Physical Characteristics of Cured Tobacco. II.

Some Factors Affecting Certain Physical Properties[1]

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The visual aspects of tobacco and its handling properties are the external manifestations of its chemical composition and microscopic structure. In an earlier report, Artho (1955) observed that tensile strength, hygroscopicity, and distensibility of cured Swiss tobaccos were related not only to chemical composition but also to histological structure. As the result of a number of intensive investigations in the physical behaviors of different types of tobaccos, Samfield and co-workers (1957; 1958a; 1958b; 1958c) suggested that many of the physicochemical properties of a tobacco may be governed by its cellulose content and, particularly, by the degree of polymerization of the cellulose (Samfield and Christy, 1960).

Numerous papers record comparative data on one or a few physical properties of tobaccos in relation to genetic or cultural factors. Parups (1958) measured the interstitial volumes of different types of Canadian tobaccos. Collins *et al.* (1961) compared the chemical composition, color brightness (Agtron Number), and equilibrium moisture contents of six varieties of flue-cured tobacco grown at four locations for three years. Moseley *et al.* (1963) studied the effects of maturity on certain properties of the cured leaf. The general effects of maleic hydrazide on the moisture-holding properties and filling values of tobaccos are well-documented (Coulson, 1959; Moseley, 1959; Gaines, 1959; Anon., 1961; Jeffery and Cox, 1962).

This paper summarizes the magnitude of the effects of cultural variables on certain physical properties in an integrated set of "normal" tobaccos.

Experimental Procedure

Two flue-cured varieties — Hicks and Coker 187-Hicks — were selected for this study primarily on the basis of the contrasting "body" of the tobaccos after curing. Hicks would be expected to develop more body than Coker 187-Hicks, particularly in the upper leaves.

Two hundred and forty uniform seedlings of each variety were transplanted in experimental plots both at the Border Belt Research Station, Whiteville, and at the Upper Piedmont Research Station, Rural Hall, N. C., in 1959. Fertilization rates, spacing, and other cultural treatments were uniform and normal for the particular station.

All plants were topped at the early flowering stage, retaining 16 leaves at Whiteville and 18 leaves at Rural Hall. Flowering (and topping) dates differed between varieties. Thus Hicks was topped prior to the harvesting of the 5th leaf, whereas the topping dates for Coker 187-Hicks was more nearly coincident with the 10th leaf harvest. Immediately following topping one half-plot of each variety was treated with maleic hydrazide (MH-30) at the rate of six pints per acre. The remaining plants were closely hand-suckered repetitively.

Leaves were harvested successively as they ripened, and were flue-cured. At the time of grading, experimental samples composed of the 5th, or the 10th, or the 15th (except the 17th at Rural Hall) "field" leaves were set aside for testing. Thus, 24 samples (2 varieties x 2 locations x 2 treatments x 3 positions) were accumulated.

An abbreviated version of the same experiment but with Burley tobacco was also grown at the Upper Mountain Research Station, Laurel Springs, N. C., in 1959. Experimental variables included the hand-suckered *versus* MH-30 contrast, leaf positions (the 8th, the 13th, and the 17th), but only one variety (Ky 16), and the single location. Six Burley samples (1 variety x 1 location x 2 treatments x 3 positions) were tested.

Preparatory for stripping and cutting, the leaves were hung in an "Aminco-Aire" Cabinet (American Instrument Company, Silver Spring, Maryland) at 25°C and 75% relative humidity for 72 hours. Each 120-leaf sample was subdivided, for analytical replication, by dealing the

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leaves into two piles. The physical-testing program is diagrammed in **Figure 1**. All tests were made in duplicate.

Average "Farm" Weight Per Leaf. After conditioning, when the moisture content of the samples approximated 18 per cent, the gross weight of each subsample was determined. This weight was divided by the number of leaves it contained or gave the "average 'farm' weight per leaf."

Strip Yield. Midribs were carefully stripped out of each leaf in a given subsample. The aggregate weight of laminae (strips) in relation to the gross farm weight of the whole leaves, expressed as percentage, is defined as "strip yield."

Dry Weight Per cm². Four disks were cut from each of five half-laminae, as shown in **Figure 1**, avoiding the larger lateral veins. The duplicate sample of 20 disks was punched from the opposite half-laminae. Since the gasket punch had a diameter of one inch, the computed area of 20 disks was 101.34 cm². These 20 disks were dried for four hours at 105°C, then weighed. The ratio, mass/area, in mg per cm², is directly related to "body" and is indicative of relative thickness or compactness or both.

Equilibrium Moisture Content. The remaining bulk of laminar halves was shredded, 33 cuts to the inch, with a Quester Cutter (Wilhelm Quester Gmbh., Cologne, Germany). The shreds were reconditioned in mesh baskets in the Aminco cabinet at 25°C and 60% r.h. for 72 hours.

Approximately one-gram test portions of the conditioned shreds were weighed, then dried at 105°C for four hours. The loss in weight, expressed in per cent of the wet weight, determined the "equilibrium moisture content (25°/60%)".

Specific Volume. Specific volume was determined by the Method A described in a previous publication

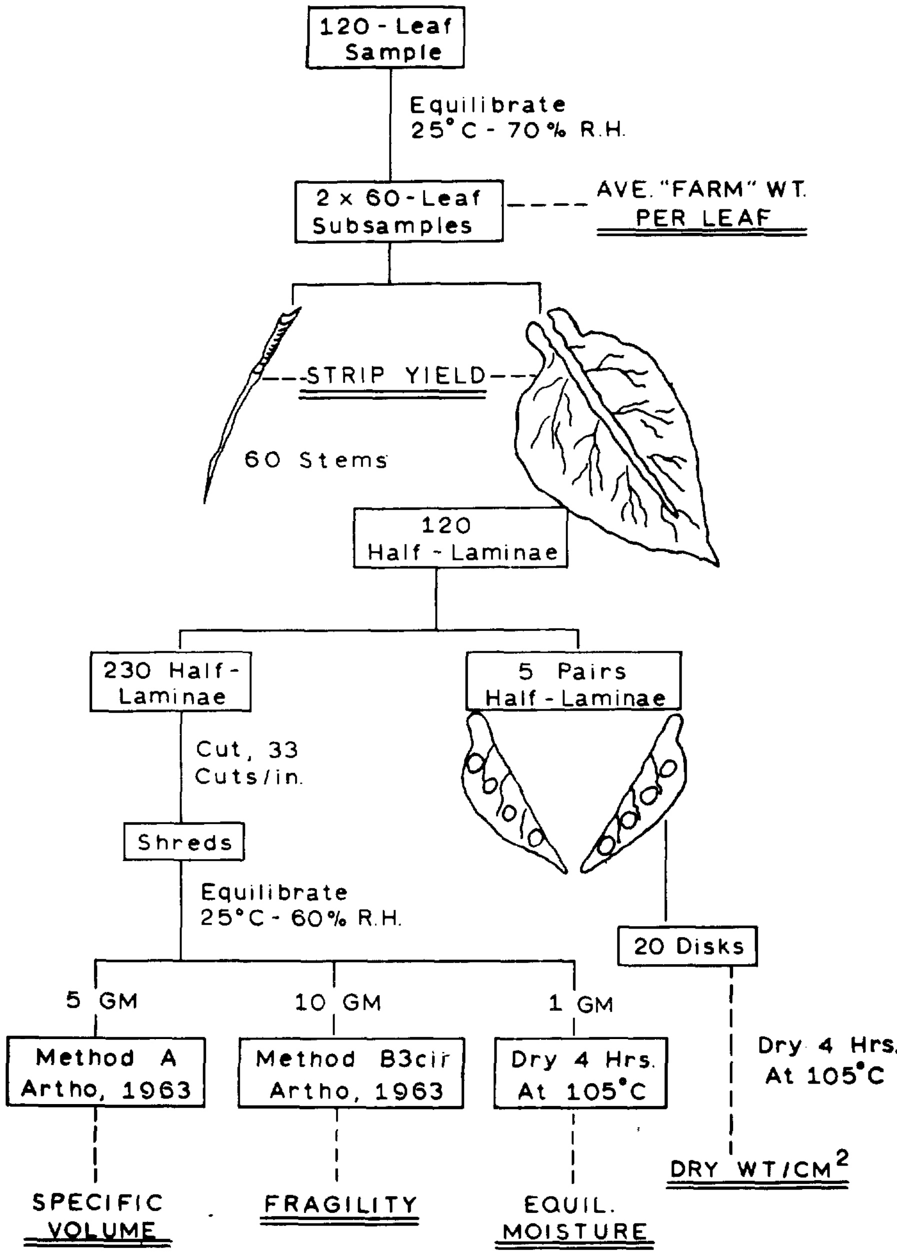

Figure 1. Flow sheet of physical-testing program.

Table 1. Range in values observed for the different physical characteristics and their associated errors of measurement

OBSERVATION	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
Highest Value	14.83	76.4	9.80	15.0	5.75	2.53
Lowest Value	5.34	59.8	3.05	11.7	3.00	1.84
Sampling Error[d]	12%	5%	21%	9%	19%	10%
Analytical Error[e]	3%	3%	5%	2%	3%	2%

[a] *Average "farm" weight of cured leaves (at about 18% moisture content).*
[b] *Equilibrated at 25°C and 60% relative humidity. "Moisture" defined as loss in weight during four hours of drying in a convection oven at 105°C.*
[c] *Fineness Index, an arbitrary designation of fragment size; the smaller the index the finer the fragment (See Artho, 1963).*
[d] *Pooled interactions involving location, expressed as coefficients of variation.*
[e] *Errors associated with duplicate measurements, as coefficients of variation.*

Table 2. Average effects of variety on certain physical properties of tobacco

VARIETY	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
Hicks	9.60	67.5	5.50	13.3	3.84	2.16
C187-Hicks	8.24	68.1	4.85	13.1	4.74	2.12
SIGNIFICANCE[d]						
Varietal Contrast	(SS)		(S)		(SS)	
Interactions with						
Location	(SS)				(SS)	
MH-30						
Position	(SS)					

a, b, c *Same as Table 1.*
d *Only significant effects and interactions are given; SS = significant at .01 level of probability; S = significant at .05 level.*

Table 3. Average effects of location on certain physical properties of tobacco

LOCATION	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
Whiteville	10.96	70.2	5.82	13.5	3.95	2.17
Rural Hall	6.88	65.4	4.53	12.8	4.63	2.10
SIGNIFICANCE[d]						
Location Contrast	(SS)	(SS)	(SS)	(S)	(SS)	
Interactions with						
Variety	(SS)				(SS)	
MH-30						
Position	(S)				(S)	

a, b, c *Same as Table 1.*
d *Same as Table 2.*

(Artho *et al.*, 1963). Five grams of preconditioned shreds were compressed in a 100-ml graduated cylinder under a 1345-gm lead piston for ten minutes. The compressed volume divided by the sample weight (5 gm) gives "specific volume" in cc per gm.

Fragility. As a measure of relative brittleness, ten-gram portions of preconditioned shreds were chopped in a Waring Blendor for 30 seconds, according to Method B3cii as described by Artho *et al.* (ibid.). The resulting fragments were sieved through a set of appropriate screens. A "fineness index" was computed to express the size-distribution of the fragments. A smaller fineness index is indicative of a more fragile tobacco.

Results and Discussion

The highest and the lowest values for each physical attribute observed among the 24 flue-cured samples are recorded in **Table 1.** Each set of data was examined by the statistical analysis appropriate for the experimental design. Varieties and Locations were whole-plots; whereas, Treatments (Hand-Suckering *vs* MH-30) were the split-plots and Leaf Positions the split-split-plots.

Although Location intentionally imposed soils and general climatic variables into the experiment, the particular weather conditions that actually prevailed at the two locations introduced an element of randomness into the design. Thus the "Experimental (Sampling) Error" against which differences were tested was made up of the pooled interactions involving Location. The "Analytical Error" was the variance associated with the duplicate measurements. The magnitudes of these errors, expressed as coefficients of variation, are also given in **Table 1.**

Tables 2, 3, 4, and **5** isolate the average effects of the imposed variables. The over-all contrasts between the two varieties are given in **Table 2.** Hicks is characterized as having produced heavier leaves (except at the lower sampling position) that were also more compact (mg per cm²) and tended to be somewhat tougher (higher fineness index), though not significantly so. The "fluffier" nature of C187-Hicks is evidenced by its higher specific volume, particularly at and above the midstalk position.

The average effects of location are summarized in **Table 3.** At Whiteville where the total rainfall and its distribution were nearly normal, the leaves of both varieties grew heavier and thicker (mg per cm²); they had a higher proportion of lamina (strip yield) and were more hydroscopic than those produced in the Rural Hall experiment. An insufficiency of rainfall at Rural Hall during the early part of the growing season retarded normal leaf development (average weight per leaf) and contributed to "chaffiness" (higher specific volume), especially at the lower two sampling positions. The dry weather apparently affected Hicks more than it did C187-Hicks in both respects.

The absence of significant interactions in **Table 4** indicates that the effects of maleic hydrazide in producing a heavier, more compact, and more hygroscopic leaf having a lower filling value are uniform responses. While the means suggest

Table 4. Average effects of manual vs. chemical sucker control on certain physical properties of tobacco

TREATMENT	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
Hand suckered	8.48	67.3	5.05	12.8	4.50	2.11
Maleic Hydrazide	9.36	68.4	5.30	13.5	4.09	2.17
SIGNIFICANCE[d]						
Treatment Contrast	(SS)		(S)	(S)	(S)	
Interaction with						
Location						
Variety						
Position						

a, b, c *Same as Table 1.*
d *Same as Table 2.*

Table 5. Average effects of leaf position (node) on certain physical properties of tobacco

POSITION	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
5th	7.64	65.4	3.50	13.0	4.68	1.96
10th	9.88	65.6	4.45	13.3	3.94	2.23
15th (or 17th)	9.24	72.4	7.57	13.0	4.26	2.22
SIGNIFICANCE[d]						
Position Contrast	(SS)	(SS)	(SS)		(SS)	(SS)
Interactions with						
Location	(S)				(S)	
Variety	(SS)					
MH-30						

a, b, c *Same as Table 1.*
d *Same as Table 2.*

Table 6. Certain physical characteristics of Burley (Ky 16 at Laurel Springs, 1959)

VARIABLE	Av. Weight per Leaf[a] gm	Strip Yield %	Weight per Area mg/cm²	Equil. H_2O[b] %	Specific Volume cc/gm	Relative Fragility F.I.[c]
Ky 16, at Laurel Springs	7.92	68.0		11.9	5.14	1.95
Treatment: H. S.	6.93	68.9		11.8	5.62	1.96
MH-30	8.90	67.2		12.0	4.65	1.95
Position: 8th	7.75	67.9		12.3	4.97	1.99
13th	7.75	66.2		11.9	5.09	1.92
18th	8.25	70.0		11.6	5.35	1.96

a, b, c *Same as Table 1.*

that the maleic hydrazide-treated tobacco is less brittle, this difference, is not statistically significant. A heavy rain shower, eight hours after the application of MH-30 to the C187-Hicks plants at Whiteville, undoubtedly moderated the effects of this chemical but not enough to show up as a significant variety x location interaction. Some distorted sucker growth and a moderate infection of brown spot did develop on this variety at Whiteville, whereas Hicks was relatively free of both.

Stalk positional effects are tabulated in **Table 5.** While, on the average, leaf weights were greatest in the middle of the plant and Hicks leaves weighed more than C187-Hicks, the significant variety x position interaction resulted from the fact that the 5th leaves of C187-Hicks were heavier than the upper leaves of C187-Hicks. The stunting effect of the early drought at Rural Hall was responsible for the location x position interaction. On both varieties, the upper leaves were significantly heavier bodied and had proportionately smaller midribs (higher strip yields). Bottom leaves were more fragile and gave the highest filling values. Again the dry weather at Rural Hall accentuated the specific volume differences at the two lower positions and gave rise to the significant location x position interaction.

The observations on Burley at Laurel Springs **(Table 6)** corroborated the results of the larger experiments. As with the flue-cured tobacco, Burley plants treated with maleic hydrazide produced heavier and more hygroscopic leaves having lower specific volumes. In Burley as with flue-cured, the heaviest leaves and the higher strip yields were found at the upper sampling position. Unlike flue-cured, specific volumes increased progressively up the stalk. The most fragile leaves of Burley came from the midstalk position.

While the data from these experiments are inadequate statistically to refute old claims or to establish new responses, these studies have demonstrated that simplified procedures utilizing relatively simple and inexpensive equipment are adequate for distinguishing differences in certain arbitrary physical properties among tobaccos. These tests offer particular utility for assessing the effects of field treatments.

Summary

A coordinated sequence of simplified procedures was used to measure leaf weight, leaf body (wt/area), strip yield, specific volume, relative fragility, and hygroscopicity on a set of twenty-four flue-cured and six Burley samples. Replicated measurements permitted the estimation of the magnitude of the effects of the imposed agronomic and cultural variables and their interactions. These studies have demonstrated that relatively simple tests can be used for the evaluation of important physical attributes of tobaccos.

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