Effect of Cellulose on Taste of Cigaret Smoke*

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INTRODUCTION

Cellulose is one of the main constituents of a cigaret [Samfield and Christy (1960)]. It is present to the extent of 15 to 20 percent by weight. The tobacco leaf lamina contains 5 to 11 percent (Table 1). Stems or midribs may run as high as 23 percent of dry weight as cellulose so that a filler blend containing cut stems (25%) in proportion to the whole leaf (75%) may have as much as 14 percent by weight of cellulose. Cigaret paper adds another 3 percent by weight. Finally, many reconstituted tobacco products contain cellulosic binders, making even more cellulose available for combustion in the cigaret product. These data are only for that fraction defined as cellulose and do not include various hemicelluloses and pectins which may also be present and which, from the point of view of pyrolysis and combustion products, may behave much like cellulose [Bacot (1960); Collins, Jones, Weybrew and Matzinger (1961)].

It is quite clear then that a first step in defining the organoleptic factors in cigaret smoke is to determine the contribution which cellulose as a major component makes. Such was the purpose of this study. At the same time, analytical results on smoke composition were examined in the hope of finding some clues regarding the importance of various constituents on smoke taste.

Some preliminary experiments in this regard gave conflicting results. We are all familiar with the acrid and harsh odor of smoke from burning paper or tobacco stems. The simple addition of cut filter paper cellulose to cut tobacco was found to make the smoke much harsher with a detection threshold at about only 2 percent added cellulose. On the other hand, it was possible to add as much as 40 percent rolled and cut stem, containing about 20 percent cellulose, to cigaret filler without a serious increase in harshness. This observation would imply that one could tolerate four times as much cellulose in the form of cut stems as in the form of cut cellulose paper. Was this difference due to the presence of other chemicals in the stems, or was it due to the difference in the way the stems were treated in making the blend?

The commercial importance of this question is quite clear. It relates to the extent to which stems should be used in the filler and how they might best be used to make a smooth and acceptable smoke. It also relates to how much effort should be made to modify the cellulose existing in the cigaret filler in order to make the smoke more acceptable. And, finally, it relates to the importance of avoiding cellulosics in reconstituted tobacco processes in order to make the best tasting smoke product.

TABLE 1
Cellulose contents of tobacco products
(weight percent)

Tobacco leaf lamina	5 to 11 %
Tobacco stems	13 to 23 %
Whole leaf cigaret filler	14 %
Cigaret paper	70 %
Cigaret with 4 % paper and 96 % filler	17 %

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EXPERIMENTAL

Four series of experiments were made. In each one alpha cellulose, in the form of cut filter paper or powdered filter paper cellulose, was added in various amounts to tobacco leaf in several different ways. Cigaret filler was prepared (without cut stems in all cases), the filler was made into cigarettes, and the cigarettes were smoked for taste and chemical analysis.

Series A: Alpha cellulose filter paper was cut and blended in with cut leaf filler in the amounts of 0, 17, 28, and 44 percent additive in the final blend.

Series B: In this case the filter paper cellulose in the form of a fine powder was blended in a Manton-Gaulin homogenizer with ground leaf tobacco, water, and a little glycerine to produce a paste. This paste was then cast on glass plates to make upon drying a strong flexible film suitable for cutting into cigaret filler. Films with 0, 17, 28, and 44 percent added cellulose content were made.

Series C: This series was like Series A except that the tobacco leaf portion was composed of a Manton-Gaulin homogenized 100 percent leaf tobacco film with no added cellulose as in Series B. To the cut tobacco film was added cut filter paper in various amounts to make blends which were then rolled into cigarettes. Again 0, 17, 28, and 44 percent cellulose combinations were made.

Series D: Like Series C except that the filter paper was first soaked in an aqueous solution of tobacco leaf solubles and dried so that about one-third of the treated filter paper weight was the tobacco solubles. This treated filter paper was then shredded, cut, and blended with cut homogenized tobacco film, and made into cigarettes. Combinations with 17 and 44 percent added cellulose content were made.

Chemical analyses of the smoke were made in two parts. Total particulate matter was determined by the Cambridge Filter method commonly employed by the cigaret companies in the United States [Ogg (1964)]. Gas phase compositions were determined by gas chromatography, infrared, and mass spectrographic methods. Complete analytical results are beyond the scope of this presentation. We will concentrate our attention on differences which we found to be significant and meaningful.

Taste differences were detected by the use of expert panels trained to give standardized descriptions of smoke flavor and harshness notes. The distinction between flavor and harshness was discussed in a previous paper presented to this Congress at its Third Meeting in Salisbury [Resnik, Danker,

TABLE 2

Summary of organoleptic tests

Harshness index = number of panelists out of 10 finding smoke harsher*

Series	Cellulose form	Added cellulose in blend			
		0%	17%	28%	44%
A	Filter paper shreds with leaf tobacco	4.4	5.6		
		4.0		6.0	
		0.0			10.0
C	Filter paper shreds with tobacco homogenate	4.0	6.0		
			4.6		5.4
		3.7			6.3
B	Homogenate with cellulose powder and leaf tobacco combined	4.7	5.3		
		5.0		5.0	
		5.0			5.0
D	Filter paper soaked in tobacco solubles with tobacco homogenate	5.2	4.8		
			4.5		5.5
		4.7			5.3

* Differences less than 1.0 are of doubtful significance.

TABLE 3

Smoke yield of "total particulate matter"
(TPM mg/g of filler)

Series	Added cellulose in blend			
	0%	17%	28%	44%
C	24	39	40	44
B	24	26		25
D	24	30	31	33

TABLE 4

Changes in gas phase composition with increasing cellulose as determined by mass spectrometric analysis

	Series C	Series B
Xylenes	0	—
Toluene	0	—
Benzene	+	—
Hexenes	0	—
Pentenes	0	—
Isoprene	—	—
Butene	+	—
Propenes	+	—
Propyne	+	+
Acetylene	+	+
Butadiene	+	—
Methylfuran	+	—
Methylchloride	—	—
Methanol	—	—
Butanone	0	—
Acetone	+	—
Acetonitrile	+	—

— = decrease + = increase 0 = no change

TABLE 5

Gas phase components which increased with increasing cellulose content from gas-liquid chromatography

	Series A	Series B	Series D
Furan	+		
2-Methylfuran	+	+	
Dimethylfuran	+		
Furfuryl alcohol		+	
Furfural		+	
5-Methylfurfural		+	
Acetaldehyde	+		
Propionaldehyde	+		
Isobutyraldehyde	+		+
Crotonaldehyde	+	+	+
Acrolein	+		+
2-Butanone	+	+	
3-Butene-2-one	+		+
Pentadiene	+		
Methyl acetate			+

and Daylor (1963)]. In the present investigation the panelists were asked to rate only harshness — the acrid, biting sensations in the oral cavity and nose. At each session of the panel a comparison was made between two cigarettes within a series. Each panelist rated the harshness intensity on the tongue, mouth, throat, and nose. From the combined ratings of the group a harshness index was estimated for each cigarette. This index is in effect the number of panelists out of ten who found the cigarette in question to be the harsher of the two being compared. Thus, a rating of 10 means that all panelists agreed that the cigarette was harsher. A rating of 5 would indicate that the panel was evenly divided between the two cigarettes in question and could not establish a difference. Many comparisons were made with different numbers of persons on the panel, resulting in fractional ratings as shown in Table 2.

RESULTS

Results of the organoleptic tests are summarized in Table 2. It is clear from these data that in Series A and C, in which cut filter paper cellulose was added to the blend, the panelists found the smoke to be increasingly harsh as the cellulose content increased. In Series B and D, on the other hand, in which the cellulose was either intimately homogenized with the tobacco or presoaked with tobacco solubles, the panelists found essentially no increase in harshness with increasing amounts of cellulose.

It would be expected that with changes in filler composition, changes in smoke composition would also be observed. Results are shown in Tables 3, 4, and 5.

In Table 3 there are listed the "Total Particulate Matter" (TPM) values obtained by the standard American "Cambridge Filter" method. Note that in Series C the TPM increases as more shredded filter paper is added to the blend, whereas in Series D the addition of cellulose did not increase the quantity of particulate smoke. These results would seem to indicate quite clearly that the burning of the cellulose in the intimate presence of tobacco components is significantly different from that of cellulose alone. This point is emphasized by differences in gas phase smoke composition summarized in Tables 4 and 5.

FIGURE 1
Mass spectrometric data
(micrograms in gas phase per gram of filler)
series B: — series C: - - -

In Table 4 we have indicated the direction of component change in gas phase produced by increasing cellulose content for smoke from Series C and Series B cigarettes as determined by mass spectrometric analysis. Note that in Series C, where the cellulose is added as shredded filter paper, many of the components measured increase in quantity with increasing cellulose content. In Series B, in which the cellulose in the form of a powder is made a component of the homogenate sheet, the same gas phase components of the smoke are mostly decreasing as the amount of cellulose is increased. In both cases the alkynes (acetylene and propyne) increase appreciably as the cellulose content goes up.

Changes for acetylene, acetonitrile, isoprene and methylfuran are plotted in Figure 1.

Similarly in Table 5 we have indicated the direction of gas phase component changes for Series A, B, and D, as determined by gas-liquid chromatography. Again it is quite clear that variations in smoke composition with increasing cellulose content of the cigarette filler differ depending upon the method of addition. In particular, note the furan and aldehyde increases in Series A.

Changes in GLC peak heights for some of these components from Series B cigarettes are plotted in Figure 2.

It is obvious from these results that the complete chemical characterization of smokes from these various cigarettes is almost hopelessly complex. Nevertheless, the data shown lend credence to the organoleptic observations and support to the inferences one might make from them.

DISCUSSION AND CONCLUSIONS

At the beginning of this report it was pointed out that in an early comparison it was found that the addition of 2 percent free filter paper cellulose had the same harshness effect as about 40 percent rolled and cut stems in the cigarette blend. This result is now not surprising in view of the observations described herein. In stems one would expect the 80 percent of noncellulosic material to modify materially the burning of the 20 percent cellulose present and hence to produce an

FIGURE 2
Gas-liquid chromatographic peak heights (series B)

entirely different taste effect. Thus, while the smoke of whole stems may not be a desirable organoleptic experience, certainly not all of its undesirable characteristics should be ascribed to the cellulose fraction. Furthermore, the results from a comparison of Series B and D indicate that the intimacy of mixture of the cellulose with other substances in tobacco rather than the physical form of the cellulose is an important factor in the resulting smoke taste.

These findings also point up the hazard of trying to predict the contribution of a blend component by smoking the pure component alone. This practice is common among cigaret people and has probably led to many erroneous conclusions.

Finally it should be said that our chemical composition data are not of such a nature that we can define the flavor and harshness factors in smoke from high cellulose filler. Certainly from Table 5 one would suspect such compounds as the furans and the aldehydes to be derived from the cellulose portion of the filler. Yet we know there are many other contributors to organoleptic response which we did not analyze in this investigation. That work is left for the future.

SUMMARY

Experiments were performed to define the contribution of the cellulose component in cigaret filler to the organoleptic qualities of smoke. Pure cellulose shreds added to leaf tobacco gave the smoke a harsh quality readily detected by the smoker. Similar amounts of cellulose powder and tobacco dust, homogenized together and made into a film which was then used as cigaret filler, did not show the harshness effect even up to levels of 44 % added cellulose content in the mixture. Pre-soaking the cellulose paper in aqueous tobacco solubles also prevented the harshness in smoke observed from pure cellulose shreds. It was concluded that the intimate mixture of noncellulosic components with the cellulose in tobacco lamina and stems to a large extent modifies the burning of the cellulose component from that of pure cellulose paper. Chemical analyses showed that the manner of cellulose addition influenced appreciably the cigaret smoke composition, thus accounting qualitatively for the organoleptic changes noted.

ZUSAMMENFASSUNG

Es wurde experimentell untersucht, in welchem Maße in Cigarettentabak enthaltene Cellulose zu organoleptischen Eigenschaften des Rauches beiträgt. Der Zusatz von klein geschnittener, reiner Cellulose zum Blatttabak verlieh dem Geschmack des Rauches herbe Eigenschaften, die vom Raucher leicht zu bemerken waren. Wenn jeweils gleiche Mengen Cellulosepulver und Tabakstaub in einem Homogenisierungsprozeß miteinander verbunden und zu einem Film verarbeitet wurden, der dann als Füllung für die Cigaretten benutzt wurde, zeigte sich der herbe Geschmack nicht, selbst wenn der Cellulosegehalt der Mischung bis auf 44 % gebracht wurde. Eine Tränkung des Cellulosepapiers in den wasserlöslichen Bestandteilen des Tabaks verhinderte ebenfalls die Bildung des herben Geschmacks, der bei Verwendung reiner Cellulose Teile festzustellen war. Aus den Beobachtungen wird gefolgert, daß die enge Vermischung cellulosefreier Bestandteile mit der Cellulose des Blattgutes und der Mittelrippen des Tabaks den Abbrand der Cellulosekomponente weitgehend beeinträchtigt, indem sie andere Bedingungen schafft, als sie beim Verglimmen reinen Cellulosepapiers vorliegen. Chemische Analysen zeigten, daß die Art der Cellulosebeimischung die Zusammensetzung des Cigarettenrauches merklich beeinflußt und somit die beobachteten Veränderungen der organoleptischen Eigenschaften desselben bedingt.

RÉSUMÉ

Des expériences ont été faites pour définir la part revenant au composant cellulosique du tabac de remplissage de la cigarette dans les qualités organoleptiques de la fumée. Des fragments de cellulose pure ajoutés au tabac ont donné à la fumée un caractère âcre facilement discerné par le fumeur. Des quantités similaires de poudre de cellulose et de poussière de tabac ont été intimement mélangées et on en a fait un film qu'on a utilisé pour confectionner des cigarettes; elles ne présentaient pas d'âcreté, même jusqu'au taux de 44 % de poudre de cellulose dans le mélange. Le trempage du papier de cellulose dans des solutions aqueuses de tabac empêchait également l'âcreté

de la fumée que l'on observait dans le cas d'addition de brins de cellulose pure. On en a conclu que le mélange intime de composants non-cellulosiques avec la cellulose dans le tissu et les côtes de tabac modifie dans une large mesure la combustion du composant cellulosique par rapport à celle du papier de cellulose pure. Des analyses chimiques ont montré que la façon dont est ajoutée la cellulose influence appréciablement la composition de la fumée de cigarette, rendant compte ainsi, qualitativement, des modifications organoleptiques notées.

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