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Effects of Additive Use on Silage Quality and *In vitro* Digestibility of Some *Brassica silages*

Unal KILIC[1]*, Abdulkadir ERISEK[2]

[1]Department of Animal Science, Faculty of Agriculture, University of Ondokuz Mayis 55139 Samsun Turkey
[2]Livestock Central Research Institute Ankara-Turkey
*Corresponding Author E-mail: unalk@omu.edu.tr

Abstract This study was conducted with the aim of determining the effects of silage additives (5% wheat) on nutrient contents, forage qualities and *in vitro* true digestibility (IVTD) of *Brassica* silages such as fodder turnip (*Brassica rapa*), fodder mustard (*Brassica nigra*) and canola (*Brassica napus L*.). Ankom Daisy incubator was used to establish the IVTD content of silages and forages were incubated for 48 hours. Data was then tested using one-way ANOVA. Results of this study showed that 5% wheat supplemented to the *Brassica* silages increases the lactic acid (LA) content and silage quality. Required pH (RpH) values for all silages were lower than measured pH (MpH) values the MpH value was decreased only with the additive supplemented to the canola silage. In terms of dry matter digestibility (DMD), dry matter intake (DMI) and relative feed value (RFV) the highest value was found in the additive supplemented canola silage while fodder turnip silage showed the lowest value. In terms of IVTD, the highest value was found in the additive supplemented fodder mustard silage while fodder turnip silage showed the lowest value. As conclusion, it was found that the nutritive values of fodder mustard and canola silages are higher than fodder turnip silages; and the high crude protein content and low lignin content of fodder mustard silage proves to be advantageous.

Keywords Canola, fodder mustard, fodder turnip, silage, *in vitro* digestibility

1. Introduction

Production of fodder crops must be increased in order to close the forage gap in the ruminant nutrition. It is known that forage needs, especially in the wintertime, are provided for drying or ensiling hay. It is important to produce alternative forages to close this gap. It is believed that *Brassica* crops such as fodder turnip, fodder mustard and canola will contribute to closing the forage gap as they can be harvested in a short time and they can be cultivated as second crops [1]. *Brassica* crops can be harvested in 2.5 to 3 months after they are cultivated and they offer 4 to 10 ton/decare yield [2-4]. Thus, it is believed that *Brassica* crops are ideal alternatives for forage source. It is know that ruminants enjoy consuming fresh leaves, roots and silages of *Brassica* crops. As *Brassica* forages may cause a number of health issues (glucosinolates, nitrate, toxicity etc.) in animals when they are consumed fresh [5], it is recommended to clean the *Brassica* roots thoroughly, not to allow overconsumption, not to use these crops in a way to make up more than 50% of the total forage, and to introduce these crops gradually to the animals [1, 6]. Drying forage for hay proves to be an issue in a region receiving heavy rainfall, while drying process also leads to the loss of leaves, seeds and nutritional value of the forage. As branches and stems become overly stiff when *Brassica* crops are dried, they are known to cause tearing of the rumen wall in animals. Ensiling technique decreases anti-nutritional effects of *Brassica* forages [7]. Kincaid et al [8] reported that nitrate-N concentration in the preensiled forage was reduced about 80% (from

139 mg/kg nitrate-N to 28 mg/kg nitrate-N) in canola-peas ensilage. Beside, it is reported that the most suitable forage type for *Brassica* crops is silage production [1].

This study is designed with the hypothesis of ensiling *Brassica* forages (fodder turnip, fodder mustard and canola), which are not commonly used as forages and may lead to a number of health issues in animals when consumed fresh and hay, with 5% wheat additive will improve the silage quality, *in vitro*true digestibility and forage nutritional values. Moreover, potential of *Brassica* silages as alternative forage sources for ruminants is explored.

2. Materials and Methods

Feeds supply and silage making: Polybra variety fodder turnip (*Brassica rapa*), black mustard variety fodder mustard (*Brassica nigra*) ve Bristol variety canola (*Brassica napus L*) seeds were sown at the Research an Application Farm of The University (3 parcels of 50 m^2) in winter and harvested respectively at 21.46%, 20.50% and 22.75% DM, between 26 April 2012 -7 May 2012. Brassica's fresh materials were chopped to about 2 cm, wilted for 24 hours and then were packed into 5 replicate laboratory type PVC silos [9]. Two groups of each forage, one being the control group and the other being silage with 5% ground wheat, were prepared. The silos were opened after two months.

Chemical analyses: Al the silages were dried in a forced-air oven at 65 °C for 48 hours. Then, dried silages were milled in a hammer mill through a 1 mm sieve for chemical analysis and *IVTD's* assays. The samples were analyzed for dry matter (DM), ashand crude protein (CP) contents were analysed according to AOAC [10] procedure. Kjeldahl N and CP was calculated by multiplying N by 6.25. 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.* [11] using Ankom 2000 semi-automated fiber analyser (Ankom Technology). The ether extract (EE) content was determined using Ankom ^{XT15} analyzer [12]. The contents of organic material (OM), nitrogen free extract (NFE), cellulose and hemicellulose were determined by calculation.

Determining *in vitro* true digestibilities of silages: In this study, the rumen content was obtained from 3 Sakız x Karayaka rams (average 40 kg live weight and two years old) just now slaughtered at slaughterhouse. Rumen content mixed and it was taken under CO_2 atmosphere, strained through two layers of cheesecloth and was put into a thermos (39 °C) with 2 handful rumen content and was transported to the laboratory within 15-20 minutes.

Ankom Daisy incubator (filter bag system digestibility) makes *in vitro*NDF disappearance study easy and efficient because it use an equipment which was designed with four rotating digestion jar and maintains constant, uniform heat and agitation within a controlled (39.5 °C) chamber [11,13]. Daisy incubator instrument contains 4 cylinder incubators which 1 cylinder need 1600 ml buffer solution and 400 ml rumen fluid as inoculums and bag filter. Filter bags F57 (25 pieces) could be placed inside the each other 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. After incubation, filter bags was cleaned under water flow and dried. The bags was 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, W2: Weight of sample, W3: Final weight after NDF analysis, C1: The bag without sample was prepared also for correction.

Determining rumen fluid pH, total volatile fatty acids (TVFA) and ammonia nitrogen (NH_3-N): Rumen fluid pH values were determined using digital pH-meter (Hanna Instrument) in three replicates. The total volatile fatty acid (TVFA) and NH_3-N analysis of rumen fluids were done according to Markham [14] steam distillation in three replicates.

Determining pH and VFA analysis in Brassica silages: The pH values of silages were determined at samples obtained from different parts of silages. With this aim, 25 g silage sample was put in a mixer, 100 ml destile water added and mixed for 5-10 minutes. Then, the fluid part of the mix was filtered to a beaker via a filter paper and after 15-20 minutes the pH was measured using a digital pH-meter in three replicates. The lactic acid (LA) and acetic acid (AA) contents of silages were determined spectrophotometrically [15].

Determining forage quality and silage quality: The relative feed value (RFV) of *brassica* silages were calculated as follows [16];
Dry matter digestibility (DMD, %) = 88.9-(0.779 x ADF%)
Dry matter intake (DMI, liveweight, %) = 120/(NDF%)
Relative feed value (RFV, %) = (DMDxDMI)/1.29
The quality class of the *Brassica's* silages were determined by using Flieg score (FS) as following formula [9].

Flieg score (FS) = 220+(2 x dry matter % – 15) –40 x pH

The required pH value in a silage is related to DM content. In other words, each silage should have a pH value which is determined according to its DM content. The "required pH values" were determined by using following formula [17]. This pH value prevents the proliferation of clostridia and enterobacteria.

Required pH (RpH) = 0.00359 x DM (g/kg) + 3.44

Determination of aerobic stability in Brassica's silages: After opening of the silos, high amounts of oxygen enter the silo caps and consequently silages begin to deteriorate. Aerobic stability test was performed with the aim of determining the silos life of silages [18]. Aerobic stability test were done according to Ashbell *et al*. [18] in three replicates.

Statistical Analysis: One-way ANOVA was used in the statistical analyses of the observations. 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.

3. Results and Discussion

Chemical compositions of the samples: Table 1 shows the nutritional values of the *Brassica* silages included in the experiments (as DM). It was found that additive use significantly increases the DM content in every *Brassica* silages (P<0.001). This is provided with the 5% wheat additive which has a higher DM content (89.03%) when compared to fresh materials. In addition, among the *Brassica* silages tested, canola silages with 5% wheat additive were found to have the highest DM content while fodder turnip control and fodder mustard control silages have the lowest (P<0.001). These DM contents found in the silages are shown to be normal values [9]. Nevertheless, it is recommended to delay the harvest or to subject the crops to the withering process for 2 nights before ensiling *Brassica* crops. Thus, it will be possible to increase the DM and NFE content of the material to be ensiled which in return will improve the silage quality.

Table 1: The effects of additive use in silages on their nutritive content, DM%

Silages	%DM	%Ash	%EE	%CP	%CF	%NFE	%NDF	%ADF	%ADL	%HCel	%Cel
FMS-C	23.43±0.20cd	11.38 ± 0.12a	3.36 ± 0.30a	14.60 ± 0.25a	46.78 ± 1.14b	24.14 ± 1.19e	48.25 ± 0.60d	41.10 ± 1.13c	6.77 ± 0.31b	7.15 ± 1.73	34.33 ± 0.82d
FMS+A	24.75±0.27b	10.79 ± 0.02c	2.24 ± 0.33abc	12.06 ± 2.03ab	34.98 ± 0.45d	38.04 ± 1.17bc	49.36 ± 0.22cd	43.74 ± 0.22b	7.51 ± 0.11b	5.61 ± 0.01	36.23 ± 0.33c
FTS-C	22.11±0.27d	10.12 ± 0.05d	1.90 ± 0.48bc	7.76 ± 0.18cd	44.63 ± 0.49c	35.39 ± 0.02c	61.16 ± 1.01a	53.05 ± 0.96a	10.24 ± 0.83a	8.11 ± 0.05	42.81 ± 0.13a
FTS+A	23.94±0.16bc	9.21 ± 0.02e	1.25 ± 0.34c	7.30 ± 0.02d	51.10 ± 0.46a	31.13 ± 0.85d	58.37 ± 0.10b	50.50 ± 1.05a	9.81 ± 0.42a	7.87 ± 1.14	40.69 ± 0.63b
CS-C	24.32±0.53bc	11.1 ± 0.06b	3.34 ± 0.14a	10.32 ± 0.24bc	35.68 ± 0.37d	39.58 ± 0.95b	50.61 ± 0.30c	44.78 ± 0.08b	9.14 ± 0.01a	5.84 ± 0.38	35.64 ± 0.07cd
CS+A	27.91±0.37a	9.98 ±	2.68 ±	10.89 ±	33.57 ±	43.10 ±	46.01 ±	39.48 ±	6.96 ±	6.53 ±	32.52 ±

		0.10d	0.20ab	0.16b	0.44d	0.38a	0.61e	0.21c	0.26b	0.40	0.06e
Sig..	<0.001	<0.001	0.018	0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.343	<0.001

FMS-C: Fodder mustard silage control, FMS+A: Fodder mustard silage with additive, FTS-C: Fodder turnip silage control, FTS+A: Fodder turnip silage with additive, CS-C: Canola silage control, CS+A: Canola silage with additve, DM: dry matter (Natural form), EE: Ether extract, CP: Crude protein, CF: Crude fibre, NFE: nitrogen free extracts NDF: neutral detergent fibre, , ADF: acid detergent fibre ADL: acid detergent lignin, HCel:hemicellulose, Cel: cellülose a,b,c..: Means with different supercripts in the same column are significantly different..

It was found that additive use decreases the ash content, therefore, increases the OM content in every *Brassica* silages (P<0.001). The reason behind this finding is that ground wheat has a higher OM content [19] when compared to *Brassica* crops. Fodder mustard was found to have the highest crude protein (CP) content among the silages (P<0.001). However, additive use had an insignificant effect on the CP content of all silages (P>0.05). In fact, forages must have a minimum amount of 10% CP content in order for the rumen microbial activities to be sustained normally [20]. CP content of the *Brassica* silages included in this study ranged between 7.30% and 14.60%. Accordingly, it can be said that using fodder turnip silages with a CP content between 7.30-7.76% alone may lead to disruptions in microbial activity.

It was reported in the literature that for *Brassica oleracea* DM content ranges between 15.6-17.6%, CP content ranges between 10.6-20.1% DM and ash content ranges between 13.5-14.3% DM with respect to the harvest time [21; 22]. These values are lower than the DM contents detected in all the three *Brassica* forage crops included in this study, with the exception of ash contents which were higher. CP contents, on the other hand, were higher than fodder turnip and canola and were similar in case of fodder mustard.

In this study, the highest NFE content was found in canola silages with high DM content (P<0.001). Fodder turnip silages was found to have the highest NDF, ADF and ADL contents among the silages (P<0.001). This can be interpreted as animals will not prefer fodder turnip silage over other silages as their digestibility is relatively lower. Moreover, there was no improvement in the digestibility of fodder turnip silages despite the additive use (P<0.001). Accordingly, it can be said that consumption of fodder turnip silage as the only forage source may have negative effects on feed intake and digestibility. Fodder turnip silage also has the highest lignin content while fodder mustard silage has the lowest. In addition, additive usein the canola silages was found to reduce NDF, ADF and ADL contents (P<0.001) and to improve silage quality.

Canbolat [23] reported that chemical composition of canola changes with the changing vegetative periods and that maturation and delayed harvest have a negative effect on the nutritional value of this crop. Different results are available in the literature as the researchers focused on different species. Indeed, it is known that different *Brassica* species offer different nutrient contents [24,25]. Decreasing CP content with continued maturity can be explained with the decrease in the protein ratio available in the roots and leaves [26]. A significant increase in ash, NDF and ADF content of wild mustard was reported with maturation [27].This was also supported by Mishra *et al*. [28] study which reports lower NDF and ADF contents when *Brassica* crops are harvested earlier. Westwood and Mulcock, [24] suggested that a minimum of 27% to 30% NDF concentration is required for optimal cattle rumen functionality. In this study, all the tested silages had an NDF content between 46.01% to 61.16%, thus, it is recommended not to use *Brassica* silages as the only forage source and to blend it with proper forages. Fraser *et al* [22] defined the NDF content of Kale silage between 34.0% to 45.4% DM which were similar to those findings from canola silages. Nevertheless, Barry [29] identified a NDF content below 30% for 4 different *Brassica* crops and suggested that this may lead to subacute ruminal acidosis in animals. Accordingly, the lower NDF content indicates that *Brassica* crops were harvested earlier than usual. Considering the NDF contents found in this study, there is no reason to believe it will lead to acidosis.

Additive use in *Brassica* silages is found to have a positive effect on the nutritional value and CP contents of the *Brassica* forage crops were found between 7.30% and 14.6 % DM. These values agree with the reports of Moorby *et al*. [30] and ensiling canola with wheat additive (10.89 % DM) is similar to the literature. ADF and NDF contents found in this study are higher than the ones reported by Moorby *et al*. [30]. This may be explained with the fresh barley forage additive, an easily dissolved carbohydrate source, during the ensiling process at 1:1 ratio. Indeed, ADF and NDF contents improve both digestibility and dry matter intake. Among the *Brassica* silages, fodder turnip silages with and without additive had the lowest EE contents. Compared with the other *Brassica* crops, it can be said that differences in species has an effect on the EE content.

It is known that secondary components (glucosinolate, nitrate etc.) found in *Brassica* forage crops may affect the feed intake and may lead to a number of health issues. Therefore, consumption of fresh and early-harvested *Brassica* forage crops and blending these crops with another forage source are recommended [1,29]. Any differences found for *Brassica* forage crops in other studies may account for the differences in species studied, harvest time, soil structure, leaf rate, etc.

Effects of additive use on IVTD and forage quality of silages: Rumen liquid pH, NH_3-N and TVFA contents which are used to identify the IVTD of silages, were found to be 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 [31-33]. Therefore, rumen liquid cannot account for the differences in the findings of this study.

DMD, DMI, RFV, and IVTD of the forages are shown in Table 2. According to Table 2, canola with additive and fodder mustard control group have the highest DMD values. The lowest DMD value, on the other hand, was found in fodder turnip silages (P<0.001). In terms of DMI and RFV, canola with additive found to have the highest values (P<0.001) while fodder turnip control silage had the lowest (P<0.001). It is recommended to use additives as the additive use improves the silage quality for fodder turnip and canola silages. Canbolat [23] reported the DMD, DMI and RFV contents of canola which is harvested in different periods as 76.61-44.69%, 3.32-1.56% LW and 181.61-54.04, respectively, for the period between pre-maturation and post-maturation. As it is shown, the forage quality is decreased with the maturation due to the increased NDF and ADF contents. The findings of this study are in agreement with the findings of Canbolat [23] for canola.

Table 2: The effects of additive use in silages on forage quality and IVTD, DM%

Silages	DMD, %	DMI,% LW	RFV	RFV Quality	IVTD, %
FMS-C	56.88 ± 0.88a	2.49 ± 0.03b	109.67 ± 0.33b	2.Good	66.84 ± 0.73b
FMS+A	54.82 ± 0.17b	2.43 ± 0.01bc	103.33 ± 0.79c	2.Good	71.63 ± 1.51a
FTS-C	47.57 ± 0.74c	1.96 ± 0.03e	72.39 ± 2.33e	5 Reject	54.89 ± 1.21c
FTS+A	49.56 ± 0.81c	2.06 ± 0.00d	78.98 ± 1.17d	4.Poor	55.37 ± 0.81c
CS-C	54.02 ± 0.07b	2.37 ± 0.01c	99.29 ± 0.46c	3.Fair	67.74 ± 1.44b
CS+A	58.14 ± 0.16a	2.61 ± 0.03a	117.58 ± 1.88a	2.Good	65.80 ± 1.17b
Sig.	**<0.001**	**<0.001**	**<0.001**		**<0.001**

FMS-C: Fodder mustard silage control, FMS+A: Fodder mustard silage with additive, FTS-C: Fodder turnip silage control, FTS+A: Fodder turnip silage with additive, CS-C: Canola silage control, CS+A: Canola silage with additve, 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.

It was found that mustard silages and canola silage with wheat additive have a better forage quality when compared to the others, in terms of the forage silage quality. However, these results are of a lower quality when compared to the standard dried clover hay [16]. Indeed, Canbolat *et al*. [25] reported that canola offers a lower digestibility value when compared to some other legumes such as alfalfa and vetch, and reported OMD and true OMD contents as 71.77% and 65.79%, respectively. The reason behind the low OMD 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 fiber components (ADF, NDF and ADL) [25]. Hart and Horn [34] reported the digestibility of fodder turnip silage as 62.0-63.0%. Nevertheless, Vipond *et al* [21] reported OMD for *Brassica oleracea* silage as 77.0% DM. These findings indicate that different *Brassica* crops may have different digestibility values.

In this study, the poorest silage quality was found in fodder turnip silages, as expected. Among *Brassica* silages, the highest IVTD values were obtained from fodder mustard with wheat additive while the lowest IVTD values were obtained from fodder turnip silages (P<0.001). In this respect, fodder turnip has a lower nutritive value when compared to other *Brassica* forage crops. These differences may depend on several factors such as differences in species, soil structure, etc. In addition, it can be said that *Brassica* silages have similar digestibility values when compared to the other forages used for ruminant nutrition.

Table 3 shows the effects off wheat additive in silage on lactic acid, acetic acid, MpH, RpH and aerobic stability. According to Table 3, it is seen that additive use in silages has an impact on the LA and AA (P<0.001).

Preferred especially because it is an easily dissolved carbohydrate source, wheat additive increases the lactic acid content of the silages [9], therefore, contributing widely to the silage fermentation.

Table 3: The effects of additive use in silages on organic acids, pH and AS

Silages	LA, %	AA, %	RpH	MpH	AS, CO_2: g/kg DM
FMS-C	1,83 ± 0,02[e]	1,97 ± 0,03d	3,52	4,98 ± 0,08a	30,18±0.73b
FMS+A	2,11 ± 0,06d	3,15 ± 0,03a	3,53	4,85 ± 0,11ab	25,34±0.56d
FTS-C	1,16 ± 0,02f	2,22 ± 0,03b	3,52	5,05 ± 0,14a	33,45±0,58a
FTS+A	4,01 ± 0,05a	1,87 ± 0,03e	3,53	5,03 ± 0,08a	29,20±0,64c
CS-C	2,61 ± 0,01c	2,27 ± 0,02b	3,53	4,93 ± 0,09a	31,07±0.77b
CS+A	2,76 ± 0,04b	2,11 ± 0,02c	3,54	4,56 ± 0,09b	26,56±0,41d
Sig.	**<0.001**	**<0.001**		**0.027**	**<0.001**

FMS-C: Fodder mustard silage control, FMS+A: Fodder mustard silage with additive, FTS-C: Fodder turnip silage control, FTS+A: Fodder turnip silage with additive, CS-C: Canola silage control, CS+A: Canola silage with additive, LA: lactic acid, AA: Acetic acid, RpH: Required pH value, MpH: Measured pH value, AS: Aerobic stability, a,b,c..: Means with different superscripts in the same column are significantly different.

MpH values of the *Brassica* forage crops used in this study ranged between 4.56 and 5.03 while their RpH values ranged between 3.52 and 3.54. Grain additive had no effect on the MpH value of fodder turnip while it decreased the MpH value of other silages, as expected (P<0.001). When RpH and MpH values of the silages were compared, it can be seen that the MpH value is higher. This can be explained by the calculation of the RpH value using the DM content of the silage material. RpH value is important only for the estimation of the fermentation. No statistical analyses were conducted with this respect. Fraser *et al* [22] reported an MpH value between 4.33 and 4.90 for *Brassica oleracea* silages and found that MpH value decreases to 4.1 with the inoculant addition. Keogh *et al* [35], on the other hand, reported that rumen pH value is 5.91 when *Brassica* and meadow grass blend silages have a *Brassica* ratio of 85%. Moorby *et al*. [30]s uggested that the use of green *Brassica* (kale) and barley for silage mixed at 1:1 ratio are of excellent quality for dairy cows. According to the literature, it is seen that mixed cultivation of *Brassica* and grains is favorable for the silage quality.

Vipond *et al* [21] reported a pH of 4.1, and DM of 17.6% for *Brassica oleracea* (kale) silage and the RpH value as reported by Meeske [17] was calculated as 4.07. This value is similar to the MpH value. Different MpH and RpH values obtained from the forages used in the study may account for the differences in the species, differences in DM, etc. Moorby *et al.* [30] reported dry matter content at 34.6%, OM content at 93.5% DM, CP content at 10.8% DM, ADF and NDF contents at 21.7% DM and 44.0% DM, respectively, EE content at 2.47% DM, lactic acid content at 5.82% DM and acetic acid content at 0.92% DM for the silages. pH value found in this study is similar to the RpH value found by Moorby *et al* [30]; while LA contents were lower and AA contents were higher. The reason behind these differences was Moorby *et al.* [30] ensiled *Brassica* forage crops with barley at 1:1 ratio. Barley is a easily dissolved carbohydrate source. In this study, it was found that grain addition increases the LA content in every *Brassica* silages, as expected (P<0.001). Hart and Horn [34] added a lower amount of wheat straw to the fodder turnip as additive and found the silage pH at 4.6 and LA content at 4.5%. Fraser *et al* [22] reported AA content between 2.08% and 4.75% and LA content between 5.61% and 7.90% for *Brassica oleracea* silages. Researchers suggested that LA and AA contents are reduced as the harvest is delayed and that *Brassica oleracea* can easily be ensiled [22]. The LA content (1.16-4.01%) reported in this study is lower than these findings which may be due to the differences in species, harvest time and different additives used.

Higher LA content and lower AA content is preferable for silage fermentation [9]. In this study, additive use significantly reduces the AA content in all silages except fodder mustard which is rich in CP content (P<0.001). Although, high AA contents are not desirable in terms of silage quality, it proves to be advantageous in aerobic stability of fodder mustard. Indeed, higher AA contents and increased aerobic stability is expected in silages rich in CP content [36]. The lower carbohydrate content found as a result of aerobic stability analysis made on the silages suggest that aerobic stability of the silages is maintained for a longer period of time, i.e, they have a longer lifecycle [25]. In this case, it was found that the aerobic stability (AS) of the silages is significantly reduced with the additive use, as shown in Table 3. In this study, fodder mustard was found to have the highest aerobic stability, as expected. It was found that additive use has a positive effect on the aerobic stability of all *Brassica* silages (P<0.001). Canbolat *et al.* [37] reported an aerobic stability at 34.31 CO_2 (g/kg DM) for alfalfa silage which is similar to the findings of this study for fodder turnip. Nevertheless, Filya and Sucu [38] reported the AS value for wheat, sorghum and maize at 26.62 CO_2 (g/kg DM), 21.48 CO_2 (g/kg DM) and 17.85 CO_2 (g/kg DM), respectively. As it is seen, ground wheat addition to the *Brassica* silages have a positive impact on the aerobic stability when compared to sorghum and maze silages. Beside, Limon-Hernandez et al. [7] reported that 4% molasses adding canola (*Brassica napus*) silages improved the dry matter content by 9% and *in vitro* digestibility decreased significantly. Consequently, it is adviced that brassica silages must ensiling with easy soluble carbohydrate sources as like molasses, ground cereal etc.

Qualities of the *Brassica* silages are given in Table 4 with regards to the assigned Flieg scores calculated using their total scores and DM and pH contents of the silages according to the sensory analysis conducted by five specialists.

Table 4: Quality classes of the silages with respect to sensory scoring and Flieg scores

Silages	Smell	Structure	Color	Total Point	Quality according to Total Point	Flieg Point	Quality according to Flieg Point
FMS-C	14.0	4.0	1.8	19.8	Excellent	37.65±3.17bc	Fair
FMS+A	12.7	3.7	1.9	18.3	Excellent	45.30±4.35b	Satisfactory
FTS-C	11.5	4.0	2.0	17.5	Good	32.11±5.62c	Fair
FTS+A	11.8	3.8	1.9	17.4	Good	36.89±3.13bc	Fair
CS-C	11.0	4.0	1.5	16.5	Good	41.65±3.43bc	Satisfactory
CS+A	13.0	3.8	2.0	18.8	Excellent	63.32±3.41a	Good
Significant						**<0.001**	

FMS-C: Fodder mustard silage control, FMS+A: Fodder mustard silage with additive, FTS-C: Fodder turnip silage control, FTS+A: Fodder turnip silage with additive, CS-C: Canola silage control, CS+A: Canola silage with additve, a,b,c..: Means with different supercripts in the same column are significantly different

With respect to the total score, FMS-C, FMS+A and CS+A silages are classified under the "excellent" quality class while the others were classified under "good" quality class. In the classification performed according to the Flieg scores, CS+A was found to be the top quality silage among others. According to these scores, FMS-C, FTS-C and FTS-A were classified as "fair"; FMS-A and CS-C were classified as "satisfactory", and CS+A was classified as "good". According to the Flieg scores, the use of additive in silages improves the quality for fodder mustard and canola silages ($P<0.001$), while, it has no effect on the silage quality of fodder turnip.

4. Conclusion

As conclusion, it was observed that fodder mustard and canola silages offer higher nutrition values 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 the higher CP content and lower lignin content of mustard silage is an advantage. In terms of DMD, DMI, and RFV, the highest value was found in canola silage with additive while fodder turnip silage showed the lowest value. Fodder turnip silage without additive was classified in "5-reject" quality class; while fodder mustard silages and canola with additive were classified in "2-good" quality class. In terms of *in vitro* true digestibility (IVTD), the highest value was found in the fodder mustard silage with additive while fodder turnip silage showed the lowest value. Nevertheless, it was found that additive (5% wheat) use has positive impact on the ensiling process, that it increases the lactic acid content in silage fermentation and that it improves silage quality. It is recommended that the future research can focus on the effects of *Brassica* forage crops on the animal performance with *in vivo* experiments, and the use of *Brassica* forage crops in order to reduce the methane production in ruminants.

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