, harvest time, soil structure, leaf-stem ratio, etc.

Sun et al. (2012) showed that the DM (9.4-12.6%), ash (9.2-14.0%), CP (16.2-19.3%), EE (1.1-3.4%), ADF (12.1-16.3%) and lignin (5.1- 6.3%) contents of canola fresh changes at a great extent. The researchers also identified DM (10.1%), ash (14.9%), CP (13.0%), EE (1.7%), ADF (18.0%) and lignin (6.3%) contents of fodder turnip fresh. In this study, it was found that the EE content of canola and fodder turnip were in the specified limits; ash and CP contents were lower than the specified limits, while ADF and ADL contents were higher than the specified limits. These findings may be explained with their varying DM contents. Indeed, it is known that the researchers harvested the crops when they had a rather low DM content (Westwood and Mulcock, 2012). It is also believed that these results may be explained with different harvest times, different species studied, leaf-stem ratio, along with differences in fertilization practices.

Kamalak et al. (2005) reported that nutritional content of wild mustard changes with the vegetation period, and that NDF, ADF content increases as the crops mature, which suggests that early harvest of these crops is necessary in order to obtain quality forage. However, harvest after early flowering and maturity did not have an impact on the nutritional content and DM (95.9% -96.5%), CP (13.2-7.7%), NDF (66.5-74.1%), ADF (56.4-65.8%) and ash (7.4-5.6%) contents were reported. The decline in the CP with continued maturity may be explained with the decrease in the protein ratio in the roots and leaves. Indeed, protein ratio decreases with maturation (Buxton, 1996). A significant increase in ash, NDF and ADF content of wild mustard with maturation was reported (Kamalak et al, 2005). In the study, Mishra et al. (2000) reported that NDF and ADF contents increase with maturation, and that these values are lower when the crops are harvested early. In this context, all Brassica fodders used in this study were found to have lower NDF and ADF contents when compared to other reports, which is thought to be an indicator of early harvest.

It is widely accepted that a minimum of 27% to 30% NDF concentration is required for optimal cattle rumen function (Westwood and Mulcock, 2012). Barry (2013) identified NDF content below 30% for 4 different Brassica fodders and suggested that this may lead to subacute ruminal acidosis (SARA). SARA risk was not the case in this study as all forages were found to have NDF content above 30%.

Fraser et al, (2001) reported a DM content ranging between 15.6 and 16.8%, CP content ranging between 11.4 and 15.8% DM and ash content ranging between 13.5 and 14.3% DM for Brassica oleracea with respect to the harvest time. These values were lower than the DM contents found for all fodders included in this study, while it was quite higher in the case of ash content. In terms of CP content, the results were consistently higher than fodder turnip and canola, while being similar in the case of fodder mustard (Westwood and Mulcock, 2012). Indeed, it is known that different Brassica species offer different nutritional contents (Westwood and Mulcock, 2012).

Forage quality and the impact of different forage types on IVTD: The pH, amonnia-N (NH3-N) and total volatile fatty acids (TVFA) contents of rumen liquid which are used to identify *in vitro* true digestibility of fodders, were found to be as 6.58 (5.91-6.85), 307 mg / l (264-402 mg / l) and 117 mmol / L (88-134 mmol / l), respectively. It was observed that the rumen liquid used in this study complies with the literature reports and that it offers standard rumen liquid properties (Kaya et al 2011; Sahin et al 2013).

DMD, DMI, RFV, RFV quality class and IVTD of the fodders are shown in Table 2. Accordingly, mustard silages mark the highest DMD, DMI and RFV values, while turnip silages showed the lowest values. In terms of IVTD, the highest value was obtained from mustard hay.

Table 2. Forage quality and IVTD values of Brassica’s in different forage types

Forage Type	DMD, %	DMI, % BW	RFV	RFV Quality	IVTD,%
Canola silage	54.02 ± 0.07c	2.37 ± 0.01a	99.29 ± 0.46b	3	67.74 ± 1.44b
Mustard silage	56.88 ± 0.88a	2.49 ± 0.03a	109.67 ± 0.33a	2	66.84 ± 0.73b
Turnip silage	47.57 ± 0.74e	1.96 ± 0.03c	72.39 ± 2.33d	5	54.89 ± 1.21d
Canola fresh	56.23 ± 0.07ab	2.39 ± 0.05a	104.03 ± 2.10ab	2	68.26 ± 0.70b
Mustard fresh	54.75 ± 0.07bc	2.38 ± 0.07a	101.08 ± 2.91b	3	64.56 ± 1.08bc
Turnip fresh	54.71 ± 0.88bc	2.37 ± 0.00a	100.63 ± 1.78b	3	61.05 ± 2.78c
Canola hay	52.19 ± 0.08d	2.20 ± 0.02b	88.81 ± 0.94c	3	64.15 ± 0.90bc
Mustard hay	54.85 ± 0.51bc	2.38 ± 0.05a	101.43 ± 2.88b	3	73.54 ± 3.28a
Turnip hay	51.33 ± 0.00d	2.13 ± 0.02b	84.69 ± 0.90c	4	61.2 0± 0.05c
Sig.	**<0.001**	**<0.001**	**<0.001**		**<0.001**

IVTD: *In vitro* true digestibility, DMD: Dry matter digestibility, DMI: Dry matter intake, RFV: Relative feed value, BW: Body weight, a,b,c..: Means with different supercripts in the same column are significantly different. According to the Quality Grading Standard assigned by The Hay Marketing Task Force of the American Forage and Grassland Council, the RFV were assessed as roughages based on prime >151; 1 (premium) 151-125; 2 (good) 124-103; 3 (fair). 102-87; 4 (poor). 86-75; 5(reject).< 75.

Fodder turnip fresh, hay and silages, on the other hand, accounted for the lowest IVGS values. In this respect, fodder turnip has a lower nutritional value when compared to other Brassica fodder crops. Canbolat et al. (2013) reported that canola offers a lower digestibility value when compared to some other legumes such as clover and vetch. The reason behind this finding was that canola is poor in terms of carbohydrate and protein contents that can be used by rumen microorganisms; while being rich in cell wall structural elements (ADF, NDF and ADL). Indeed, especially the increase in ADF content adversely affects digestibility.

Barry (2013) reports that many Brassica fodder crops including canola and fodder turnip have a higher DMD content (81.0-89.0%) when compared to several meadow grass and legumes, while Sun et al, (2012) found that the DMD content of Brassica fodder crops ranges between 80.0-89.0%. Fraser et al. (2001) suggested that the NDF digestibility of green Brassica oleracea plants is between 70.2 and 80.2% for sheep. These values are higher than the values found for canola and fodder turnip in this study, while they are similar to the IVTD value found for mustard hay. Vaithiyanath et al. (2003) reported 3.55% BW for DMI and 52.0% for DMD of mustard hay. These values are higher than the DMI (2.38% BW) value obtained in the study for mustard hay, while being similar to the DMD value (54.85%) found.

Westwood and Mulcock (2012) found that the digestibility of fodder turnip ranges between 85.3 and 87.8% for early harvest while ranging between 86.0-90.3% for late harvest; and reported that the digestibility of canola (rape), Brassica Swede, and oleracea species are in the ranges between 78.6 and 92.8%, 92.4 and 94.3% and 73.1and 81.4%, respectively. IVTD values obtained in this study were consistently lower than the literature and they were found to be as 68.26%, 64.56% and 61.05% for canola fresh, mustard fresh and turnip fresh, respectively. These differences may account for the differences in species studied, harvest time, soil structure, etc.

Canbolat et al. (2013) suggested that DMD (59.64% -70.61%), DMI (2.18- 3:32% BW) and RFV (100.82-181.61) values for canola are adversely affected with delayed harvest time; and reported values 44.49%, 1.56 %BW and 54.04, respectively, for the canola hay. These values are similar to the DMD and DMI values obtained in the study for canola hay, while this study found a lower value for RFV (88.81). These differences in findings are associated with NDF and ADF content, and these values were significantly higher in this study.

It was found that canola is similar to that of the meadow grasses in terms of digestibility, and that canola leaves, leaf stem, and parts above the root vary in their digestibility (89.0-77.0%), while the digestibility of leaves and roots were similar for lambs (83.0-78.0%) and sheep (84.0; 79.0%) (Armstrong et al., 1993). In this context, digestibility may vary according to the age of the animals, not to mention the parts of the Brassica fodder crops used and the leaf-stem ratio.

Kaur et al. (2009) investigated canola and clover grass as 10%, 25% and 40% of the diet, and found that both feeds showed similar results in terms of hay consumption. However, it was determined that the pH of the rumen was higher than that of the clover (5.70) in canola (6.17). Indeed, rumen VFA profile is very important in animal nutrition and there are significant correlations between VFA profile and the gas production in the rumen (Doane et al. (1997). Thus, Brassica fodder crops which have similar properties are expected to increase *in vitro* gas production in the rumen with the pH increase which will lead to increased rumination. This is preferable for dairy cattle nutrition. However, it should be taken into account that silage will decrease rumen pH. In addition, Moorby et al. (2003) suggested that the use of green brassica and barley for silage mixed at 1:1 ratio are of excellent quality for dairy cattle.

Correlations between variables: According to the matrix of correlations between variables (Table 3) significant relationships between ash and CF and NFA; IVTD and DMD, DMI, RFV, NDF and ADF; CP and DMD, DMI, RFV, NDF and ADF; CF and NFE; NDF and ADF, Cel, DMD, DMI and RFV; ADF and Cel, DMD, DMI and RFV; Cel and DMD, DMI and RFV were identified. And among these relationships, the use of NDF and ADF contents of the fodders in the calculation of DMD, DMI and RFV played an important role as the correlation between them was high.

It must be taken into consideration that feeding green Brassica fodder crops to animals may lead to a number of health problems (nitrate/nitrite poisoning, etc.); that it may result in rumen injury when the animals are fed with dried crops as dried stems are stiffened; that leaves and seeds which are high in nutrition may be lost during the drying process and that the drying process is a big issue in areas exposed to abundant rainfall. Nevertheless, it is especially important to be attentive to the thorough cleaning of roots during harvest (microorganism contamination risk) and they should not be consumed in excessive amounts.

Table 3. Correlation matrix for the variables

	Ash	EE	CP	CF	NDF	ADF	ADL	NFE	HCel	Cel	DMD	DMI	RFV
IVTD	.249	.124	.586**	-.114	**-.643****	**-.678****	-.343	-.175	-.115	-.341	**.678****	**.626****	**.652****
Ash		.168	.386*	**.668****	-.002	.088	-.429	**-.842****	-.255	.360	-.088	.005	-.035
EE			.325	-.248	-.331	-.353	-.395	-.077	-.050	-.034	.353	.343	.359
CP				.085	**-.619****	**-.610****	-.488*	-.487*	-.234	-.187	**.610****	**.634****	**.639****
CF					.303	.312	-.267	**-.888****	.076	.440	-.312	-.289	-.297
NDF						**.951****	.100	-.003	.476*	**.732****	**-.951****	**-.997****	**-.989****
ADF							.133	-.027	.179	**.751****	**-1.000****	**-.943****	**-.979****
ADL								.492*	-.060	-.554*	-.133	-.129	-.147
NFE									.066	-.350	.027	-.015	-.005
HCel										.191	-.179	-.489*	-.361
Cel											**-.751****	**-.706****	**-.725****
DMD												**.943****	**.979****
DMI													**.990****

IVTD: *in vitro* true digestibility, EE: Ether extract, CP: Crude protein, CF: Crude fibre, NDF: nötr detergent fibre, ADF: acid detergent fibre, ADL: acid detergent lignin, NFE: nitrogen free extracts, HCel:hemicellulose, Cel: cellulose . DMD: Dry matter digestibility, DMI: Dry matter intake, RFV: Relative feed value, *:P<0.05, **:P<0.01.

Therefore, it is recommended that Brassica fodder crops should not be the only feed source and they must be combined with other quality forage sources. Also, it was reported that animal diet should not consist more than 75% of Brassica fodder crops, otherwise it would be challenging to ensure appropriate rumen activity (Hall and Jung, 2008; Barry, 2013).

Conclusion

In this study, it was observed that fodder mustard and canola silages offer a higher nutrition value when compared to fodder turnip silages; that turnip silages will be less appetizing for the animal as they have a higher NDF content; and that high CP content and low lignin content of mustard silage is a favorable advantage. The highest lignin values, in the study, were found for mustard fresh, turnip fresh and canola hay, and it was established that silages are more advantageous than the other forage preservation methods. In this study, mustard silages marked the highest DMD, DMI and RFV values, while turnip silages showed the lowest values. In terms of IVTD, mustard hay showed the highest value while turnip forages (fresh, hay and silages) showed the lowest values. Consequently, in case of silage preparation from Brassica fodder crops, it was concluded that the negative effects of these crops are eliminated during fermentation, that the animal consume these silages with appetite, that the difficulties observed in drying process are avoided, therefore, silage is the best preservation method for Brassica fodder crops. It is recommended for the future in vivo studies to focus on co-cultivation of Brassica fodder crops with different fodder crops and their impact on the animal performance.

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