Quality Effects of Controlled-Chamber Alfalfa Wilting

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Fresh whole alfalfa was wilted in controlled temperature–humidity–wind chambers to moisture contents of 77–28%, then frozen and freeze-dried. CO_2 losses of 3–4% were measured. Proximate, carbohydrate, carotenoid, and amino acid analyses were performed in order to assess quality changes. Alfalfa could be wilted to 45% moisture content without serious quality impairment. Subsequent drum-dehydration can and should be modified to avoid deleterious over-drying of the wilted alfalfa while also reducing fuel consumption.

The extent to which field-wilting (i.e., partial sun-curing) has been adopted in the alfalfa dehydration industry has not been widely reported, although experimental evaluation of the treatment continues to be reported (Israelsen, 1965; Ohyama, 1970; Livingston et al., 1976, 1977; Pulkinen, 1978; Klopfenstein et al., 1978). However, its practicability has been demonstrated by dehydrating firms in Britain (Aspinwall, 1976), France (Ombredane, 1974), the United States (Ronning, 1975; Vinci, 1977), and elsewhere. Savings in fuel requirements, increased throughput, lower hauling costs, and improved product quality are some of the advantages cited. However, the necessity of a second harvesting pass through the field and the possibility of rain damage to the alfalfa during wilting must be considered. The investigations reported here dealt with product quality and the question of respiration and other losses during wilting and were conducted in controlled-environment chambers for closer monitoring of the wilting process.

Alfalfa wilting trials in California previously reported by this laboratory showed large losses of carotene and xanthophyll when alfalfa was chopped and wilted to below 60% moisture content (Livingston et al., 1975) but only moderate losses when mowed, windrowed, and field-wilted at temperatures above 90 °F to 65% moisture content (Livingston et al., 1976). A series of field-wilting trials conducted in Kansas in June and July, 1975, demonstrated that alfalfa could be field-wilted to 50% moisture content while retaining 69 and 80% of the original carotene and xanthophyll contents (Livingston et al., 1977). Earlier wilting experiments (Amella, 1975) conducted in controlled temperature/humidity chambers at this laboratory had shown carotene retention slightly higher than xanthophyll retention when wilting alfalfa to 65–69% moisture during 6 h. When modified controlled-condition chambers of increased drying capacity were constructed here, we undertook wilting trials to clarify the apparent reversal of carotene and xanthophyll stability found during field-wilting vs. chamber-wilting. Provision was also made for determining dry matter respiration loss by measuring CO_2 production during wilting in these chambers. In addition, these trials enabled us to further investigate the effect of wilting upon the amino acid content of alfalfa.

EQUIPMENT AND PROCEDURE

The two chambers used were each approximately 1.22 × 1.22 × 1.52 m, volume 2265 L and were provided with blowers and baffles so arranged that air velocities of 149–210 (average 171) m/min across the samples were measurable with an Anemotherm Air Meter, Model 60 (Anemostat Corporation of America, New York). The alfalfa was contained in aluminum boxes 15.2 × 15.2 × 20.3 cm, open at the top, and having the opposite 15 × 20 cm sides made of fly screen. Six sample boxes each containing 300 g of fresh, unchopped alfalfa were placed end-to-end in each chamber at right angles to the flow of air. Temperatures were controllable to approximately ±3 °C at 32 °C (HT) or 18 °C (LT) and relative humidity to approximately ±8% at 65% (HH) or 40% (LH) as measured periodically by a Bendix Psychrometer, Model 566 (Bendix, Environmental Science Div., Baltimore, MD). Light was provided by a bank of fluorescent tubes (cool white, F96T12/CW/HO) covering the area above the chambers, supplemented by 5 Rough Service 100 W incandescent lamps above each chamber, all separated from the chamber interior by a plexiglas sheet and cooled by a forced draft through the lighting compartment. Light intensities, measured by a variable-wavelength radiometer (Bailey, 1976), are indicated for various wavelengths in the visible range in Table I. For CO_2 sampling, each chamber was provided with a perforated 4.8-mm i.d. polyethylene tube extending across the enclosed blowers compartment, leading via a sealed port to an infrared carbon dioxide analyzer/recorder, Horiba, Model PIR-200 (Horiba, Ltd. Kyoto, Japan) or Beckman, Model 865 (Beckman Instruments, Inc., Fullerton, CA). One liter/minute of the chamber atmosphere was pumped to the analyzer and 2 L/min of room air was pumped into the chamber, compensating for slight leakage and providing a slight positive pressure within the chamber. (This dilution, ca. 1:400, had no significant effect upon the CO_2 measurements.) During wilting trials, when the CO_2 concentration approached the recorder chart upper limit, the chamber was opened to dilute its atmosphere; it was then closed, and the rate of CO_2 concentration increase was again recorded. Numerous rates thus obtained were averaged for each wilting trial.

Following wilting, each sample was weighed in its box for calculation of weight loss. The samples were then transferred to plastic bags and frozen and stored until they could be freeze-dried and ground (0.5-mm screen, Wiley mill) for analysis. Fresh alfalfa was also sampled for moisture determination by oven-drying or freeze-dried for other analyses. Carotene and total xanthophyll were de-

Table I. Light Intensities in Controlled-Environment Chambers

λ, mμ	μW	λ, mμ	μW	λ, mμ	μW
400	0.046	470	0.158	575	0.844
410	0.062	480	0.196	585	0.898
418	0.052	500	0.276	590	0.870
425	0.072	520	0.358	600	0.828
430	0.180	530	0.442	620	0.806
440	0.264	535	0.562	640	0.694
450	0.160	540	0.710	660	0.546
455	0.128	560	0.764	680	0.365
465	0.142	570	0.754	700	0.192

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termined by the method of Kohler et al., (1967) as modified by Livingston et al. (1971); nonepoxide xanthophyll analysis was according to Livingston et al. (1969) using the absorptivity value 210 at 475 mμ for calculation. Amino acids were determined on meal hydrolysates by the method of Kohler and Palter (1967), starch according to McCready et al., (1950), and total and reducing sugars by the method of Potter et al., (1968).

RESULTS

Moisture Removal. The new chambers had adequate moisture-removal capacity for the amount of alfalfa wilted. The six individual sample boxes provided better replication and eliminated sample loss error. It was necessary, however, to switch positions of the sample boxes hourly in order to obtain uniform wilting. As indicated in Table II, moisture losses of 26% of fresh weight in 4 h (1976) and 54% in 10 h (1977) were achieved, the latter representing two-thirds of the moisture originally present. In these trials, high and low temperature and relative humidity conditions were investigated. These were chosen to simulate diverse weather areas of the United States and Canada and less favorable drying conditions often prevailing in, e.g., Britain and northern Europe. At the high temperature, 4 h of wilting at low humidity resulted in 24% greater H_2O loss percent fresh weight than 4 h at high humidity; 10 h of low-humidity wilting gave 70% greater loss than 10 h of high-humidity wilting. At the lower temperatures, wilting at low humidity provided moisture reductions 20% greater in 4 h and 37% greater in 10 h than wilting at high humidity. By analysis of variance, which included temperature, humidity, and their interactions, the effects were significant at the 5% level.

In the 1978 trials we attempted to simulate field wilting of alfalfa extended over a greater range of moisture reduction, almost to the condition of sun-cured hay. Temperature, humidity and lighting were varied to simulate day and night conditions during prolonged wilting. Removing sample boxes (one from each chamber) at intervals enabled us to determine extent of wilting and to analyze the alfalfa for quality changes discernible at different moisture levels. Alfalfa was wilted to 64.5% moisture, a level previously considered to be adequate for carotenoid retention, and to three lower moisture levels. In these trials, wilting performances of the two chambers were shown by Tukey's test for nonadditivity to differ only slightly. Moisture loss dependence upon wilting time was not simply linear but also had a quadratic curve component.

Carotenoid Retention. In the 1976 chamber-wilting trials, carotene (C) retention during 4 h of wilting was 4–12% higher than total xanthophyll (X) retention (which was also high, however) during evaporation of 14–31% of the alfalfa moisture (Table III). Nonepoxide xanthophyll (NEX) was better retained than total xanthophyll. More prolonged chamber-wilting trials in 1977, during 10 h, resulting in removal of 18–67% of the moisture originally present, were more typical of field operations. Higher carotene losses during the higher temperature wilting were statistically significant (at 5% lsd) but were not significantly influence by humidity. Contrary to the 4-h results, C retention was lower than X retention, especially in the high-temperature trials. NEX was again found to be apparently more stable than X, but neither showed significant loss during 10 h of wilting. The 1978 results confirmed the lower C retention found the previous year and showed that this difference between C and X retention was maintained during wilting, eliminating 59–91% of the original moisture in fresh alfalfa. Incremental carotene

Table II. Moisture and Respiration Losses during Wilting

	wilting conditions[a]											
	1976				1977				1978			
	LT, HH	LT, LH	HT, HH	HT, LH	LT, HH	LT, LH	HT, HH	HT, LH	HT, LH 8 h +LT, HH 4	+LT, HH 4 +HT, LH 8	+HT, LH 8	+LT, HH 4 +HT, LH 5
total hours wilted	4	4	4	4	10	10	10	10	12	24	32	41
% H_2O in fresh alfalfa	73.8	77.2	75.8	77.7	78.0	76.9	77.9	80.1	81.7	81.7	81.7	81.7
% H_2O in wilted alfalfa	71.0	74.2	69.4	69.8	74.4	71.4	67.7	57.2	64.5	45.5	35.2	27.9
% H_2O loss on fresh wt	9.7	11.7	20.9	26.0	14.1	19.3	31.5	53.6	48.4	66.4	71.7	74.6
% of original H_2O lost	13.1	15.1	27.7	33.4	18.1	25.1	40.4	66.6	59.2	81.3	87.8	91.3
CO_2 loss % dry solids during wilting[b]	0.58	0.69	2.01	1.61	0.85	0.73	4.03	3.54	2.67	0.95	0.37	nil
starch, % in fresh[b]		4.74	3.50	3.50	5.23	6.86	7.17	3.64	2.97	2.97	2.97	2.97
% in wilted[b]		4.37	2.60	2.39	3.74	3.39	2.72	2.74	1.46	1.52	1.48	1.39
total sugar, % in fresh[b]		6.54	8.14	6.54	5.92	5.44	6.53	5.41	5.91	5.91	5.91	5.91
% in wilted[b]		7.55	7.55	6.06	6.21	6.81	7.66	5.37	6.38	6.56	6.40	5.47
reducing sugar, % in fresh[b]		4.06	3.13	3.66	3.08	2.48	3.75	2.54	2.81	2.81	2.81	2.81
% in wilted[b]		4.52	2.87	4.11	3.27	3.41	4.23	2.60	2.19	2.03	2.17	1.28

[a] HT = high temperature, LT = low temperature, HH = high humidity, LH = low humidity. [b] Moisture-free basis.

Table III. Carotenoid Changes during Wilting

	1976				1977				1978			
wilting conditions[a]	LT, HH	LT, LH	HT, HH	HT, LH	LT, HH	LT, LH	HT, HH	HT, LH	HT, LH 8 hrs + LT, HH 4	+LT, HH4 +HT, LH 8	+HT, LH 8	+LT, HH 4 +HT, LH 5
total hours wilted	4	4	4	4	10	10	10	10	12	24	32	41
% original H_2O lost	14.0	15.5	27.0	30.8	18.1	25.1	40.4	66.8	59.2	81.3	87.8	91.3
carotene, mg/lb, in fresh[b]	151	138	151	142	178	177	161	170	168	168	168	168
mg/lb, in wilted[b]	142	136	145	127	159	162	129	132	140	105	93	86
% retained	94.0	98.6	96.0	89.4	89.3	91.5	80.1	77.6	83.3	62.5	55.4	51.2
mg/lb, in dehy[b,c]	128	122	130	114	143	145	116	119	126	92	84	77
total xanthophyll, mg/lb in fresh[b]	352	368	363	374	350	350	326	342	348	348	348	348
in wilted[b]	313	331	333	301	337	330	290	310	331	268	242	237
% retained	88.9	89.9	91.7	80.5	96.3	94.3	89.0	90.6	95.1	77.0	69.5	68.1
mg/lb in dehy[b,c]	283	299	301	272	305	298	262	280	299	242	219	214
nonepoxide xanthophyll, mg/lb, in fresh[b]	209	219	220	213	213	221	195	209	217	217	217	217
mg/lb, in wilted[b]	198	205	203	182	216	219	188	207	224	187	176	169
% retained	94.7	93.6	92.3	85.4	101.4	99.1	96.4	99.0	103.2	86.2	81.1	77.9
mg/lb in dehy[b,c]	179	185	184	165	195	198	170	187	202	169	159	153

[a] HT = high temperature, LT = low temperature, HH = high humidity, LH = low humidity. [b] Moisture-free basis. [c] Calculated, using 10.2% C loss and 9.6% X or NEX loss during dehydration.

Table IV. Effects of Wilting on Carotenoid Storage Stability in Alfalfa Meal[a]

wilting trial conditions and results[b]	sample	weeks stored	carotene, % loss	total X, % loss	NEX, % loss
low temp, high humidity	fresh, freeze-dried	4	37.1	35.7	20.5
75.2% H_2O in fresh	wilted, freeze-dried	4	38.9	39.7	25.2
72.2% H_2O in wilted	F	8	67.3	53.5	39.6
10.6% H_2O loss on fr wt	W	8	68.7	54.8	45.5
	F	12	79.6	60.0	47.2
	W	12	82.1	62.2	53.0
LT, LH	F	4	46.3	41.9	27.8
79.6% H_2O in fresh	W	4	44.4	40.8	28.4
76.7% H_2O in wilted	F	8	74.7	57.8	48.0
12.4% H_2O loss on fr wt	W	8	76.0	59.0	50.5
	F	12	86.0	67.9	58.8
	W	12	87.0	71.4	64.2
HT, HH	F	4	38.1	36.5	22.2
77.3% H_2O in fresh	W	4	37.0	40.0	21.9
71.4% H_2O in wilted	F	8	64.3	50.0	38.9
20.9% H_2O loss on fr wt	W	8	64.0	51.8	38.4
	F	12	77.5	60.2	49.1
	W	12	77.2	61.0	46.8
HT, LH	F	4	46.6	42.8	28.8
81.2% H_2O in fresh	W	4	44.7	37.2	24.0
74.9% H_2O in wilted	F	8	74.2	56.8	44.6
25.0% H_2O loss on fr wt	W	8	75.2	58.3	48.6
	F	12	86.7	69.2	58.5
	W	12	86.2	69.3	60.7

[a] Fresh or wilted alfalfa freeze-dried and ground before storage. [b] LT = low temperature, LH = low humidity, HT = high temperature, HH = high humidity.

losses were statistically significant (5% lsd) at 12, 24, and 32 h of wilting but not at 41 h. Again, NEX retention was higher than that of X.

It is more useful, however, to consider whether the amounts of carotenoids retained following wilting are such that after dehydration adequate levels of carotene and xanthophyll remain. It has been shown (Livingston et al., 1968, 1976) that during commercial dehydration of alfalfa to normal meal moistures, losses of 12–24% C and 20–50% X or NEX may be expected. Dehydration of wilted alfalfa in a commercial plant in Kansas in 1975 (Livingston et al., 1977) was carried out with average losses of 10.2% of carotene and 9.6% of NEX. The significantly lower losses, particularly of xanthophylls, are attributable to the much lower dehydrator outlet temperatures which are possible and necessary when dehydrating wilted alfalfa. Applying these expected dehydration losses to the wilted alfalfa carotene and pigmenting xanthophyll (NEX) contents indicates that the commercial 60 mg/lb of carotene standard for 17% crude protein dehydrated alfalfa can be readily exceeded despite extensive wilting, if no leaf loss occurs. Xanthophyll contents commercially advertised such as 169, 182, 200 mg/lb (cf. 78 and 120 mg/lb for 17% and 20% protein meal as listed in the annual *Feedstuffs* analysis table) are equivalent to 159, 171, 188 (cf. 73 and 113) mg/lb of NEX (Knowles et al., 1972); as the calcu-

Table V. Proximate Analyses[a] before and after Wilting

	1976				1977				1978			
wilting conditions[b]	LT, HH	LT, LH	HT, HH	HT, LH	LT, HH	LT, LH	HT, HH	HT, LH	HT LH 8h, +LT, HH 4h	+LT HH 4h, +HT LH 8h	+HT, LH 8 h	+LT HH 4h, +HT LH 5h
total hours wilted	4	4	4	4	10	10	10	10	12	24	32	41
% N in fresh alfalfa		5.41	4.10	5.52	4.10	3.97	4.01	3.81	4.73	4.73	4.73	4.73
in wilted alfalfa		5.45	4.10	5.66	4.06	4.23	4.20	3.99	4.78	4.56	4.99	4.90
% fat in fresh alfalfa		4.82	3.88	3.72	5.39	4.18	4.24	4.93	4.49	4.49	4.49	4.49
in wilted alfalfa		4.14	3.81	3.30	5.09	4.30	3.67	4.14	3.42	2.65	2.88	2.72
% fiber in fresh alfalfa		11.44	16.92	11.86	17.58	16.71	17.95	21.96	16.84	16.84	16.84	16.84
in wilted alfalfa		11.65	17.59	12.55	17.69	17.55	19.23	22.46	17.49	17.74	17.93	17.16
% ash in fresh alfalfa		9.59	9.45	9.89	9.52	9.74	9.74	9.43	10.45	10.45	10.45	10.45
in wilted alfalfa		9.88	9.75	10.16	9.78	10.13	10.09	9.41	10.84	11.44	10.69	11.05

[a] Moisture-free basis. [b] HT = high temperature, LT = low temperature, HH = high humidity, LH = low humidity.

Table VI. Effect of Wilting on Amino Acids (g/16 g of N)

date	hours wilted	% H_2O remaining	conditions[a]	Lys	Met	ammonia	Asp	Glu	Cys
1976	0	79.6		5.01	1.63	1.91	12.29	8.51	1.31
1976	4	76.7	LT, LH	5.22	1.88	1.90	12.38	8.49	1.40
1976	0	81.2		5.77	1.88	2.08	14.59	9.54	1.33
1976	4	74.9	HT, LH	4.98	1.62	1.86	12.23	8.10	1.33
1978	0	81.7		5.42	1.68	2.49	16.86	9.01	1.25
1978	12	64.5	HT, LH 8 h, +LT, HH 4h	5.08	1.61	2.62	17.15	7.96	1.24
1978	24	45.5	+LT, HH 4 h, +HT, LH 8 h	4.85	1.56	2.46	17.78	7.72	1.21
1978	32	35.2	+HT, LH 8 h	4.84	1.55	3.03	18.62	7.94	1.20
1978	41	27.9	+LT, HH 4 h, +HT, LH 5h	4.89	1.56	3.15	17.61	7.36	1.24

[a] HT = high temperature, LT = low temperature, HH = high humidity, LH = low humidity.

lated dehydration values in Table III show, these NEX levels can be retained while wilting to 45% moisture.

Leaf Shattering. To achieve such results, leaf loss during harvesting must be minimized. [Zink found, in field experiments in Kansas, that alfalfa could be field-dried without loss of dry matter to about 40% average moisture (Zink, 1936). Nash concluded from the literature and his own experiments under relatively slow-wilting conditions at Edinburgh, Scotland, that appreciable dry matter loss occurs only in severe wilting, i.e., greater than 24 h (Nash, 1959).] In our Kansas field wilting trials in 1975, we observed considerable windborne particulate loss during pickup of alfalfa wilted to 44% moisture content. In the handling of wilted samples in the 1978 chamber-wilting trials, we noted that leaf shattering was nil in the 65% moisture samples, very little at 45% moisture, but appreciable in the 35% moisture alfalfa (even though stems were still pliable).

Storage Stability. We conducted a limited trial to determine whether wilting alfalfa adversely affected its carotenoid storage stability. One gram samples of meals from unwilted and wilted alfalfa from the 1976 trials were stored in the dark in vials open to the atmosphere, in a 38 °C constant temperature room for 4, 8, and 12 weeks, then analyzed for carotenoids. As shown in Table IV, carotene stability was unaffected by wilting, total xanthophyll stability, in most cases, was not seriously affected, while nonepoxide xanthophyll losses varied with no obvious pattern, but were lower than total xanthophyll storage losses.

CO_2 Losses. In addition to particulate loss in handling, dry matter may be lost as CO_2 due to plant respiration during the earlier stages of alfalfa wilting. The controlled-environment chambers provided a means to measure the rate and total quantity of CO_2 produced during the wilting trials. The 1976 and 1977 data of Table II show a statistically significant dependence of CO_2 loss on wilting temperature, and the prolonged 1978 trials show a significant dependence of CO_2 loss on wilting time, through 32 h. Both factors correlate CO_2 loss with H_2O loss, in a general way. However, the *rate* of H_2O loss inversely determines the total amount of respiration occurring. Therefore, as the data show, low humidity, which accelerates drying at a given temperature, leads to somewhat lower overall CO_2 loss. The 1978 data show that after the moisture content of alfalfa was reduced to 35%, no further measurable CO_2 loss occurred. In a similar finding, Wolf and Carson reported that respiration in alfalfa leaves removed from the plant declined sharply when a dry weight of about 60% was reached (Wolf and Carson, 1973). By oven-drying the final 41-h wilted samples of 1978 to constant weight, maximum dry solids loss was found to be 6.5%. Dry matter losses of 3–4% due to respiration CO_2 loss may thus be expected in wilting windrowed alfalfa to below 50% moisture under hot, dry conditions.

Soluble Carbohydrate Changes. In all of the chamber trials starch decreased during wilting. Losses ranged from 7.8 to 62.1% of that present in the fresh alfalfa (0.37 to 4.5% dry matter, average 1.76%). Total sugars generally but not always increased, but much less than the decrease in starch. Reducing sugars also increased during wilting (with one exception) in the 4- and 10-h trials. The net carbohydrate loss averaged 0.81 and 1.44%, respectively, of the total dry matter for those trials. These results are, in general, compatible with the view that in excised plant material starch and sucrose are converted into hexoses which are then metabolized to CO_2 (James, 1953; Wylam, 1953). In the 1978 trials, reducing sugars decreased in the wilted samples while total sugars increased somewhat. Since this trial simulated prolonged field wilting in which the low-temperature periods were periods of darkness, as in overnight wilting, the reducing sugars net decrease may be due to a lower rate of conversion of starch or sucrose to hexoses during the dark periods. In the final 9-h period, moisture content became so low that apparently the metabolic processes were altered and normal respiration ceased. Net carbohydrate loss averaged 1.0% of dry matter for 12-, 24-, and 32-h wilting periods, but increased to 2.0.% for the 41-h trial.

Proximate Analyses. There was a small but consistent increase in percent ash found in the wilted alfalfa and a much more substantial percent loss of ether extractables (although the weight loss was small). The wilted alfalfa showed, usually, a small apparent increase in nitrogen content (Table V), probably not significant, especially since small increases in percent fiber were also found. The increases in percent ash and fiber may simply reflect loss of organic metabolites during wilting and consequent percent increase of the remaining components. In this chamber-wilting procedure there is no leaf loss in handling, although in field operations this is a definite hazard if alfalfa is wilted to below approximately 45% moisture. Protein degradation is not a serious problem in such wilting; e.g., Yemm found no release or accumulation of ammonia in mature barley leaves during the first 24 h of wilting (Yemm, 1939); such protein breakdown, he found, came even more slowly in young leaves. We had previously found that the nonprotein nitrogen/total nitrogen ratio increased during the first 4-h wilting period, but not thereafter (Livingston et al., 1977). In the 1978 trials ammonia content did not increase through 24 h of wilting, then increased 22 and 27% through 32 and 41 h of wilting (Table VI). This increase may indicate the beginning of protein breakdown (James, 1953).

Amino Acids. Earlier field-wilting trials (Livingston et al., 1977) had shown both losses and gains in certain amino acids in alfalfa; however, the analyses were done on *dehydrated* fresh and wilted alfalfa and showed the additional effect of heat-dehydration. Thus, an apparent increase in lysine was found in a 10-h field-wilted sample dehydrated to a moderately high moisture but a substantial loss of lysine in the same wilted sample dehydrated to 2.2% meal moisture. In the chamber-wilting trials, no subsequent heat-exposure was involved. The first 4-h wilting trials did show a slight increase in lysine in the low-temperature wilted alfalfa but a 25% loss in the high-temperature trials (Table VI). However, the more prolonged 1978 trials revealed no lysine increase, but a loss of 10.5% during 24 h of wilting, with no further loss thereafter. Methionine showed the same response. Aspartic acid increased during 24 h of wilting, then stabilized. Glutamic acid decreased somewhat sporadically. Cystine was virtually unaffected by wilting. Thus, some changes in amino acids took place during the first 12 h of wilting, the rate slowing, usually, during the following 12 h, with little change thereafter.

SUMMARY

Field-wilting of alfalfa prior to conventional heat-dehydration is a growing practice with attractive fuel- and cost-saving benefits. However, it is important to maintain the quality advantages which dehydrated alfalfa buyers expect in this feed material. Our chamber-wilting trials showed that one-third of the original moisture can be removed in one-half day's wilting, two-thirds in a 10-h day and more than 80% in a 24-h period. Carotene is less stable during wilting than total xanthophyll, which is less stable than nonepoxide (pigmenting) xanthophyll. However, one can wilt even to 45% moisture content, then drum-dehydrate (to 6% or more moisture content) while retaining adequate carotene and xanthophyll to meet usual commercial grade specifications. Leaf-shattering losses should be low under such wilting management. Dry matter losses due to respiration during wilting (CO_2 loss) were found to be 3–4% under hot, dry, and windy wilting conditions. Proximate analyses did not indicate any serious quality impairment due to wilting. There was some loss of lysine and methionine, but this was small during the first 12 h. Dehydrator operators should be careful to lower drum temperatures and/or throughput time so that wilted alfalfa is not impaired in quality by over-drying.

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