Storage of Burley Tobacco in Bales and Bundles

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ABSTRACT

BALES and bundles of burley tobacco were stored for seven months from spring to fall. Leaves darkened during storage at all moisture levels and stalk positions with the exception of the bottom stalk position, which darkened only slightly. There was no difference in color change and dry weight loss between burley tobacco in bales and bundles. Normal and high moisture bales and bundles were often graded as unsound because of a deviant odor caused by bacterial activity. A bale weight loss of about 8% occurred at normal moisture with the loss being divided evenly between moisture and dry weight losses.

INTRODUCTION

Tobacco has traditionally been stored on the farm for only a few weeks; however the advent of loose leaf stripping techniques for baling burley leaves has permitted faster stripping (Duncan et al., 1979, and Morrison and Yoder, 1974) and has thereby increased storage time by 2 to 3 months. In addition, the recent practice of selling this year's tobacco produced in excess of quota for deferred payment at the beginnig of next season has been prohibited by regulations in 1981. Thus, the burley producers who exceeds his quota must store the excess tobacco until the next marketing season. In 1982 when over-production was widespread the Burley Growers Cooperative Association dried and stored the tobacco as a service to farmer. In other years such as 1984 considerable burley will have to be stored over the summer by certain producers who have exceeded their quota.

Bunn and Henson (1978) conducted a three-month storage experiment and found that tobacco stored at a moisture level that will keep in the "tied hand" (bundle) will also keep in the bale. A comparison of storage of bales and bundles beyond 3 months was needed so that recommendations could be made to producers concerning storage over the summer months. A two-year experiment was conducted to compare storage of bales and bundles of burley tobacco from spring to fall.

The objectives of this research were:

1. To compare leaf color of burley tobacco in bales and bundles at the beginning and end of storage.
2. To determine moisture loss from bales during storage.
3. To determine changes in certain chemical constituents of bales and bundles during storage.
4. To determine bacterial and mold levels during storage.

MATERIALS AND METHODS

A factorial experiment was designed to evaluate storage of burley tobacco from spring to fall using two types of packages (bales and bundles), three stalk positions (bottom, middle and top), three leaf moisture levels (low, normal and high) and two replications. The experiment was run for two years with a different treatment each year (restricted and unrestricted diffusion) during the years. Burley variety KY 14 was grown using recommended cultural practices. The tobacco was harvested and cured in the conventional manner. The tobacco was removed from the barn and stripped into three farm grades when the natural weather created a leaf moisture content corresponding to the high moisture level. Two-thirds of the stripped leaf was then placed into conditioning chambers for drying to the two remaining moisture levels. The average initial moisture content for the low, normal, and high moisture levels were 16.1, 22.2, and 28.1% (all db) for the first year and 17.8, 23.0 and 31.4% for the second year. The three farm grades were comprised of leaves from the bottom, middle and top thirds of the stalk.

Both bales and tied bundles were included in the experiment. Bales were formed using methods and equipment recommended by Duncan and Smiley (1980). Bales were 0.3 m x 0.9 m x 0.6 m and weighed about 31, 37 and 43 kg at low, normal and high moisture, respectively. The leaves were oriented parallel to the 0.3 m x 0.9 m surfaces, i.e., the top and bottom of the bale, with the leaf midribs parallel to the 0.9 m dimensions. The butts of the midribs were placed at the ends of the bale with the tips of the leaves overlapping in the center of the bale. The leaves were compressed vertically parallel to the 0.6 m dimension under 5 kN of force. A bundle contained about 80 leaves (0.5 kg) secured by two or three leaves wrapped (commonly called "tied") around the stem-end of the remaining leaves. Each bale or each group of 36 bundles comprised a replication.

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The first year each bale and group of bundles was wrapped in plastic to retard moisture exchange with ambient air. During the second year, newly-made bales and bundles were exposed to the air so that moisture diffusion occurred. The tobacco was stored in a well-ventilated barn for seven months from spring to fall.

Each replication of tobacco was graded by representatives of the Agricultural Marketing Service at the beginning and end of storage. Any change in leaf color during storage was determined from the federal grade. Numerical values were assigned to the color designations of the federal grade. Yellow leaves were assigned 0, tan - 1, tannish red - 2, red - 3, and dark red - 4. The change in leaf color during storage was determined by subtracting the color of each replication at the beginning of storage from the color at the end of storage. A t-test was used to determine the statistical significance (5% level) of change in color during storage. The effect of type of package, leaf moisture, and stalk position on change in color during storage was determined by analysis of variance. Differences among means were determined by Duncan's new multiple range test. Each year's data were analyzed separately.

Samples for moisture, chemical analysis, and microorganism determination were removed initially, and at 1, 3, 5, and 7 months. Bundles were sampled by removing leaves. Bales were sampled by coring. A 2.5 cm diameter core was taken from the top to the center of the bale. Moisture content determinations (% db) were made on the combined lamina and midrib by oven drying. Chemical analyses were made on leaf lamina only and were standard laboratory analyses run by the University of Kentucky tobacco laboratory. These samples were evaluated for alkaloids, total nitrogen, protein nitrogen, water soluble nitrogen, nitrate nitrogen, calcium, phosphorous, and potassium. Calcium, phosphorous, and potassium were used to determine dry matter loss. Each value of mineral content at 1, 3, 5, and 7 months was expressed as a percent increase or decrease relatively to the 0 month value. The percent change in calcium, phosphorous, and potassium were averaged to arrive at dry matter loss. Levels of chemical constituents were expressed as percent of dry weight. Changes in the level of chemical constituent were determined by subtracting the initial level (% db) from the final level. Changes in the level of chemical constituents were statistically analyzed using analysis of variance and Duncan's new multiple range test.

RESULTS AND DISCUSSION

Color Change

The tobacco darkened in color during 7 months of storage by an average 1.17 units from approximately tan to tannish red. The average color change with time was significant by t-test. Mean values of color change are shown in Table 1 as affected by type of package, moisture content and stalk position. All differences in the results section of this report were tested at the 95% level. Darkening leaf color was a function of stalk position but was not a function of moisture content and type of package. Leaves from the bottom stalk position darkened significantly less than leaves from the middle and top stalk positions. Leaves from the bottom stalk position are lighter bodied which may have contributed to their darkening less than the other stalk positions. The data shown in Table 1 was from the second year only. The first year's data was erratic, because different representatives from the Agricultural Marketing Service were used before and after storage. A uniform set of data was obtained the second year by using the same grader before and after storage. Several bales and bundles from normal and high moisture were judged to be unsound after storage, indicating that they were unsuitable for marketing. All low moisture bales and bundles were judged to be sound.

TABLE 1. MEAN VALUES OF COLOR CHANGE (SEE NUMERICAL DEFINITION IN MATERIALS AND METHODS) AS AFFECTED BY TYPE OF PACKAGE, LEAF MOISTURE CONTENT, AND STALK POSITION.

Treatment	Color change
Bale	1.28 a
Bundle	1.06 a
Low moisture	1.17 a
Normal moisture	1.17 a
High moisture	1.17 a
Bottom stalk position	0.20 a
Middle stalk position	1.58 b
Top stalk position	1.75 b

Any means having different letters beside them are significantly different by Duncan's new multiple range test (5% level).

Weight Loss

Weight losses during storage arise from three sources; dry weight loss, moisture loss and shatter. Shatter losses have been determined by Bunn et al. (1979). Dry weight losses during storage were determined to be significant by t-test. Analysis of variance showed that dry weight losses for restricted diffusion varied significantly with moisture content but did not vary significantly with stalk position or type of package. There were no significant effects for unrestricted diffusion. Mean values of dry weight losses for restricted diffusion (first year) and unrestricted diffusion (second year) and mean values of moisture loss (db) for unrestricted diffusion are shown in Table 2 as a function of the initial moisture levels. Dry weight losses apply to both bales and bundles, but moisture losses apply only to bales. Farmers can easily add moisture to bundles but not to bales. Therefore, moisture loss will result in less dollar return in bales and was included here as part of the permanent weight loss of bales. Both dry weight losses and moisture losses increased with initial moisture content as expected. Dry

TABLE 2. MEAN VALUES OF DRY WEIGHT LOSSES DURING STORAGE FOR RESTRICTED DIFFUSION (FIRST YEAR) AND UNRESTRICTED DIFFUSION (SECOND YEAR) AND MEAN VALUES OF MOISTURE LOSS (% db) DURING STORAGE OF BALES ONLY FOR UNRESTRICTED FLOW AS A FUNCTION OF INITIAL MOISTURE LEVEL.

Source of Weight Loss	Weight Loss (% db) Initial Moisture Level Low	Normal	High
Dry weight loss*	1.5	4.5	7.3
Dry weight loss†	3.5	4.0	5.1
Moisture loss† (bales)	2.1	4.0	5.4
Total weight loss† (bales)	5.6	8.0	10.5

*Restricted diffusion.
†Unrestricted diffusion.

weight losses were lower for unrestricted diffusion than for restricted diffusion at normal and high moisture. Drying during storage reduced the moisture level of the tobacco subjected to unrestricted diffusion below that of the tobacco with restricted diffusion. Therefore, the average moisture content during storage of the tobacco subjected to unrestricted diffusion was lower than the moisture content of the tobacco with restricted diffusion which caused lower dry weight losses for unrestricted diffusion at normal and high moisture level. However, the dry weight loss was higher for unrestricted diffusion than for restricted diffusion at the low moisture level. The initial low moisture content for unrestricted diffusion was 1.7 percentage points higher on the average than the initial low moisture content for restricted diffusion. The average moisture content during storage was higher for the unrestricted case compared to the restricted case at the lower moisture level, therefore, tobacco with unrestricted diffusion had a higher dry weight loss than tobacco with restricted diffusion.

The most important data from the producer's standpoint was total weight loss. At normal moisture, about an 8% total weight loss from moisture and dry weight losses may be expected. Moisture and dry weight losses during storage may be reduced by preparing burley tobacco at low moisture. Dry weight losses accounted for about half of the total weight loss at normal and high moisture.

Chemical Changes

The t-test showed that total nitrogen and protein nitrogen increased significantly, alkaloids decreased significantly, and nitrates and water soluble nitrogen changes were insignificant for restricted diffusion of moisture during storage. For unrestricted diffusion, protein nitrogen increased significantly, water soluble nitrogen decreased significantly, and total nitrogen, alkaloid, and nitrate changes were insignificant. The effect of type of package, initial moisture content, and stalk position on the change in total nitrogen, protein nitrogen, water soluble nitrogen, and alkaloids during storage are shown in Tables 3 and 4 for restricted and unrestricted diffusion of moisture, respectively. Nitrates were not affected significantly by any of the treatments and were not included in the tables. Alkaloids decreased significantly at a faster rate in bundles than in bales for both restricted and unrestricted diffusion. The rate of decrease was more than natural aging but less than fermentation (Tso, 1972). With restricted diffusion, treatments had no significant effect on protein nitrogen and water soluble nitrogen but the increase in total nitrogen was significantly higher at normal and high moisture than at low moisture and was also significantly higher for the top stalk position than the bottom and middle stalk positions. With unrestricted diffusion, total nitrogen decreased significantly in bales and increased significantly in bundles, protein nitrogen increase was significantly greater from bottom to top of plant, water soluble nitrogen decreased at a significantly greater rate in bales than bundles and for the top stalk position compared to the other stalk positions, and the decrease in alkaloids was highest for the top stalk position.

TABLE 3. MEAN VALUES OF THE CHANGE IN CHEMICAL CONSTITUENTS (% db) AS A FUNCTION OF TYPE OF PACKAGE, INITIAL MOISTURE LEVEL AND STALK POSITION DURING STORAGE WITH RESTRICTED DIFFUSION OF MOISTURE.

	Chemical Constituent, % (db)			
Treatment	Total Nitrogen	Protein Nitrogen	Water Soluble Nitrogen	Alkaloids
Bale	+ 0.18 a	+ 0.03 a	+ 0.11 a	− 0.13 a
Bundle	+ 0.13 a	+ 0.06 a	− 0.06 a	− 0.36 b
Low moisture	+ 0.05 a	+ 0.04 a	+ 0.01 a	− 0.17 a
Normal moisture	+ 0.23 b	+ 0.03 a	+ 0.16 a	− 0.19 a
High moisture	+ 0.19 b	+ 0.07 a	− 0.08 a	− 0.38 a
Bottom stalk position	+ 0.12 a	+ 0.05 a	+ 0.03 a	− 0.25 a
Middle stalk position	+ 0.07 a	+ 0.04 a	0.00 a	− 0.25 a
Top stalk position	+ 0.27 b	+ 0.05 a	+ 0.06 a	− 0.24 a

Any means having different letters beside them are significantly different by Duncan's new multiple range test (5% level).

TABLE 4. MEAN VALUES OF THE CHANGE IN CHEMICAL CONSTITUENTS (% db) AS A FUNCTION OF TYPE OF PACKAGE, INITIAL MOISTURE LEVEL AND STALK POSITION DURING STORAGE WITH RESTRICTED DIFFUSION OF MOISTURE.

	Chemical Constituent, % (db)			
Treatment	Total Nitrogen	Protein Nitrogen	Water Soluble Nitrogen	Alkaloids
Bale	− 0.18 a	+ 0.16 a	+ 0.34 a	− 0.01 a
Bundle	+ 0.12 b	+ 0.16 a	− 0.04 b	− 0.21 b
Low moisture	− 0.08 a	+ 0.16 a	+ 0.24 a	− 0.14 a
Normal moisture	− 0.03 a	+ 0.15 a	+ 0.17 a	− 0.16 a
High moisture	+ 0.01 a	+ 0.17 a	− 0.16 a	− 0.01 a
Bottom stalk position	0.00 a	+ 0.05 a	− 0.05 a	+ 0.01 a
Middle stalk position	+ 0.05 a	+ 0.19 b	− 0.13 a	− 0.02 a
Top stalk position	− 0.15 a	+ 0.25 c	− 0.39 b	− 0.30 b

Any means having different letters beside them are significantly different by Duncan's new multiple range test (5% level).

Microorganism Populations

Typical examples of bacterial and eucaryote (molds) populations are shown in Figs. 1 and 2, respectively, for the high moisture level and restricted diffusion. Initial bacterial populations were about 1/2 to 1 order of magnitude higher for bales than for bundles. At low and normal moisture, bacterial populations remained constant with time at 10^6-10^7 colony forming units/g dry matter. At high moisture, Fig. 1 shows that bacterial population increased about two orders of magnitude to 10^8-10^9 colony forming units/g dry matter carrying with it the potential for deterioration. Molds actually decreased during storage, as shown in Fig. 2. These results show that bacterial populations are a contributing

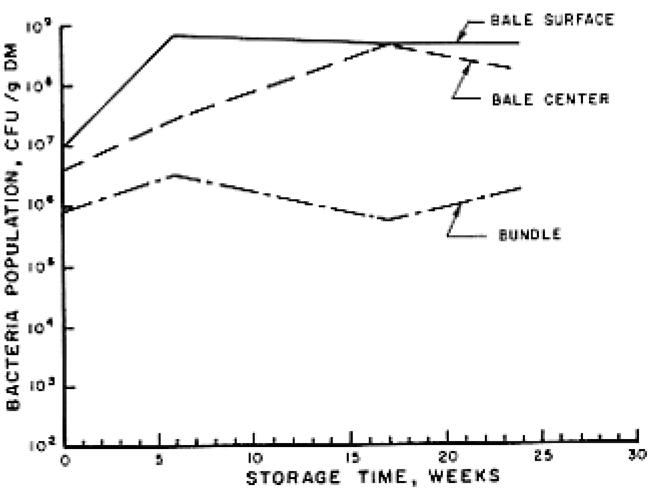

Fig. 1—Bacteria population (colony forming units/g dry matter) of bales and bundles as a function of time of storage.

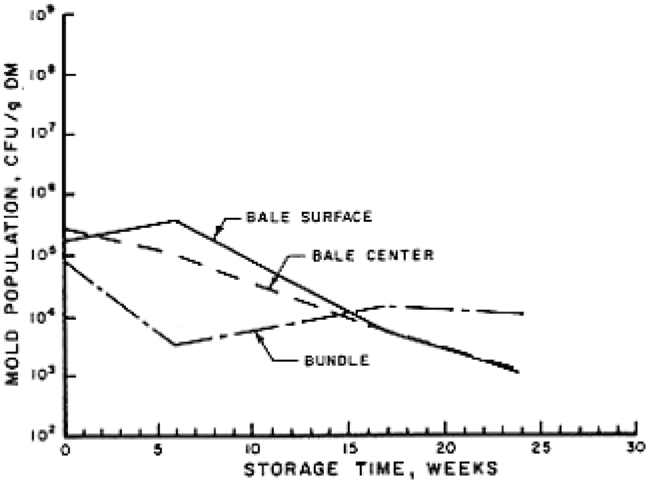

Fig. 2—Mold population (colony forming units/g dry matter) of bales and bundles as a function of time of storage.

factor to the deviant odors that often cause burley to be marked unsound for marketing.

CONCLUSIONS

Our conclusions were:

1. There was no significant difference in color change and dry weight loss between burley tobacco in bales and bundles.
2. Leaves darkened significantly during storage at all moisture levels and stalk positions with the exception of the bottom stalk position which darkened only slightly.
3. Burley tobacco had a significantly greater rate of alkaloid loss in bundles than in bales.
4. Tobacco stored over the summer at normal and high moisture was often graded as unsound because of a deviant odor caused by bacterial activity.
5. A bale weight loss of about 8% can be expected from spring to fall storage at normal moisture with the loss being divided evenly between moisture and dry weight losses.

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