N4.23 - EVALUATION OF THE NUTRITIVE VALUE OF ENSILED WHEAT STRAW AND APPLE MIXTURES (mrodrigu@utad.pt)

A.L. Rodrigues, C.V.M. Guedes, L.M.M Ferreira, and M.A.M. Rodrigues, *CECAV-UTAD, PO Box 1013, 5000-911 Vila Real Codex, Portugal*

1 – MESSAGES

- Agriculture residues represent 25% of the available energy for ruminant feeding.
- In 2003/2004, 43 million metric tons of apples were produced. Around 10% of it is low calibre apple and, in Portugal, is normally thrown away.
- Silage in vitro organic matter digestibility of low calibre apple with wheat straw increased with apple incorporation.
- Ensiling of these mixtures requires silage additives.

2 – INTRODUCTION

The world cereal production is extremely high leading to the production of approximately 2 million tons/year of straw. The utilization of fruit by-products may also be used has an energetic supplement for low nutritive value feeds. The present experiment aimed to study the effect of low calibre apple incorporation with wheat straw mixtures and to evaluate its conservation as silage.

3 –METHODS

Four mixtures of apple and wheat straw, containing 100% (M_{100}), 85% (M_{85}), 70% (M_{70}) and 50% (M_{50}) of apple were used. For each mixture three ensiling times were used (15, 30 and 45 days). All treatments were conducted in quadruplicate.

Wheat straw was cut in 5cm particles and apples were mowed until a homogenous paste was obtained. Feeds were manually mixed and ensiled in 5 dm^3 micro-silos.

Samples of mixtures were taken before ensiling and at each ensiling time. Part of the sample was immediately used for pH (Sheperd and Kung, 1996) and volatile fatty acid (Czerkawsky, 1976) determinations. The rest of the sample was dried and mowed to 1mm for posterior chemical analysis and in vitro digestibility and fermentation kinetics studies.

Samples were analysed for dry matter (DM), ash and total nitrogen as Kjeldahl nitrogen according to AOAC (1990). The cell wall content of samples was determined according to van Soest *et al.* (1991). Hemicelluloses (Hem) and Cellulose (Cel) contents were calculated as the difference between neutral detergent residue (NDF) and acid detergent residue (ADF) and ADF and acid detergent lignin (ADL), respectively. Non fiber carbohydrate (NFC) were calculated according to NRC (2001).

In vitro organic matter digestibility (IVOMD) was determined using the Tilley and Terry (1963) procedures. Gas production kinetics was studied according to Cone et al. (1997).

The results were subjected to analysis of variance using one-way ANOVA through the GLM procedure of SYSTAT (Wilkinson et al, 1992). When significant, means were compared using protected LSD test according to Snedcor and Cochran (1980).

4 – RESULTS AND DISCUSSION

The chemical composition of wheat straw and apple mixtures before ensiling is shown in Table 1. Cell wall contents of mixtures decreased with higher levels of apple incorporation. On the contrary, the IVOMD increased, as the concentrations of apple in the mixtures were higher.

Table 1 - Chemical composition of feeds before ensiling.

	DM	NDF	ADF	ADL	CP[†]	NADF[†]	NNDF[†]	IVOMD	pH
	($g\ kg^{-1}$)	($g\ kg^{-1}$DM)				($g\ kg^{-1}$totalN)		($g\ kg^{-1}$OM)	
M_{100}	179,3	107,4	80,0	24,3	22,8	283,7	473,3	876,8	3,7
M_{85}	290,8	502,6	317,0	45,9	18,7	326,1	460,9	589,5	3,8
M_{70}	406,8	656,1	412,8	59,4	17,4	369,1	383,0	483,1	4,2
M_{50}	557,4	753,2	470,0	66,7	27,2	302,8	386,6	456,6	5,0
P	873,6	885,1	544,0	74,5	18,8	389,7	442,7	358,0	5,8

[†] NADF – nitrogen linked to the ADF fraction; NNDF - nitrogen linked to the NDF fraction; CP – crude protein.

In relation to the fresh material there was a general decrease of 20% in the IVOMD, along ensiling time, for all treatments (Table 2a).

Regarding the chemical composition of the silages it is important to enhance the same tendency for the Non Fiber Carbohydrate (NFC) fraction along the ensiling process (Table 2). However, the observed data show a reduction of 3%, 48%, 27% and 16% for M_{100}, M_{85}, M_{70} and M_{50}, respectively.

The pH values observed in the silages indicate that the fermentation process did not reach stabilisation (Table 2b).

Table 2a- Effect of wheat straw and low calibre apple mixtures on silage nutritive value at 15, 30 and 45 days.

Mixture	Time	DM	Ash	NDF	ADF	ADL	Cel	Hem	NFC	IVOMD
		(g kg^{-1})	(g kg^{-1}DM)							(g kg^{-1}OM)
M_{100}	15	78,5^{a}	66,6^{j}	274,8^{a}	226,0^{a}	103,8^{h}	122,2^{a}	55,8^{b}	600,2^{k}	769,9^{j}
	30	64,1^{a}	44,1^{h}	344,9^{c}	273,8^{c}	119,6^{i}	154,2^{c}	74,4^{c}	526,1^{i}	726,8^{i}
	45	72,0^{a}	46,3^{i}	292,5^{b}	245,4^{b}	100,1^{g}	145,4^{b}	51,6^{a}	581,9^{j}	702,8^{h}
M_{85}	15	250,4^{c}	25,6^{a}	506,0^{d}	331,4^{d}	56,1^{a}	275,2^{d}	179,7^{d}	462,0^{h}	545,8^{g}
	30	206,7^{b}	30,7^{d}	681,0^{e}	437,2^{e}	79,0^{bc}	358,2^{e}	247,8^{f}	247,8^{g}	482,2^{f}
	45	220,4^{b}	30,7^{d}	691,6^{f}	455,6^{f}	77,1^{b}	378,5^{f}	241,7^{e}	237,7^{g}	452,0^{e}
M_{70}	15	344,3^{de}	28,4^{b}	736,8^{g}	473,8^{g}	80,9^{cd}	392,9^{g}	268,2^{g}	205,2^{f}	435,4^{d}
	30	322,8^{d}	28,8^{bc}	753,9^{h}	475,1^{g}	84,6^{e}	390,5^{g}	284,2^{h}	184,7^{e}	429,0^{d}
	45	331,6^{d}	29,9^{cd}	789,2^{i}	511,4^{h}	78,4^{bc}	433,0^{i}	283,7^{h}	149,6^{d}	385,3^{b}
M_{50}	15	470,8^{f}	35,0^{e}	882,7^{k}	535,1^{i}	82,6^{de}	452,5^{j}	297,5^{j}	107,1^{b}	403,8^{c}
	30	466,5^{ef}	41,0^{g}	797,3^{i}	513,8^{h}	91,1^{f}	422,7^{h}	293,9^{j}	117,5^{c}	397,4^{c}
	45	502,2^{g}	36,7^{f}	833,6^{j}	550,4^{j}	85,5^{e}	464,9^{k}	291,5^{i}	89,9^{a}	371,0^{a}
	Effects									
	Mixture (M)	***	***	***	***	***	***	***	***	***
	Time (T)	*	*	***	***	**	***	***	***	***
	Interaction (MxT)	NS	***	***	***	NS	***	***	***	NS
	SEM									
	Mixture (M)	7,99	0,47	3,23	2,22	1,14	1,83	1,23	3,50	3,47
	Time (T)	6,92	0,41	2,80	1,92	0,99	1,59	1,06	3,03	3,01
	Interaction (MxT)	13,83	0,82	5,60	3,84	1,97	3,17	2,12	6,07	6,01

NS – Not significant

*(P<0,05); **(P<0,01); ***(P<0,001)

a,b,c,d,e,f,g,h,i,j,k Within columns, means with different superscripts are significantly different (P<0.05)

SEM – Standard error of mean

Table 2b- Effect of wheat straw and low calibre apple mixtures on silage nutritive value at 15, 30 and 45 days.

Mixture	Time	N_{total} (g kg^{-1}DM)	CP (g kg^{-1}DM)	NADF [(1)] (g kg^{-1} Nt)	NNDF [(2)] (g kg^{-1} Nt)	NADF [(1)] / NNDF [(2)] (%)	pH	ACET† (mmol/100ml)
M_{100}	15	6,9 ^{g}	43,2 ^{g}	590,8 ^{h}	685,3 ^{j}	86,1 ^{de}	3,7 ^{a}	15,0 ^{g}
	30	9,6 ^{i}	60,1 ^{i}	493,7 ^{g}	622,4 ^{i}	79,2 ^{bc}	3,8 ^{b}	25,2 ^{i}
	45	9,2 ^{h}	57,7 ^{h}	482,6 ^{g}	571,9 ^{h}	84,4 ^{d}	3,9 ^{d}	21,2 ^{h}
M_{85}	15	3,5 ^{b}	21,7 ^{b}	292,9 ^{b}	426,4 ^{ef}	68,6 ^{a}	3,8 ^{cd}	8,5 ^{f}
	30	4,5 ^{de}	28,3 ^{de}	324,2 ^{c}	423,4 ^{ef}	76,6 ^{bc}	3,8 ^{c}	7,8 ^{e}
	45	4,4 ^{d}	27,5 ^{d}	362,3 ^{f}	472,0 ^{g}	76,7 ^{bc}	4,0 ^{f}	4,0 ^{c}
M_{70}	15	3,2 ^{a}	20,1 ^{a}	314,6 ^{c}	416,2 ^{e}	76,0 ^{b}	4,2 ^{h}	3,8 ^{c}
	30	3,5 ^{b}	21,9 ^{b}	329,3 ^{cd}	367,5 ^{c}	89,7 ^{f}	4,1 ^{g}	5,9 ^{d}
	45	3,3 ^{ab}	20,8 ^{ab}	346,3 ^{e}	435,8 ^{f}	79,6 ^{c}	4,2 ^{h}	2,9 ^{b}
M_{50}	15	4,1 ^{c}	25,7 ^{c}	343,0 ^{de}	382,2 ^{d}	89,8 ^{f}	5,0 ^{k}	4,2 ^{c}
	30	5,3 ^{f}	33,0 ^{f}	266,8 ^{a}	307,4 ^{a}	87,9 ^{de}	4,8 ^{i}	2,7 ^{b}
	45	4,7 ^{e}	29,3 ^{e}	286,7 ^{b}	328,2 ^{b}	88,5 ^{e}	4,9 ^{j}	1,9 ^{a}
	Effects							
	Mixture (M)	***	***	***	***	*	***	***
	Time (T)	***	***	NS	*	NS	***	***
	Interaction (MxT)	*	*	*	**	NS	***	***
	SEM							
	Mixture (M)	0,07	0,43	5,45	4,28	12,21	0,0067	0,21
	Time (T)	0,06	0,37	4,72	3,70	10,57	0,0058	0,18
	Interaction (MxT)	0,12	1,26	9,43	7,41	21,15	0,012	0,36

NS – Not significant

*(P<0,05); **(P<0,01); ***(P<0,001)

a,b,c,d,e,f,g,h,i,j,k Within columns, means with different superscripts are significantly different (P<0.05)

NADF[(1)] - (N-ADF x ADF)/Ntotal); NNDF[(2)] - (N-NDF x NDF)/Ntotal);†ACET – Acetic acid

SEM – Standard error of mean

.

Analysing the NFC content of silages and comparing it to the original material before ensiling shows that, in the first 15 days, the level of fermentation of M_{85} was very low. In fact for mixtures M_{100}, M_{70} and M_{50} 20-30% of NFC were utilised while in M_{85} only 2% of this fraction was fermented.

5 – CONCLUSIONS

- Adding apple to wheat straw results in mixtures with high OM digestibility.
- The ensiling of these mixtures showed that there is no stabilisation of the fermentation process leading to a decrease of the nutritive value of the silages.
- In order to improve the silages from these feeds the utilisation of additives, to rapidly decrease the pH, should be considered.

6 – REFERENCES

Association of Official Analytical Chemists (AOAC), 1990. Official Methods of Analysis. 14th Edition, Vol 1, AOAC, Washington DC, USA, 684pp.

Cone, J.W., Van Gelder, A.H., and Driehuis, F., 1997. Description of gas production profiles with a three-phasic model. Anim. Feed Sci. Technol., 66: 31-45.

Czerkawski, J.W., 1976. The use of pivalic acid as a reference substance in measurements of production of volatille fatty acids by rumen micro-organisms in vitro. Br. J. Nutr., **36**: 311-315.

National Research Council. 2001. The Nutrient Requirements of Dairy Cattle, 7th Revised Edition. National Academy of Sciences, Washington, D.C., 381pp.

Sheperd, A.C. and Kung, L.J.R., 1996. An enzyme additive for corn silage: effects on silage composition and animal performance. J. Dairy Sci., 79: 1760-1766.

Snedcor, G. W. and Cochran, W. G., 1980, Statistical methods. 7.ed. Iowa State University, Iowa, 507p.

Tilley, J.M.A. and Terry, R.A., 1963. A two stage technique for the in vitro digestion of forage crops. J. Brit. Grassland Soc., 18: 104-111.

Van Soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods of dietary fiber, neutral detergent fiber, and nonstarch polyssacarides in relation to animal nutrition. J. Dairy Sci.,.74: 3583-3597.

Wilkinson, L., Hill, M., Welma, J.P., and Bierkenbeuel, G.K., 1992. Systat for windows: Statistics. 5th edition, Evanston, I.L., Systat Inc., 750pp.