www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Ensiling fruit and vegetable residues as ruminants feed

K. Karkoodi* **and S. A. Ghaffari**

Department of Animal Science, Saveh Branch, Islamic Azad University, Saveh, Iran

Abstract

The present study was carried out to assess the ensiling possibility of fruit and vegetable residues (FVR), collected from Central Terminal of Karaj with the treatments comprised of 25, 30, 35 and 40% of DM (a mixture of fruit and vegetable and wheat straw) and each of them was mixed with 0, 2 and 4% of sugar beet molasses respectively. This study was carried out in 4×3 factorial designs, involving four levels of dry matter and three levels of molasses. The apparent evaluation showed that silages were scored from 5.3 to 16.68 (out of 20) and significant ($P<0.05$) differences were found among these treatments. The pH values ranged from 4.22 to 5.33 and DM content was between 25.2 and 42%, in addition, there were significant ($P<0.05$) differences in pH and DM. Also, some changes ($P<0.05$) in the content of OM, Ash, total N, ammonia N, ammonia N ratio to total N, VFA and *in vitro* digestibility were detected among these treatments. We concluded that the silage contained 35% of DM and 4% of molasses was a superior treatment for ensiling of FVS.

Keywords: Fruit and vegetable residues; silage characteristics; *In vitro* digestibility

To cite this article: Karkoodi K and SA Ghaffari, 2012. Ensiling fruit and vegetable residues as ruminants feed. Res. Opin. Anim. Vet. Sci., 2(6), 397-101.

Introduction

Nowadays, owing to the high cost of feed stuff and shortage of grains, the utilization of non conventional sources of feed as ruminant diet has attracted the nutritionists. Many reports dealing with the utilization of fruit and vegetable residues (FVR) as animal feed have been published (Ahmed et al., 1994; Sayed and Abdel-azeem, 2009; Karkoodi et al., 2012). The utilization of by-products and food residues as animal feed would assist in decreasing the expense of waste management and also would result in increasing the consumption of grain by human. FAO in 1991 reported that the total waste produced from tomatoes in the world was approximately 3.70 million ton/year (FAO, 1991).

Sayed and Abdel-azeem (2009) reported that it would be efficient and safe to utilize dried tomato pomace in the diet of rabbits up to level of 20% without any adverse effect on performance. It should be mentioned that many other studies have reported the benefits of utilizing citrus pulp, apple pulp and food industry wastes in ruminant diet (Gasa et al., 1989; Cerda et al., 1994; Mokhtarpour, 1996). It is known that vegetable and fruit residues could be used in fresh, dried or ensiled forms in animal feeding (Church, 1991). Cerda et al. (1994) observed digestibility of tomato, celery, faba bean and French bean silage to be comparable with high silage quality. The main goal of silage making is to preserve as much of the nutritional value of the original crop as possible. Silage additives play some roles in improving nutrient composition, value of silage, palatability, decreasing storage losses by developing rapid fermentation, declining fermentation losses by limiting extent of fermentation, and in improving bunk life of silage through increase in aerobic stability (McDonald et al., 1991). Carbohydrates are added to silage to provide adequate energy for bacteria to produces lactic acid. Molasses has been used as a silage additive for many years. It constitutes 60% soluble carbohydrate and is able to increase both dry matter and lactic acid content. On the other hand, it can also lead to decrease pH and buffering capacity (McDonald et al., 1991; Fazaeli and

***Corresponding author:** K. Karkoodi, Department of Animal Science, Saveh Branch, Islamic Azad University, Saveh, Iran

Mahdavi, 1996). The large number of FVR residues (around 200 to250 ton/day) is accumulated in the Central Terminal of Tehran, the capital of Iran, which can contribute to the environmental pollutants and daily disposal expenditure (Shamma and Asefi, 1995).

The objective of this study was to evaluate the possibility of making silage and determination of nutritive value of FVR.

Materials and Methods

The samples used in this research were selected from the Karaj Fruits and Vegetables Central Market in Alborz province. After the separation of exogenous materials from FVR as a dry matter of 10-12%, the samples were chopped with a 37-tooth sprocket to obtain their size equal to 2-3 cm. Then, the residues were ensiled according to the formulas that were presented in Table 1. Each of 12 treatments was replicated 3 times.

Table 1: Experimental silages

Treatments	Molasses%	DM%
1	0	25
2	0	30
3	0	35
4	0	40
5	2	25
6	2	30
7	2	35
8	2	40
9	4	25
10	4	30
11	4	35
12	4	40

Table 2: The effects of treatments on the silage characteristics

Treatments	pH	DM%	Score
1	4.26 ±0.05^{bc}	25.2 ±0.4^{d}	14.3 ±0.2^{c}
2	4.42 ±0.01^{b}	29 ±1.4^{c}	16.2 ±0.1^{abc}
3	4.39 ±0.02^{b}	32.6 ±0.2^{c}	14.8 ±0.3^{bc}
4	5.33 ±0.12^{a}	40.1 ±0.1^{a}	5.3 ±1.6^{d}
5	4.23 ±0.04^{c}	25.6 ±0.5^{d}	15.0 ±0.8^{abc}
6	4.26 ±0.01^{bc}	30.2 ±1.0^{bc}	16.9 ±0.3^{a}
7	4.36 ±0.05^{bc}	32.4 ±1.8^{b}	15.2 ±0.4^{abc}
8	5.19 ±0.02^{a}	41.1 ±0.6^{a}	6.4 ±0.7^{d}
9	4.22 ±0.05^{c}	28.5 ±0.8^{c}	16.6 ±0.9^{ab}
10	4.27 ±0.02^{bc}	29.7 ±1.2^{b}	15.8 ±0.4^{abc}
11	4.32 ±0.07^{bc}	32.6 ±0.3^{b}	15.1 ±0.3^{abc}
12	5.28 ±0.03^{a}	42 ±0.1^{a}	5.5 ±0.9^{d}

Means with the different superscripts within a column are significantly different (P<0.05)

For apparent evaluation of silage, at the end of ensiling period (2 months), the bags were opened and the representative samples were taken to evaluate the silage quality by visual appraisal that included smell, colour, texture and the amount of mould (Saedi et al., 1992). The score of apparent evaluation of silage was assessed by four experts. About 250 g of each FVR were obtained and immediately subdivided into 3 portion to determine DM content, pH and chemical composition. The DM content was determined by drying at 65ºC for 48h in oven. The pH of samples was determined with Metrohm 633 pH meter. Total nitrogen and ammonia nitrogen were determined by Micro-Kjeldahl method (Singh et al., 1994). Twenty g of each sample was weighed accurately in beaker and 200 ml of distilled water was added to sample. It was stirred for two minutes. Then it was filtered through a dried filter and after that 20 ml of filtrate was taken to use in steam distillation apparatus. After distillation according to equation of Stuchbury et al. (1991), the total amount of total volatile fatty acids was determined, using 10 ml of filtrate that was obtained from previous part and transferred in centrifuge tube. The samples were centrifuged at 3000 for 10 minutes. The filtrate was transferred to condenser. The titre of each sample was calculated by equation of Stuchbury et al. 1991.

In vitro dry matter (DM), organic matter (OM) and digestible organic matter (DOM) in dry matter coefficients of digestibility were assessed using the 2-stage digestion procedure as described by Tilley and Terry (1963).

Statistical analysis

Data from this experiment were subjected to variance (ANOVA) using SAS statistical software (version 9.0) as a factorial completely randomized statistical module ($Y_{ij} = \mu + T_i + e_{ij}$) and differences among treatments were tested using Duncan's multiple test. In all cases, P<0.05 was considered as significant.

Results and Discussion

Table 2 indicates the results of apparent evaluation of silages that were carried out by visual appraisal. Significant differences (P<0.05) were found among these treatments in different months. According to a scoring system, the scores ranged from 5.3 to 16.86 and treatments 1, 2, 3, 5, 6, 7, 9, 10 and 11 were found in an acceptable category and treatments 4, 8 and 12 were categorized as unacceptable (Saedi and Shamma, 1992).

There were significant differences (P<0.05) in pH among treatments as observed in Table 2. The mean pH ranged from 4.22 to 5.33. Treatment 9 had the lowest pH and the highest pH belonged to treatment 4. It is recognized that the pH of silage must be defined in relation to dry matter so as to indicate the degree of success achieved in the ensilage process (Frank and Redman, 1986). The silage with the pH of 4.2 is considered to be high quality when its dry matter is 25%. Also, the silage would be classified as a good and acceptable when the mean pH is around 4.3-4.4 and above (Mykhchy, 1983; Saedi and Shamma, 1992).

Table 3: Effect of treatments on the ammonia nitrogen and volatile fatty acid

Treatments	$N\text{-}NH_3$	TN	$N\text{-}NH_3/TN$	TVFA
1	0. 18 ±0.002[a]	1.06 ±0.07[bcd]	17.87 ±1.63[a]	92.4 ±7.08[cde]
2	0.13 ± 0.009[b]	0.98 ±0.02[d]	13.45 ±1.25[b]	97.76 ±2.97[abcde]
3	0.13 ± 0.005[b]	1.09 ±0.06[abcd]	12.47±1.18[bcd]	117.13 ±5.99[abc]
4	0.09 ±0.006[cde]	0.97 ±0.008[d]	9.65 ±0.46[de]	119.84 ±2.12[ab]
5	0.17 ± 0.01[a]	1.21 ±0.06[a]	14.17 ±0.77[b]	111.3 ±10.12[abc]
6	0.1 ± 0.003[bcd]	1.02 ±0.04[d]	10.48 ±0.7[cde]	84 ±18.18[de]
7	0.12 ± 0.01[b]	1 ±0.05[d]	12.58 ±1.4[bc]	94.03 ±3.92[bcde]
8	0.08 ± 0.003[de]	1 ±0.01[d]	8.91 ±0.15[ef]	109.38 ±2.38[abcde]
9	0.12 ± 0.002[b]	1.2 ±0.06[ab]	10.06±0.56[cde]	96.83 ±20.21[abcde]
10	0.07 ± 0.01[e]	1.06 ±0.02[cd]	6.67 ±0.08[f]	72.8 ±5.04[e]
11	0.11 ± 0.006[bc]	1.18 ±0.04[abc]	10 ±0.91[cde]	122.03 ±2.22[a]
12	0.09 ± 0.008[cde]	1.05 ±0.01[cd]	8.97 ±0.55[ef]	110.32 ±5.81[abcde]

Means with the different superscripts within a column are significantly different ($P<0.05$); TN: total nitrogen, TVFA: total volatile fatty acids

Table 4: *In vitro* digestibility of the treatments (%)

Treatments	DMD	OMD	DOMD
1	57.36 ±1.35[cd]	62.18 ±2.38[bc]	54.46 ±1.27[cd]
2	56.80 ±1.48[cde]	62.48 ±1.63[bc]	53.96 ±1.4[cd]
3	53.86 ±1.44[de]	59.25 ±1.59[cd]	51.50 ±1.08[d]
4	54.26 ±2.48[de]	52.62 ±3.21[ef]	44.07 ±2.2[e]
5	59.19 ±0.18[abc]	63.13 ±0.78[bc]	56.23 ±0.17[abc]
6	61.63 ±0.34[ab]	68.13 ±0.38[a]	58.84 ±0.33[ab]
7	57.57 ±2.78[bcd]	62.28 ±2.6[bc]	54.69 ±2.64[bcd]
8	55.87 ±0.65[cde]	56.15 ±1.34[de]	44.00 ±2.26[e]
9	63.04 ±1.60[a]	66.19 ±1.68[ab]	59.51 ±1.35[a]
10	62.92 ±0.69[a]	68.85 ±0.92[a]	59.46 ±0.79[a]
11	62.49 ±1.21[a]	65.67 ±1.27[ab]	59.32 ±0.93[a]
12	52.70 ±1.38[e]	50.19 ±1.21[f]	40.94 ±0.38[e]

DMD: Dry matter digestibility; OMD: Organic matter digestibility; DOMD: Digestible organic matter in dry matter. Means with the different superscripts within a column are significantly different ($P<0.05$)

Therefore, the treatment 5 and 9 with the pH of 4.23, 4.22, respectively and its dry matter was 25% designated as a high quality silage and treatment 1 with the pH of 4.26 is an acceptable silage. The silage with 30% dry matter and pH is 4.3 enters into the high quality category. When pH increases to 4.4-4.8 and above the silage is categorized in good quality. So the treatment 6 and 10 with the mean pH of 4.26 and 4.27, respectively were placed in high quality silage and treatment 2 with the pH of 4.24 were classified as good and acceptable silage.

In addition, the high quality silage generally contains 35% of dry matter and its pH should be lower than 4.5 (McDonald et al., 1991; Saedi and Shamma, 1992). According to this definition, treatments 3, 7 and 11 with the pH of 4.39, 4.36 and 4.32, respectively were the high quality silage. Also, the silage with 40% dry matter in order to inter into high quality silage needs to have the pH lower than 4.7.

Determining the pH of forage can reveals some aspects relating to the type of fermentation that has taken place and the quality of forage. It can also give some clues to what may have gone wrong during the ensiling process if the pH is too high. In this regard, the appropriate pH in the silage depends on the percentage of dry matter. In other words, when the percentage of dry matter increases, high means pH are acceptable (Frank and Redman, 1986). In the present study, adding sugar beet molasses to treatment 5, 6, 7, 8, 9, 10, 11 and 12 led to improved fermentation and also resulted in the decrease pH as a consequence of increasing the soluble carbohydrate and dry matter content. These results were also reported by Fazaeli and Mahdavi (1996) and McDonald et al. (1991). It is hypothesized that low soluble carbohydrate and dry matter in silage lead to activation of clostridium and molds production. These results have been observed previously (Mykhchy, 1983; McDonald et al., 1991; Saedi and Shamma, 1992). The results of this study showed that by increasing 5% of dry matter and inclusion of molasses, the pH in treatments 2, 6, 11 reduced. Teymoornejad (2000) obtained the mean pH of FVR silage in spring and winter as 4.52 and 6.02%, respectively which were significant between the two seasons of study.

Significant differences ($P<0.05$) in dry matter were found which ranged from 25.2 to 41.97% (Table 2). The lowest and highest dry matter content were found in treatment 1 and 12 (25.2 and 41.9% respectively), according to diverse ratio of different ingredient silage such as wheat straw, molasses, fruit and vegetable residue. In the present study, the treatment 1, 5 and 9 had the lowest ratio of straw and these treatments were treated with 0, 2 and 4% molasses respectively. As a consequence of adding 4% molasses, the dry matter significantly increased that led to improved silage. This result agreed with that found by Mykhchy (1983) and McDonald et al. (1991) who reported the effect of adding molasses on dry matter of silage. However, the ideal dry matter in silage is around 30-35%, while the dry matter generally ranges from 15 to 60% (Chamberlain and Wilkinson, 2000). Treatment 6 (Table 2) with 30.17% dry matter and pH 4.26 was the best treatment in terms of relationship between pH and dry matter.

The result obtained in this experiment showed that the treatments 2, 4, 7, 8 and 12 contained the lowest total nitrogen (Table 3). It may be due to addition of straw that increased dry matter and decreased Cp. As illustrated in Table 3, there were significant differences (P<0.05) among treatments in terms of ammonia nitrogen which ranged from 0.07 to 0.18%. The highest ammonia-n belonged to treatment 1 with 25.2% dry matter and treatment 10 had the lowest ammonia-n with 29.68% dry matter. Ammonia-n level of total nitrogen can expose some aspects concerning the quality of fermentation and the potential of consumption of silage and it has been used as a general criterion of determination of its quality. When ammonia-n level of total nitrogen is lower than 5 g of 100 g, it would be deemed to be the satisfaction of secondary fermentation (Chamberlain and Wilkinson, 2000), while the rate of ammonia-n level in silage is generally between 5 and 15 g of each 100 g. The high ammonia-n level causes depression of energy metabolism (Chamberlain and Wilkinson, 2000). Therefore, it can be assumed that treatment 1 and 5 had weak fermentation, the treatment 2, 3, 6, 7, 9 and 11 had moderate fermentation and the treatment 4, 8, 10 and 12 had good fermentation. Excellent fermentation in FVR silage was not found that may be probably due to low dry matter. In contrast, the treatments with high dry matter would be categorized in good silage. In fact, ammonia-n results from degradation of protein and convert it into ammonia and amines (Saedi and Shamma, 1992). Therefore, the treatment 10 (contained the lowest ratio of FVR and the highest ratio of straw wheat and molasses) had the lowest percentage of CP. Fazaeli and Mahdavi (1996) also reported the effect of reducing CP concentration and increasing dry matter content in silage on the declining in ammonia-n level.

As is shown by the Table 3, in terms of total volatile fatty acids, there were significant differences (P<0.05) among treatments and the highest and the lowest of total volatile fatty acids were found in treatments 11 (122.03 mmol) and 10 (72.8 mmol). The importance of determination of lactic acids and volatile fatty acids score in forage silage is to control moisture level (Frank and Redman, 1986; Reis et al., 2000). The production levels of lactic acids and TVFA are a reflection of unsuitable fermentation or secondary fermentation of lactic acids to butyric acid and degradation of amino acids to ammonia and acetic acid. In the ideal case, the total number of VFAs in the silage should be less than 0.2 of total silage fermentation acids (Chamberlain and Wilkinson, 2000).

The results of *in vitro* digestibility are given in Table 4. Based on these results, mean digestibility was 58.17%. The minimum DM digestibility was found in treatment 12 (52.7%) and the maximum was in treatment 9 (63.04%). These results were higher than reported by Teymoornejad (2000) in FVR which was conducted in winter and spring (43.5 and 49.61% respectively). DM digestibility in superior treatment (10) was 62.92% that was similar with treatment 9. In terms of OM digestibility, acquired percentages were between 50.19 and 68.85% and the highest was found in treatment 10 and the lowest was shown in treatment 12. Also a significant difference (P<0.05) was found between these two treatments. OM digestibility in FVR in spring and winter were 35.52 and 40.04% respectively (Teymoornejad, 2000). This diminution in OM digestibility in spring and winter in comparison with autumn could be explained by the high ash content in winter and spring that lead to decrease DM and OM digestibility.

Conclusions

The results of this study indicated that treatment 10 having DM (29.68%), OM (78.07%), ash (21.93%), total N (1.06%), ammonia N (0.07%), ammonia N ratio to total N (6.67%), *in vitro* DM digestibility (62.92%), *in vitro* OM digestibility (68.85%), *in vitro* DOM digestibility (59.46%), pH (4.27), VFA (72.8 mmol) was considered as a superior treatment.

References

Ahmed, S.S., El-Gendy, K.M. and Ibrahim, H. 1994. Growth performance, digestibility, carcass traits and some physiological aspects of growing rabbits fed tomato pomace as a substitution for alfalfa meal. *Egyptian Journal of Rabbit Science*, 4 (1): 1-18.

Cerda, D., Manterola, H., Mira, J., Sirhan, L. and Vallejo, O. 1994. Studies on the use of agro industrial by-products in animal feeding. VIII. Study on silage potential of five horticulture crop residues. *Advance Production Animal*, 19 (1-2): 105-114.

Chamberlain, A.T. and Wilkinson, J. M. 2000. Feeding the dairy cow. 3rd (rev.ed). Published by Chalcomb Publication, Southampton, UK.

Church, D.C. 1991. Livestock feeds and feeding. 4th (rev. ed). Prentice Hall Inc. Englewood Cliffs, NJ.

FAO, 1991. Production year book, vol.44.food and agricultural Organization of the United Nation. Rome.

Fazaeli, H. and Mahdavi, R. 1996. Effect of rice straw, molasses, oatmeal and salt on silage quality of berseem clover. *Journal of Pajoohesh and Sazandegi*, 34:116-119. (Article in Persian, with an abstract in English).

Frank, R. and Redman P. 1986. Forage conservation and feeding forming. *LTD Press*, Pp: 24-27.

Gasa, J., Castrillon, C., Baucells, M.D. and Guada, J.A. 1989. By- products from the canning industry as feedstuff for ruminants: Digestibility and its prediction from chemical composition and laboratory bioassays. *Animal Feed Science and Technology,* 25: 67 - 77.

Karkoodi, K., Fazaeli, H. and Mirghaffari, S.S. 2012. Assessing the nutritive value of fruit and vegetable residues as ruminant feed. *Turkish Journal of Veterinary and Animal Sciences*, 36 (1).

McDonald, P., Henderson, A.R. and Heron, S. 1991. The Biochemistry of Silage. Kingston, Kent: Chalcombe Publications. P: 340.

Mokhtarpour, Q.R. 1996. Utilization of tomato pomace in feel-lot lamb diets. Proceedings of 1st Country Animal Nutrition Research Seminar. Pp:191-197. (Article in Farsi with an abstract in English).

Mykhchy, M.H. 1983. How plants produce silage for animal feed. Issue number one. Publishing Public Relations Department of Agriculture.

Reis, J., Paiva, A. and Tiesenhausen, P.D. 2000. Chemical composition, voluntary intake, digestibility of the silage of passion fruit residues with elephant grass.

Saedi, H.M. and Shamma, M. 1992. Livestock and poultry food and their method of food preservation. Volume II. Tehran University Press.

SAS Institute, 2002. SAS User's Guide, Version 9.0 ed. SAS Inst., Inc., Cary, NC.

Sayed, A.B.N. and Abdel-azeem, A.M. 2009. Evaluation of dried tomato pomace as feedstuff in the diets of growing rabbits. *International Journal for Agro Veterinary and Medical Science,* 3:12-18.

Shamma, M. and Asefi, A.R. 1995. Utilization of fruit and vegetable residues in feedlot presidency of recycling organization of Tehran municipality. (article in Farsi with an abstract in English).

Singh, C.A., Sarker, A.B. and Roy, T.C. 1994. Chemical composition and digestibility of garbage fed to Hampshire pigs. Department of Animal Production and Management, College of Veterinary Science, Assam Agricultural University, India, *Livestock Adviser,* 19: 5, 20-24.

Stuchbury, T. and Scaife, J.R. 1991. Practical Manual, Farm Animal Biochemistry. Department of Agricultural Biochemistry, Aberdeen University, U.K.

Tilley, Y.M.A. and Terry, R.A.A. 1963. A two stage technique for the *in vitro* digestion of forage crops. *Journal of British Grassland and Society,* 18: 104-111.

Tymoornejad, N. 2000. Determination of nutritive value of fruits and vegetable wastes *in situ* and *in vitro* techniques in spring and winter seasons. MSc thesis of Islamic Azad University, Karaj branch. Iran. (Thesis in Farsi with an abstract in English).