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Full Length Research Paper

Effects of molasses and ground wheat additions on the quality of groundnut, sweet potato, and Jerusalem artichoke tops silages

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In this study, the effects of molasses (M) and ground wheat (GW) additions on the quality of groundnut (*Arachis hypogaea* L.) (GN), sweet potato (*Ipomoea batatas* L.) (SP) and Jerusalem artichoke (*Helianthus tuberosus* L.) (JA) tops silages were investigated. GW and M were added in the silages at 0, 2, 4 and 6% in fresh matter basis (W0, W2, W4, W6 and M0, M2, M4, M6). Additions of the silage additives increased the DM of the silages (P<0.01). Compared with the silages having no additives, CP contents of the silages supplemented with both silage additives were higher. Four percent GW added SP silage had more CP content (11.59%) while 6% GW added JA had less CP content (4.7%). Except for JA silage (P > 0.05), M and GW decreased pH in the GN and SW tops silages (P < 0.01). The ADF, NDF and ADL contents were significantly decreased (P < 0.001) by increased level of GW and M. The lactic acid contents of the GN silages with 2 and 4% GW and SP silage with 6 % GW were lower than the desired level (2%). Flieg scores of all silages were excellent, except GN silages added with 0, 2 and 4% GW which had good score.

Keywords: Groundnut, sweet potato, Jerusalem artichoke, silage, wheat and molasses additives, silage quality.

INTRODUCTION

Increases in the world population means that food production must be also increased. If disposal materials or by-products can be used as animal feed, they will represent no competition with human consumption, although it must be ensured that these products are healthy to animals and do not increase environmental pollution. In light of this, an interesting range of crop by-products can be considered as feedstuff (Meneses et al., 2007). Livestock producers can save money if they used by-product in animal nutrition by offering allowance level without affecting animal performance negatively (Megias et al., 1998). By-products can be obtained from ground-nut (GN), sweet potato (SP) and Jerusalem artichoke (JA) when processed or directly used as feedstuff for animal feeding. Their green vegetative mass yield 2.43, 5.00 and 4.40 tone per ha, respectively (Arslan, 2005; Dominquez, 1992; Cosgrove et al., 1991).

GN is one of the key crops in semi-arid tropic zones. It is commonly cultivated as a food-feed crop that provides pods for human food and haulms for livestock feeding (Larbi et al., 1999; Omokanye et al., 2001). SP is also used as animal feed, which has been a by-product of crops grown for human consumption. Increasing recog-nition of the great potential of the SP crop as a nutritious food for humans and animals has resulted in intensified research efforts to enhance production and consumption in recent decades (Woolfe, 1992; Yamakawa and Yoshimoto, 2002). JA can be grown for human consumption, alcohol, fructose production and livestock feed (Cosgrove et al., 1991).

The traditional problems encountered with by-products are the seasonality of supply and their high moisture content which means that spoil and are often wasted. Ensilage is usually the most appropriate way for per-

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Table 1. Average nutrient composition of fresh crop

Crop	DM,%	CP,%	EE,%	CF,%	Ash,%
GN	28.87	8.04	6.31	16.50	11.68
SP	22.48	8.28	4.79	8.00	10.11
JA	19.59	14.38	3.21	14.50	14.90

GN; goundnut haulm, SP; sweet potato vine, JA; Jerusalem artichoke tops

serving such by-products for long periods. Silages may be defined as moist forage in the absence of air and preserved by fermentation (McDonald et al., 1991).

The aims of the current study were to determine the possible effects of wheat and molasses addition on groundnut, sweet potato and Jerusalem artichoke tops silages.

MATERIAL AND METHODS

Fresh forage materials were obtained at the Research Farm of Mustafa Kemal University, Hatay (36° 15´ altitude, 36° 30´ latitude) located in the Eastern Mediterranean region of Turkey. Green part of GN, SP and JA were sliced mechanically with the size of 2-5 cm and kept in 5 L plastic cups after addition of 0 (control) , 2, 4 and 6 % wheat (W0, W2, W4, W6) and the similar levels of molasses (M0, M2, M4, M6) with 3 replicates for each addition level. These filled silage cups were stored in normal ambient temperature for 60 days. After opening cups, their contents were analysed for nutrient content and acidity pH. Dry matter of silage samples was determined after keeping 60°C for 48 h in air forced oven while their ash content were determined after furnaced at 550°C for 3 h in furnace. Ensiled forage were analyzed for pH by placing a 20 g sample in a blender jar, diluting with deionised distilled water to 200 ml, and blending for 30 s in a high-speed blender. Flieg scoring was applied by the method of Kilic (1986);

Flieg score = 220 + (2 x % DM -15) - 40 x pH

Crude protein content of materials was determined by Kjeldahl method, ether extract by Soxholet method; NDF, ADF and ADL levels by Ankom fiber technology. Lactic acid and VFA (that is acetic and butyric acids) were measured by Lepper's distillation method (Karabulut and Canpolat, 2005). Data were analysed by using SPSS software (Windows version of SPSS, release 10.01) with Univariate analysis. The comparisons between means were made by using Duncan Multiple Range Test in the same software.

RESULTS AND DISCUSSION

The nutrient content of fresh biomass and tops silages of GN, SP and JA were given in Tables 1 - 4. The present DM content of the whole aerial parts of SP forage is lower (Table 1) than those reported by Orodho et al. (1993) and Woolfe (1992). Addition of M and GW to GN, SP vine and JA tops silage increased DM content of silages, possibly due to the high DM content in additives (Tables 2, 3 and 4). DM content of SP tops silage was lover than those of the GN and JA tops silages. Except GN, DM contents of SP and JA tops silages were significantly higher than those of control treatments (P < 0.01). In the present study, the DM content of JA was higher and pH level was lower than those of Hay and Offer (1992)'s silages. Compared with the control, crude protein content of silages were higher in wheat groups, while 2 and 4% molasses added silages had lower protein content, but it was higher in 6% molasses added treatment (P < 0.01).

Incorporation of molasses into the forage reduced CP, probably due to the low CP of molasses (McDonald et al., 1991). Others, however, reported increased silage CP with molasses (Aksu et al., 2006; Rezaei et al., 2009). Treatments both M and GW increased the ash content of silages, except JA silage. Ash was increased with increase levels of molasses due to the high mineral content in molasses. The crude ash percent of wheat groups was lower than the control group (P < 0.01).

The pH of silages is one of the most important quality criteria of silages. The low pH obtained which is usually accomplished through the fermentation of sugars in the crop to lactic acid by lactic acid bacteria, decrease plant enzyme activity and prevents the proliferation clostridia and enterobacteriae (Woolford, 1984). The pH was greatly influenced by the crops and additives treatment. Higher pH level of GN silages was attributed to lower level of lactic acid production by bacteria and lack of enough sugar for bacterial consumption (Seale et al., 1986). The detected pH level (4.79) of GN control group supports this assumption. The M6 GN silage group supplemented with molasses had enough sugar let to decrease pH in 3.91. Castle and Watson (1985) and McDonald (1981) reported that addition of molasses into silages decreased pH. JA and SP biomass silages had desired pH levels even in their control groups due to enough soluble carbohydrates contents. When used as silage additives, M and GW decreased silage pH in GN and SP silages, but not significantly changed pH of JA silage groups (P > 0.05).

Plant maturity is a factor that has the greatest effect on quality. The onset of maturity during the early growth stage in spring was accompanied by significant changes in nutritive value: increased ADF and NDF decreased CP and DM. It is well known that cell wall components such as cellulose and lignin are greater in stems than leaves and greater in legumes than grasses (Aman, 1993). ADF, NDF and ADL percentages were significantly decreased (P < 0.001) with increase level of wheat and molasses (Tables 2, 3, 4), because wheat and molasses have little ADF and NDF content and enhancement of cell wall degradation due to increased silage fermentation caused by the sugars in molasses (Baytok et al., 2005).

Desired lactic acid rate of silages was above 2% (Kiliç, 1986; Alçiçek, 1995). In the current study, the lactic acid rates of groundnut biomass supplemented with 2 and 4% GW and SP biomass supplemented with 6% GW were below the desired value of 2%. The other silage groups had the desired lactic acid rates (Table 6). Lactic acid production was higher in the silages treated with molasses, probably caused by an initial increase in the

Table 2. Nutrient content, pH and Flieg scale of groundnut haulm silage

Trait	DM,%	CP, %	CF,%	EE, %	Ash,%	pH	ADF, %	NDF, %	ADL, %	Flieg Scale
Cont.	28.72±0.21bc	7.44±0.20bc	15.47±1.19a	2.39±0.01d	13.91±0.03c	4.79±0.01d	38.75±0.06c	37.89±0.23e	26.70±0.29d	70
W2	28.10±0.93abc	8.00±0.06cd	19.22±0.78c	2.40±0.01d	12.86±0.08a	4.71±0.04d	32.92±0.63b	33.23±0.16c	22.15±0.14b	72
W4	30.29±0.70c	8.39±0.13d	17.88±0.60bc	2.37±0.02d	12.73±0.05a	4.62±0.08cd	28.44±0.18a	27.99±0.08a	19.81±0.00a	80
W6	33.00±0.85d	7.15±0.51ab	15.91±0.07ab	3.01±0.01e	13.17±0.02b	4.42±0.09bcd	38.38±0.008c	36.07±0.01d	27.47±0.16e	94
M2	27.00±1.02ab	6.80±0.06ab	15.72±0.30a	1.40±0.01a	14.08±0.04c	4.09±0.01ab	40.60±0.19d	38.71±0.26f	28.46±0.23f	95
M4	25.78±0.25a	6.47±0.11a	16.05±0.05abc	1.57±0.01b	16.31±0.12e	4.25±0.26abc	38.01±0.01c	36.28±0.07d	26.41±0.40d	86
M6	28.79±0.05bc	8.30±0.09d	17.35±0.15ab	1.66±0.02c	15.29±0.06d	3.91±0.04a	32.64±0.14b	31.26±0.08b	23.39±0.04c	105
Sign.	**	**	*	**	**	**	***	***	***	

Cont.; Control, W2; 2% wheat, W4; 4% wheat, W6; 6% wheat, M2; 2% molasses, M4; 4% molasses, M6; 6% molasses, Means followed by different letters in the same column differ significantly according to Duncan test at P<0.05, * Significant at P<0.05, ** Significant at P<0.01, *** Significant at P<0.001.

Table 3. Nutrient content, pH and Flieg scale of sweet potato vine silage

Trait	DM,%	CP, %	CF,%	EE, %	Ash,%	pH	ADF, %	NDF, %	ADL, %	Flieg Scale
Cont.	18.51±0.10*a*	10.07±0.16*a*	19.30±0.10*c*	2.39±0.01*b*	15.44±0.01*b*	3.68±0.01*e*	32.49±0.02*e*	30.55±0.28*d*	20.43±0.25*c*	94
W2	19.84±0.07*c*	10.82±0.06*b*	16.98±0.01*b*	2.20±0.00*a*	16.91±0.03*d*	3.58±0.03*cde*	24.40±0.45*a*	21.59±0.32*a*	15.22±2.21*a*	101
W4	23.84±0.16*d*	11.59±0.25*c*	14.50±0.50*a*	2.59±0.01*c*	17.02±0.03*d*	3.63±0.01*de*	28.37±0.28*b*	31.99±0.61*e*	15.75±0.89*ab*	107
W6	19.80±0.30*c*	10.68±0.00*b*	20.40±0.60*d*	2.66±0.02*d*	18.57±0.03*e*	3.52±0.03*cd*	31.07±0.07*d*	26.93±0.28*b*	13.99±0.41*a*	103
M2	19.14±0.15*b*	11.49±0.00*c*	19.60±0.10*cd*	2.59±0.01*c*	15.25±0.05*a*	3.35±0.09*ab*	35.18±0.01*f*	36.29±0.31*f*	20.11±0.16*c*	109
M4	20.34±0.15*c*	9.81±0.17*a*	17.94±0.05*b*	2.78±0.02*e*	16.52±0.03*c*	3.46±0.04*bc*	30.09±0.38*c*	27.51±0.20*b*	16.70±0.26*ab*	107
M6	23.96±0.14*d*	10.74±0.11*b*	16.91±0.04*b*	2.19±0.01*a*	16.98±0.04*d*	3.28±0.01*a*	31.17±0.08*d*	28.98±0.19*c*	18.67±0.08*bc*	121
Sign.	**	**	**	**	**	**	***	***	**	

Cont.; Control, W2; 2% wheat, W4; 4% wheat, W6; 6% wheat, M2; 2% molasses, M4; 4% molasses, M6; 6% molasses, Means followed by different letters in the same column differ significantly according to Duncan test at P<0.05, ** Significant at P<0.01, *** Significant at P<0.001.

number of lactic acid bacteria with addition of a water soluble carbohydrate (McDonald et el., 1991). Increasing molasses levels enhanced acetic acid concentration, (Table 5), which is consistent with Alli et al. (2006). Addition of molasses leads to hetero-fermentative fermentation in which some lactic acid is further fermented to acetic acid (Alli et al., 2006). The butyric acid content of fermented silage products, analysed by Lepper's distillation method, was to low to detect or it was assumed that butyric acid content had negative value. Therefore, butyric acid content was close to zero in silages.

When Flieg scores of silages were considered, control, 2 and 4% wheat groups of GN silages were in good quality class which had 70, 72 and 80 grades, respectively, while GN with 6% wheat plus 2, 4 and 6% molasses groups and the whole groups of SP and JA were in the excellent quality class (Tables 2 - 4).

After harvest, aboveground parts of peanut, sweet potato and Jerusalem artichoke could be used as silage materials and addition of GW and M into silages further increased the silage quailties. The grades of the silages prepared with the addition of ground wheat and molasses varied between good and the best quality grades. In conclusion, GW and M can be added at 4 or 6% level into GN, SP and JA tops silage depending upon the characteristics silage raw materials.

Table 4. Nutrient content, pH and Flieg scale of Jerusalem artichoke tops silage

Trait	DM,%	CP, %	CF,%	EE, %	Ash,%	pH	ADF, %	NDF, %	ADL, %	Flieg Scale
Cont.	37.17±0.15a	5.38±0.24bc	14.11±0.11b	2.39±0.01c	14.51±0.04d	3.74±0.03	37.16±0.30f	35.20±1.40f	24.34±0.24d	129
W2	40.01±0.06c	5.55±0.09bc	11.21±0.27a	2.20±0.01b	15.49±0.11e	3.73±0.02	26.54±0.44d	25.81±0.45cd	15.49±0.43ab	135
W4	42.16±0.14e	5.40±0.05bc	15.85±0.07c	2.59±0.01d	11.76±0.06a	3.80±0.02	19.25±0.20a	21.14±0.52a	13.43±0.35a	137
W6	39.97±0.15c	4.70±0.20a	15.52±0.52bc	2.39±0.01c	14.06±0.16c	3.83±0.03	20.78±0.20b	23.41±0.08b	13.86±0.02ab	131
M2	38.71±0.24b	5.16±0.01bc	14.20±0.77b	1.79±0.01a	15.99±0.06f	3.79±0.03	31.83±0.20e	24.70±0.27bc	19.62±2.58c	130
M4	41.47±0.19d	5.14±0.07b	18.77±0.62d	2.39±0.01c	13.84±0.09c	3.81±0.05	27.02±0.10d	27.15±0.22d	14.61±0.31ab	135
M6	41.95±0.08e	5.62±0.03c	16.09±0.17c	2.59±0.01d	13.32±0.08b	3.84±0.01	23.71±0.50c	23.63±0.05b	17.48±0.90bc	135
Sign.	**	*	**	**	**	NS	***	***	***	

Cont.; Control, W2; 2% wheat, W4; 4% wheat, W6; 6% wheat, M2; 2% molasses, M4; 4% molasses, M6; 6% molasses, Means followed by different letters in the same column differ significantly according to Duncan test at P<0.05, * Significant at P<0.05, ** Significant at P<0.01, *** Significant at P<0.001, NS; not significant.

Table 5. Acetic Acid content of groundnut, sweet potato and Jerusalem artichoke tops silage (%)

Crop	Treatment							
	Control	W2	W4	W6	M2	M4	M6	Sign.
SP	10.90±0.01*c,F*	8.64±0.01*c,B*	9.29±0.01*a,D*	10.54±0.01*b,E*	7.88±0.01*b,A*	9.19±0.01*b,D*	8.77±0.01*c,C*	***
JA	5.20±0.01*a,D*	4.76±0.00*b,E*	10.19±0.00*b,E*	11.32±0.00*c,G*	11.28±0.01*c,F*	3.62±0.01*a,A*	3.94±0.01*b,B*	***
GN	10.17±0.01*b,E*	13.68±0.01*c,G*	13.68±0.01*c,G*	3.41±0.01*a,B*	3.69±0.01*a,C*	11.42±0.01*c,F*	3.84±0.01*a,D*	***
Sign.	***	***	***	***	***	***	***	***

GN; goundnut haulm, SP; sweet potato vine, JA; Jerusalem artichoke, Cont.; Control, W2; 2% wheat, W4; 4% wheat, W6; 6% wheat, M2; 2% molasses, M4; 4% molasses, M6; 6% molasses, *** Significant at P<0.001.

Table 6. Lactic Acid content of groundnut, sweet potato and Jerusalem artichoke tops silage (%)

Crop	Treatment							
	Control	W2	W4	W6	M2	M4	M6	Sign.
SP	1.32±0.02*a,A*	2.68±0.03*b,E*	2.98±0.01*b,F*	1.79±0.01*a,B*	2.03V0.01*a,C*	2.61±0.01*a,D*	2.63±0.01*a,DE*	***
JA	3.30±0.01*c,A*	3.85±0.01*c,C*	3.49±0.02*c,B*	4.10±0.02*c,D*	4.32V0.01*c,E*	4.90±0.01*c,G*	4.46±0.01*c,F*	***
GN	1.50±0.01*b,B*	1.39±0.01*a,A*	1.62±0.01*a,C*	2.21±0.01*b,D*	2.29V0.02*b,E*	3.10±0.01*b,F*	3.93±0.01*b,G*	***
Sign.	***	***	***	***	***	***	***	

GN; goundnut haulm, SP; sweet potato vine, JA; Jerusalem artichoke, Cont.; Control, W2; 2% wheat, W4; 4% wheat, W6; 6% wheat, M2; 2% molasses, M4; 4% molasses, M6; 6% molasses, *** Significant at P<0.001.

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