Instrumentation

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CONCLUSIONS

1. Standardization of the collaborators' haze meters with Formazin as per the Beer–26 procedure of the ASBC *Methods of Analysis* (1) was satisfactory.
2. The Formazin turbidity unit/Coleman Nephelos unit (FTU/CNU) ratio varied considerably from laboratory to laboratory for the Coleman-78 and -21 Nephelos standards compared with standard Formazin dilutions.

RECOMMENDATIONS

1. Since it is impractical to circulate either beer samples or Coleman Nephelos standards, no further collaborative work of this nature should be undertaken to establish a uniform relation between Formazin haze and Coleman nephelometric haze.
2. The Subcommittee should be given a new assignment.

The object of the work of this Subcommittee for the past 2 years has been to demonstrate a collaborative correlation between Formazin haze and Coleman haze as measured with laboratory nephelometers. Last year's work led to the conclusion that it was not practical to circulate unrefrigerated beer samples for collaborative haze study, but that instrument standardization with Formazin haze was readily accomplished with the instruments used. This year's efforts were to attempt to eliminate all previous variables in order to establish a firm correlation between Formazin and Coleman haze. Two sealed Coleman Nephelos standards were to be circulated among the collaborators and compared to standard Formazin dilutions prepared according to the Beer–26 procedure of the ASBC *Methods of Analysis* (1). Also, beers of various haze levels were to be compared using both Coleman and Formazin standards for instrument calibration.

In order to further understand the optical concept of turbidity, a few comments concerning actual definition are needed. The turbidity of a liquid is defined as its extinction coefficient due to light scattering and can only be measured on the basis of this definition, *i.e.*, optically. Haze, a measure of the light scattered at an angle of 90°, is often used incorrectly to denote either the turbidity of a sample or the amount of material which causes that turbidity. The turbidity of a hazy liquid is an optical concept based, not upon the nature of the haze, but upon its appearance. Turbidity is such that the proportion of the light falling upon the liquid is scattered by it (2). Since light scattering is a function of many parameters, including particle size, wavelength, and angle of incidence, it is experimentally difficult to assign a haze number to an optical concept. Possible problems can arise in developing specific correlations between hazes of different particle sizes.

TABLE I
FTU Measurements for Standards; Prepared from the 1000-FTU Standard

	Standard FTU Dilutions													
Collaborator	500	400	300	200	100	90	80	70	60	50	40	30	20	10
1	495	405	305	203	105	...	...	...	...	...	...	...	...	...
2	475	380	290	190	95	90	80	70	60	50	45	30	20	10
3	497	393	292	188	99	88	77	66	59	46	35	27	15	5
4	520	415	303	205	100	94	81	71	59	49	39	28	20	10

TABLE II
Sealed Coleman Standards; Comparison with FTU Dilutions

	78-CNU Std. *vs.* 1000-FTU Stds.		21-CNU Std. *vs.* 100-FTU Stds.	
Collaborator	Av FTU/CNU	Range	Av FTU/CNU	Range
1	3.9	3.8–4.0	2.9	0 -
2	2.7	0	2.6	0
3	2.8	2.8–2.9	3.1	2.0–3.3
4	2.5	2.2–2.9	1.1	1.1–1.2
5	...	...	0.7	0.6–0.8

TABLE III
FTU/CNU[a] Ratios for Fresh and Punished Beers

Collaborator	No. of Samples	Av FTU/CNU, Fresh	Range	Av FTU/CNU, Punished	Range
1	24	3.3	3.0–3.6	3.2	2.9–3.2
2	25	3.2	2.8–3.8	3.6	3.3–3.8
3	24	1.5	1.3–1.7	1.6	1.4–1.8
4	25	2.6	2.4–2.8	3.0	2.9–3.0
5	10	...	...	2.3	2.2–2.4

[a]Formazin turbidity units/Coleman Nephelos units.

PROCEDURE

Each collaborator was instructed to prepare a basic Formazin stock suspension according to the Beer–26 procedure of the ASBC *Methods of Analysis* (1) utilizing 0.45 μ filtered water. If this water exhibited any haze, it was to be refiltered through two 0.45-μ pads, and this procedure repeated until the water was satisfactory. Each collaborator was asked to check his Coleman nephelometer with the following procedure. He was to make up 1000-, 500-, 400-, 300-, 200-, 100-, 90-, 80-, 70-, 60-, 50-, 40-, 30-, 20-, and 10-FTU standards. After standardizing the instrument with the 1000-FTU standard, he was to read the 500 to 100 dilutions. After standardizing the instrument with the 100-FTU standard, he was to read the 90- to 10-FTU dilutions, both of the above according to Beer–27B of the ASBC *Methods of Analysis* (1).

In an effort to define the source(s) of variance, the collaborators were instructed to prepare ten separate 1000-FTU standards and measure the Coleman-78 Nephelos standard with each of them. Similarly, they were to prepare ten separate 100-FTU standards and measure the Coleman-21 standard with each of these. All collaborators used the same two Coleman Nephelos standards which were circulated by mail.

Each collaborator was requested to measure the turbidity of 25 samples of both fresh and punished beer or wort, with both the Formazin and Coleman standards.

RESULTS AND DISCUSSION

The data for each of the dilutions examined are shown in Table I. The variances of these dilutions indicate that collaborators' instruments were essentially linear throughout the 10- to 1000-FTU range.

Comparison of the sealed Coleman standards with Formazin standards was made directly and the data are shown in Table II. Two indirect comparisons of these standards were made via examination of fresh and punished beer, and these data are shown in Table III. Collectively, these tables show that there is no inferable interlaboratory correlation between Coleman haze and Formazin haze. Since all comparison tests used essentially the same two types of haze particles, this lack of correlation can possibly be explained by a significant instrument deviation. The angle of light incidence, wavelength, and strength, and photocell sensitivity may vary only slightly among instruments, but still be sufficient to cause a different response for hazes with apparent differences in particle size. Collaborator 3 was the only one that maintained a similar value of average FTU/CNU for both the direct and indirect comparisons. The collaborators used the Coleman-21 standard for the work on fresh and punished beer. Since this standard was found to contain a haze during the course of the collaborative work, the data of the second half of Table II and all of Table III are suspect.

The manufacturer of the standard stated that a standard can develop excess haze due to oxidative degradation of the polymer matrix of the haze system when the vacuum of the seal is broken. All collaborators employed the Coleman Model #9 spectrophotometer adapted for nephelometry. In addition, Collaborator 3 obtained the Formazin haze data with a Radiometer haze meter.

Literature Cited

1. AMERICAN SOCIETY OF BREWING CHEMISTS. Methods of analysis (7th ed.). The Society: St. Paul, Minn. (1975).
2. CLYDESDALE, F. M. *Brew. Dig. 48*(10): 46 (1973).