CHARCOAL TREATMENT of BRANDY

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The physical properties and effectiveness of twenty-seven charcoals in absorbing the constituents of brandy from pure solution of each major constituent of brandy or from commercial brandy have been tested. The charcoals (0.5 gram per 100 ml.) remove acidity, furfural, and tannin, but the esters, acetaldehyde, and higher alcohols are unaffected. Many charcoals also absorb copper, iron, coloring matter, or extract material from brandy. The charcoals vary markedly in absorption ability. Fusel oils up to about 25 per cent can be removed by using larger amounts of charcoal (3 or 4 grams per 100 ml.); but at 94 per cent alcohol and 70° C. the absorption of higher alcohols is reduced. Increasing the period of contact does not improve absorption. The tests indicate that, before commercially using charcoal for brandy, the distiller should test a number of carbons. In general, charcoals fail to remove from the brandy an appreciable amount of the major chemical constituents; but they improve the organoleptic character as to obnoxious odors, tastes, and color.

During the past several years California brandy distillers have become interested in charcoal for correcting abnormalities in high-proof and beverage brandies. Hassler (*11*) recommended activated charcoal for removing objectionable impurities of color, taste, or odor from all types of spirits. This study was planned to determine how various charcoals affect the composition and quality of commercial brandy. Data are also reported on the effect of charcoals on alcoholic solutions of the more important constituents of brandy.

Table I describes the charcoals used. Tyler screens were used for measuring the predominant particle size, and the density, per cent moisture, and suspension properties of the charcoals were determined by methods suggested by Laughlin (*14*). According to Sharf (*20*) the volume of charcoal is more important than the weight in the contact-type carbon filter. The charcoal must also have weight enough to remain settled in the unit during flow. On the other hand, other factors are important—size of particles, packing, and speed of filtration (*8*). For gas absorption Bardan and Scarlatescu (*8*) found that charcoals differ in activity from themselves and one another at 20 per cent moisture compared to the absorption when nearly dry. Where equally effective, the drier charcoals should be preferred.

The suspension property was determined by placing 200 mg. of a carbon in a jar, thoroughly shaking with 10 liters of water, and allowing the suspension to stand for 15 hours. Nine liters were then siphoned off; the carbon remaining in the jar was filtered onto a Gooch crucible, dried at 140° C. for 4 hours, cooled in a desiccator, and weighed. Nine of the carbons possessed good settling properties, over 97.5 per cent of the carbon settling into one tenth of the volume. Such charcoals were obviously preferable for ease of filtration or decantation. The settling volume is not necessarily the same as the per cent suspension, though probably related to it. To determine the settling volume, 3 grams were suspended in 100 ml. of a 50 per cent alcohol solution at a pH of 3.6 (secured by adding 0.0555 mole of acetic acid) in a 100-ml. graduated cyclinder. The sedimentation volumes were determined after 2 and 24 hours, but the results secured after 2 hours are omitted because the volume, except for charcoal 19, was essentially the same as after 24 hours. As Bretschneider (*5*) showed that electrolytes markedly influence the sedimentation volume of activated charcoals, the experiment was repeated with a neutral 50 per cent alcohol. No great difference was found in the settling volume at pH 7.0 as compared with 3.6 except with four carbons which had poor settling properties at pH 7.0. (Charcoals 5, 19, and 21 showed 100 per cent suspension after 24 hours, and 12 showed little settling after 2 hours but had settled fairly well in 24 hours.) Settling of charcoals 2, 12, and 25 was also noticeably poorer in the neutral alcohol solution. A few young California brandies have a pH of 7.0 (*21*), but the usual pH is about 4. Charcoals with large settling volumes will obviously require greater care in filtration.

Most of the charcoals were neutral. The sugar charcoal and one of the activated carbons, 14, were definitely acidic, and one sample was basic. These data will be discussed further in connection with the use of charcoal to remove acidity.

EXPERIMENTS WITH PURE SOLUTIONS

The most important constituents of brandy, other than water and alcohol, are the acids, esters, aldehydes, furfural, fusel oils, and tannins. To get more directly at the influence of the carbons on these substances, solutions of each were treated in 50 per cent alcohol, in which the concentrations used were approximately the maximum amount found in California brandies (Table II). A 100-ml. portion of a solution and 0.5 gram of charcoal were shaken in a glass-stoppered flask for exactly 10 minutes and filtered by suction. The methods of analysis, unless otherwise stated, were those of the Association of Official Agricultural Chemists (*2*), except that fusel oil was determined by a modification of the colorimetric method of Penniman, Smith, and Lawshe (*17*).

The amount of charcoal and the period of contact were taken arbitrarily. These values were within the range recommended by the charcoal manufacturers and by the literature. Larger amounts would be less desirable because they are costly, because they may extract too much of the character and coloring matter from the brandy (even 0.5 gram per 100 ml. of some of the charcoals is excessive), and because in

TABLE I. DESCRIPTION, SOURCE, AND PHYSICAL AND CHEMICAL PROPERTIES OF CHARCOALS USED

Number	Description	Source	Particle Size, Mesh	Density, G./L.	Moisture, %	Suspension[a], %	Settling Vol.[b], %	Acidity[c], Ml.
1	Animal, granular	Eimer and Amend	< 10	667	2.8	0.0	7.5[d]	0.00
2	Animal, purified	Eimer and Amend	43% > 200	571	29.1	6.8	10.0	0.15
3	Animal, powdered	Braun-Knecht-Heimann Co.	77% > 200	833	3.2	1.2	5.5[d]	0.00
4	Blood, tech.	Eimer and Amend	69% > 200	714	1.9	16.2	9.5	0.00
5	Calcined	Eimer and Amend	93% > 200	625	3.9	11.2	9.0	0.00
6	Sponge, C. P.	Eimer and Amend	77% > 200	476	7.8	14.0	14.0	0.00
7	Coconut	Eimer and Amend	10–18	454	0.2	0.0	8.5[d]	Trace
8	Sugar, C. P.	Eimer and Amend	18–200	370	7.8	0.0	14.0[d]	1.01
9	Wood (activated)	Eimer and Amend	87% > 200	286	11.0	28.4	21.0	0.00
10	Carbon, S51	Darco Corp.	82% > 200	476	1.1	4.6	12.3	0.00
11	20 × 40 mesh	Darco Corp.	< 60	384	2.8	0.0	11.1	0.13
12	Crystalline	Carlisle Lumber Co.	40–200	476	3.8	1.8	11.0	Trace
13	Crystalline	Carlisle Lumber Co.	> 200	500	6.9	0.0	8.0[d]	0.00
14	KB Darco	L. H. Butcher Co.	65% > 200	357	21.2	7.5	17.0	0.00
15	G60	L. H. Butcher Co.	73% > 200	408	18.1	6.0	16.8	0.91
16	Magnechar P120	E. S. Browning Co.	80% > 200	364	8.4	18.3	16.3	Trace
17	Diamond A	Allied Carbons, Ltd.	97% > 200	416	15.4	12.1	14.3	Trace
18	Diamond D	Allied Carbons, Ltd.	70% > 200	730	5.1	11.3	100.0	0.00
19	No. 3A	Allied Carbons, Ltd.	64% > 200	769	5.4	17.7	8.0	0.00
20	No. 3N	Marshall Dill	> 200	714	10.5	15.1	14.6	0.08
21	No. 1N	Marshall Dill	71% > 200	645	5.5	21.5	8.0	0.00
22	Nuchar WW	Braun-Knecht-Heimann Co.	78% > 200	270	8.7	12.4	22.5	0.00
23	C16	Filter Paper Co.	69% > 200	337	10.3	12.5	17.2	Trace
24	C1	Filter Paper Co.	10–60	769	1.1	0.1	5.2[d]	0.00
25	C4	Filter Paper Co.	> 200	384	11.2	29.4	13.6	Basic
26	C17	Filter Paper Co.	18–60	256	5.0	3.3	20.0[f]	0.06
27	No. 5A	Mefford Chemical Co.	< 10	408	4.6	2.4	11.0[f]	0.00

[a] Per cent suspended in nine tenths of volume after 15 hours.
[b] Per cent volume occupied by carbon after 24 hours.
[c] Ml. of 0.1 N NaOH to neutralize 100 ml. of 50 per cent alcohol after 10-minute contact with 0.5 gram of charcoal.
[d] Settled immediately.
[e] 0.60 ml. of 0.1 N HCl.
[f] Most of the charcoal settled immediately, but some floated on the surface after repeated shaking.

larger amounts certain charcoals may impart obnoxious tastes. The time of contact appears less important. Kolback and Schwabe (*12*), working with beers, found 1 minute as effective as 10. The long period of contact observed by Dudley (*8*) and Feret (*9*) was probably due to the nonactivated charcoals used.

According to Amiot (*1*), in mixtures of acetic acid and alcohols the absorption of the acetic acid by animal charcoal is reduced at higher alcohol concentration, and the absorption in solutions of the various alcohols varies inversely as the absorption of the alcohol alone. The figures for the relative absorption are probably only approximately what would be expected in a complex mixture such as beverage brandy. The reduction in acidity may be due either to direct absorption by the charcoal or to neutralization by alkaline impurities. Bogojawlenskij and Humnicki (*4*) and Caspe (*7*) found that the acids in crude spirits were neutralized by alkaline properties of the charcoal. Since the charcoals removed very little ethyl acetate, the loss in acid was probably due to neutralization by impurities. This is probable because: (*a*) The common acetate ion of the two should favor greater absorption of ethyl acetate; and (*b*) the higher molecular weight of ethyl acetate should favor its greater absorption. According to Reif and von der Heide (*18*) and Zaharia, Angelescu, and Motoc (*23*) acetic acid, the chief acid in newly distilled spirits, is absorbed less by activated charcoal than are homologous higher-molecular-weight acids; furthermore, absorption decreased rapidly as the alcohol content is increased up to 40 or 50 per cent. In treating high-acid spirits, greatest removal would be effected at lowest proofs.

Only small amounts of ester or acetaldehyde were removed by the charcoals, but considerable furfural was absorbed by some of the charcoals. According to Dudley (*8*) and Bogojawlenskij and Humnicki (*4*), furfural was completely removed by somewhat larger amounts of charcoal; but Cafere (*6*) obtained only a 27 per cent loss using 0.5 gram per 100 ml. Practically no fusel oil was removed, and further experiments on fusel oils are given later. Several of the carbons removed over 50 per cent of the tannin. In general, the same charcoals that removed the least furfural removed the least tannin. Tannin was determined by the Rosenblatt and Peluso procedure (*19*).

EXPERIMENTS ON BRANDY

The removals of chemical constituents from California beverage brandy are shown in Table III. Since the brandy contained only about half as much total acid as the prepared solutions, there was, in most cases, a much larger percentage removal; and in fifteen cases the actual grams of acid removed from the brandy was as great or greater. Absorption of acid is not a simple process depending solely on the concentration of acid. Brandy 2, which contained only one fourth as much fusel oil, lost slightly larger amounts of acid in all but four cases, although Amiot (*1*) found higher alcohols to reduce the absorption of acid. The high removal of non-

TABLE II. PER CENT LOSS OF ACID, ESTER, ALDEHYDE, FURFURAL, HIGHER ALCOHOLS, AND TANNIN FROM 50 PER CENT ALCOHOL SOLUTIONS TREATED WITH CHARCOALS[a]

Charcoal No.	Acetic Acid	Ethyl Acetate	Acetaldehyde	Furfural	Higher Alcohols	Tannin
1	2.18	0.10	0.13	0.98	1.45	1.2
2	1.05	0.10	2.60	21.82	1.97	39.3
3	22.03	+0.29	1.17	16.50	+1.64	30.3
4	3.52	1.16	0.52	8.82	1.45	15.8
5	16.33	+2.12	0.58	2.94	1.45	3.4
6	33.64	1.36	1.75	27.45	+1.12	29.2
7	1.14	1.26	1.95	2.94	1.45	5.0
8	+7.03	2.92	0.59	0.00	+1.12	2.0
9	3.61	3.23	3.38	55.38	+1.12	67.3
10	2.18	0.00	2.28	52.20	2.43	56.4
11	8.93	0.31	1.82	20.50	1.45	15.9
12	6.08	0.78	2.86	45.86	4.73	53.5
13	2.28	0.10	1.30	29.88	0.92	10.4
14	+4.37	2.24	0.39	7.00	+1.77	74.5
15	1.99	0.19	1.75	36.00	+0.59	75.8
16	1.99	0.83	1.82	34.80	1.45	49.2
17	5.70	+0.19	5.13	38.22	1.97	83.7
18	2.38	0.63	0.26	0.00	0.92	0.6
19	9.68	0.73	0.00	0.00	+1.12	6.4
20	0.95	0.97	4.10	39.00	1.45	75.9
21	9.22	1.15	3.44	8.33	+2.16	3.1
22	3.04	+0.10	4.61	39.44	1.45	67.6
23	1.05	2.72	1.75	61.00	4.73	25.8
24	1.05	0.63	0.00	0.00	0.46	0.6
25	20.70	7.28	2.74	13.48	2.43	22.7
26	2.09	2.29	4.10	3.19	+1.12	8.8

[a] Filtered, untreated samples contained 105.2 mg. acetic acid, 103 mg. ethyl acetate, 15.4 mg. acetaldehyde, 4.08 mg. furfural, 152.2 mg. higher alcohols (made from 4 parts of isoamyl alcohol and 1 part of isobutyl alcohol), or 65.6 mg. tannin (all per 100 ml.): 0.5 gram of each charcoal was used per 100 ml. with 10-minute contact time.

TABLE III. EFFECT OF CHARCOAL TREATMENT ON COMPOSITION AND QUALITY OF CALIFORNIA BRANDY[a]

Charcoal No.	Total Acid[b], % Brandy 1	Total Acid[b], % Brandy 2	Nonvolatile Acid, %, Brandy 2	Esters, %, Brandy 1	Aldehydes, %, Brandy 1	Furfural, %, Brandy 1	Higher Alcohols, %, Brandy 1	Tannin, %, Brandy 1	Color, % Brandy 1	Color, % Brandy 2	Copper, % Brandy 1	Copper, % Brandy 2	Extract, % Brandy 1	Extract, % Brandy 2	Taste Score Brandy 1	Taste Score Brandy 2
1	3.5	5.2	0	4.06	+0.66	2.4	3.0	+1.0	+6	+12	0	0	3.8	+[c]	73[d]	78[d]
2	4.3	5.8	78	2.27	1.24	43.5	3.5	48.8	48	[e]	72	[e]	14.4	12.8	66	[e]
3	38.2	42.0	90	1.12	1.57	12.8	1.5	29.7	37	[e]	80	[e]	3.0	7.5	68	[e]
4	7.1	9.9	73	1.83	2.23	3.4	1.5	24.4	31	50	62	57	3.7	2.8	74	75
5	24.7	19.1	75	1.83	+0.17	29.7	+1.5	4.3	+6	5	23	55	+	+	74	70
6	50.8	38.9	73	2.27	1.65	61.5	2.0	54.5	68	77	62	89	+	1.5	73	74
7	2.0	3.0	71	4.65	0.99	10.0	3.5	1.4	+4	+11	0	6	+	+	74	76
8	+15.7	+16.1	73	1.71	0.33	6.9	1.0	+2.4	5	6	0	18	1.2	+	73	79
9	17.7	19.5	90	6.38	5.60	58.5	0.5	68.5	77	84	62	94	21.7	19.3	72	75
10	12.0	14.1	64	0.06	1.90	55.5	3.0	62.2	86	89	0	0	19.9	19.6	74	75
11	15.3	14.1	46	0.06	4.28	36.1	6.6	49.3	31	44	15	39	1.8	2.6	73	77
12	19.4	28.4	88	6.38	3.38	29.4	1.0	68.5	64	63	62	78	17.9	15.9	72	75
13	4.7	6.0	82	6.30	3.55	27.3	7.6	12.4	3	10	0	25	1.5	4.6	73	78
14	+0.6	+2.8	46	3.03	1.65	45.4	2.0	66.5	90	91	54	68	20.3	21.6	71	74
15	13.3	14.9	55	2.27	1.81	30.2	6.1	82.8	89	90	49	75	28.4	29.0	72	74
16	12.8	13.7	85	2.27	0.83	52.0	+2.0	57.0	76	88	23	45	22.0	21.6	73	75
17	19.0	19.9	83	3.92	1.65	33.9	3.5	81.3	93	92	69	89	11.3	15.9	72	77
18	4.3	3.5	38	3.27	0.17	29.4	5.1	+1.4	+8	+22	0	15	+	+	73	76
19	4.9	5.8	27	1.71	0.17	45.5	6.6	7.2	27	+ 3	10	23	..	0.3	73	75
20	9.6	13.1	59	2.30	5.94	31.5	2.5	84.6	93	94	80	79	27.3	22.2	73	74
21	16.9	16.9	50	0.53	1.98	36.1	+1.0	3.4	7	+ 4	23	52	+	+	74	75
22	14.1	17.3	64	3.92	1.57	51.3	2.0	68.0	83	83	80	94	27.2	25.1	73	72
23	9.6	11.3	82	4.65	2.47	58.7	2.0	62.2	67	80	62	43	21.8	21.9	73	75
24	0.0	2.2	0	0.18	4.45	11.8	5.1	+0.5	17	7	0	9	+	1.7	73	77
25	24.7	44.1	79	4.65	5.19	42.2	+2.0	24.9	10	+31	80	89	+	+	73	76
26	1.4	3.0	66	2.36	4.86	26.5	3.5	1.4	+3	[e]	0	[e]	+	+	69	[e]
27	1.4	1.8	27	1.42	0.70	20.9	6.0	24.8	5	6	15	29	..	+	73	75

[a] Brandy 1 (90° proof) before treatment contained 51.0 mg. acid as acetic, 33.98 mg. esters as ethyl acetate, 12.12 mg. aldehyde as acetaldehyde, 0.593 mg. furfural, 198 mg. higher alcohol, 20.9 mg. tannin, 128.3 mg. extract, and 0.065 mg. copper (all per 100 ml.). Brandy 2 (100° proof) contained 49.6 mg. acid as acetic, 9.2 mg. nonvolatile acid as acetic, 0.235 mg. copper, and 65.4 mg. extract (all per 100 ml.).

[b] Per cent loss in each case except for taste scores.

[c] Extract losses are only approximate, since it was difficult to remove all of the charcoal by filtration. Determinations marked + indicate that sufficient charcoal came through the filter to increase the extract content.

[d] The taste score on untreated brandy 1 was 73, and on brandy 2, 75.

[e] Brandy 1 treated with charcoals 2, 3, and 26 had a bad off-taste, and these charcoals were not used in brandy 2.

volatile acids from brandy 2 indicates that acids of higher molecular weight than acetic are apparently selectively absorbed. Since the acid contents of these brandies are normal, charcoals that remove the least acid should be used.

As in the alcoholic solutions, only small amounts of esters and aldehydes were removed from the brandy. Cafere (*6*) obtained an absorption of 10 per cent of the aldehyde and 26 per cent of the esters, using the same concentration of charcoal. Since the ester and aldehyde contents of the brandy are normal, their removal would be undesirable.

Little fusel oil was removed. The excessive higher alcohol content of brandy 1 was its primary defect, and unless this fusel oil concentration could be lowered by charcoal treatment, the brandy will not be materially improved. These results agree with those of Cafere (*6*) who used the same amounts of charcoal, but Bogojawlenskij and Humnicki (*4*) reported a decrease in fusel oil when raw spirits were filtered through charcoals.

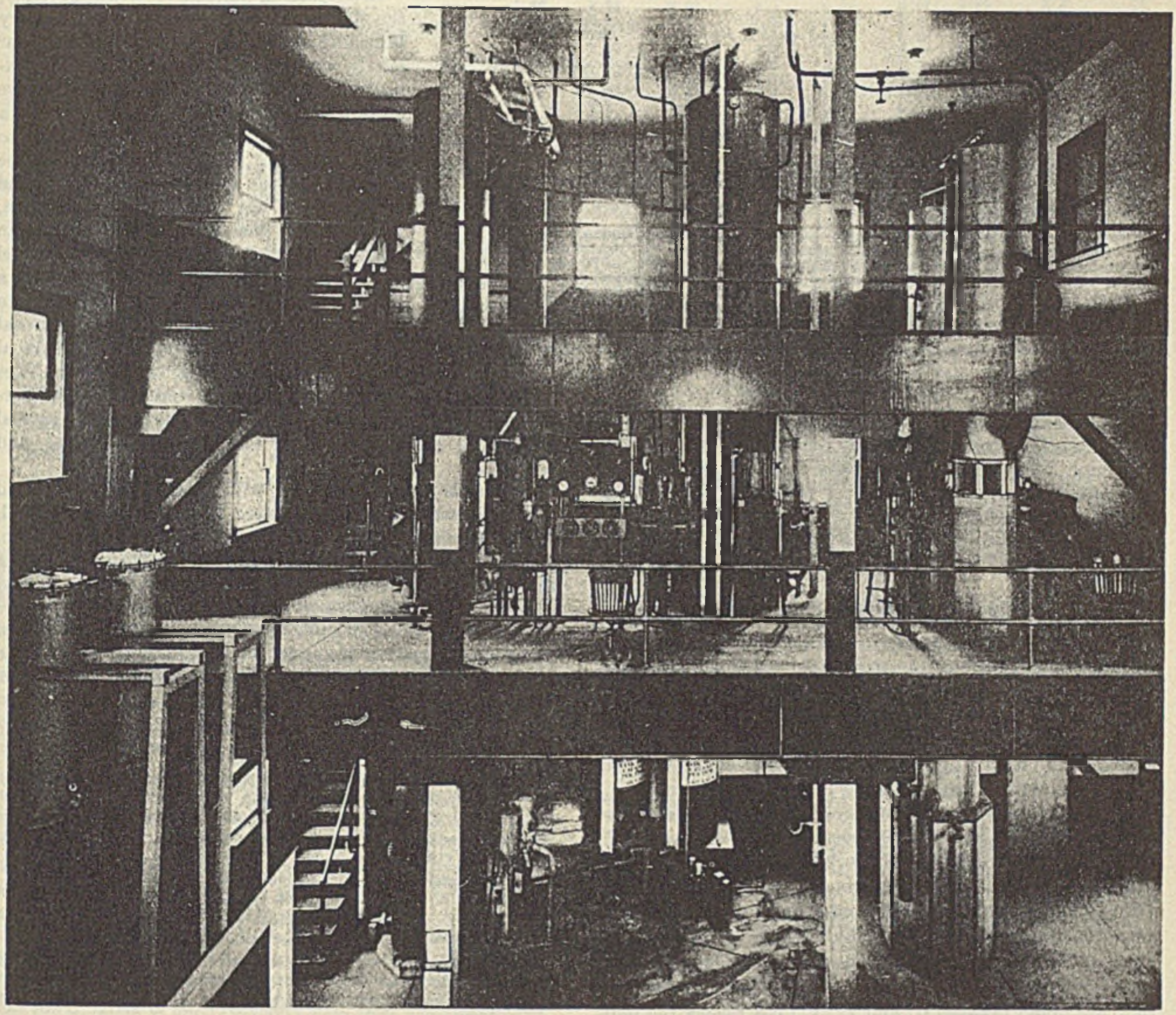
Furfural and tannin removal from brandy 1 is unnecessary, since the amounts present are not excessive. However, certain charcoals will remove large amounts of these two constituents. The per cent removals from the brandy were similar to that from the pure alcohol solutions.

The decolorizing power of different charcoals varies greatly. This property may be tested on caramel or on methylene blue solutions (*13*). Vines (*22*), however, considers such methods as artificial and as sometimes yielding anomalous results. In these tests the decolorizing power was determined by matching the color of the untreated and treated brandies against a standard color. Eastman A. B. C. dyes were separately dissolved in water (0.25 gram in 50 ml.); aliquots (1.1 ml. of the red, 1.0 ml. of the yellow, and 0.2 ml. of the blue for brandy 1, and 0.8, 1.0, and 0.3 ml., respectively, for brandy 2) were mixed and diluted to 100 ml. volume. An apparent increase in color was obtained in a few cases because very fine particles of the carbon were suspended in the treated brandy after filter-paper filtration. The percentage of color removed was similar for the two brandies, but the figures do not necessarily reveal the relative merits of the carbons in removing foreign colors. Brandy 2 had a slight greenish coloration, and in some cases its color was improved. Such offcolorations can be corrected only by experimenting with various charcoals.

The extract content (roughly the soluble solids) was determined before and after charcoal treatment for both brandies. The removal from either of the two brandies was small and of the same order of magnitude. In some cases it was impossible to secure accurate extract-removal data because of the difficulty in removing the finer charcoal particles by filtration.

The two brandies had 0.65 and 2.35 mg. per liter of copper. Tolbert (*21*) found in twenty-eight commercial California brandies from 0.20 to 7.0 mg. per liter (average 1.54); and in thirty 4-year-old brandies, whose preparation and aging were controlled by this laboratory so that there had been no known copper contamination, 0.20 to 0.50 mg. per liter. The Marsh procedure (*15*) was used for determining copper. The charcoal treatment markedly reduced the copper content of the two brandies except in a few cases. More copper was removed from brandy 2, as the low concentration of copper in brandy 1 was apparently a limiting factor in its removal by certain of the charcoals. Some of the undesirable metallic taste and dark green color of brandy 2 was probably due partially to its high copper content and also to a high iron content. Addition of iron sulfate in amounts of 2.5 to 5 mg. per liter markedly increased the greenish-black color. Per cent removal of iron from brandy 2 was approximately similar to the removal of copper.

The most sought-for improvement of charcoal treatment is in the palatability of the brandies. Mathieu (*16*) in reviewing the literature reports that the charcoal treatment removed many off-odors and off-tastes. Blind organoleptic examination of the treated and untreated samples were made, using a simple scoring system that did not take into account changes in color. The tasting was done several days after treatment to allow the brandy to recover partially from the severe oxidized or aerated taste that results from charcoal treatment. Brandy 1 was an ordinary unaged California brandy, particularly high in fusel oil. None of its treated samples were found to be improved on account of this predominative organoleptic effect. Charcoal 2 imparted a moldy smell, and charcoals 3 and 26 a kerosene or resin smell



Courtesy, Padre Vineyard Company

Modern Control Room in a California Brandy Distillery

TABLE IV. PERCENTAGE LOSS IN HIGHER ALCOHOL CONTENT OF PURE SOLUTIONS AND BRANDY WHEN LARGER AMOUNTS OF CHARCOAL ARE USED[a]

Charcoal No.	Amount Used, G./100 Ml.	% Loss in Higher Alcohol Content[b] At 0° C.	At 22° C.	At 70° C.	In 94% at 22° C.	2 hr. at 22° C.	Hexyl alcohol[c]	Brandy 1
1	6.0	1.8	7.1	1.5	7.0	3.0	3.8	18.5
5	4.0	3.5	5.8	+1.5	3.0	3.3	3.0	7.5
7	3.0	5.0	16.0[d]	12.3	4.5	17.8	23.8	23.0[d]
8	3.0	..	5.6	..	...	..	..	10.8
13	3.0	14.0	16.7	8.5	6.0	16.5	37.2	26.0
15	3.0	17.0	17.0	10.3	4.5	16.8	38.8	28.1
18	4.0	0.5	1.2	+5.3	4.5	2.3	2.7	10.8
19	4.0	3.0	2.3	2.8	4.5	6.8	7.2	9.3
20	4.0	18.9	16.9	14.3	5.5	17.5	42.7	28.1
21	4.0	0.3	7.1	0.3	4.0	8.3	7.0	17.2
22	3.0	7.3	10.1	4.5	4.5	12.3	26.2	17.5
23	3.0	16.3	13.1	4.5	4.5	15.0	33.5	22.9
24	4.0	0.5	0.5	0.0	3.5	6.5	2.7	5.5
25	4.0	5.8	4.8	+0.3	2.5	5.8	15.0	13.1
27	6.0	1.0	4.7	+0.3	5.0	4.3	2.3	..

[a] Contact period, 10 minutes unless otherwise noted.
[b] Standard made of 4 parts isoamyl and 1 part isobutyl alcohol; total 200 mg. per 100 ml. in 50 per cent ethyl alcohol unless otherwise noted.
[c] 200 mg. per 100 ml.
[d] Using 4 grams per 100 ml.
[e] This charcoal was recovered from the filter paper and re-used on a new sample, but without drying the charcoal. The process was repeated three times. The rate of absorption of the fusel oil decreased 75 per cent for the first re-use in the 0° C. test, and 50 per cent for the first re-use in the 22° C., 2-hour, and hexyl alcohol tests. The charcoal was nearly ineffective for the second and third re-uses. For the 70° C. and 94 per cent alcohol tests it was nearly ineffective on the first re-use. The maximum absorption capacity of 3 grams of this charcoal of the isoamyl-isobutyl standards is about 23 per cent.

to the brandy. Brandy 2 was a sound California brandy of moderate acid, ester, and aldehyde content and low fusel oil. The odor, however, was burny and woody, and the taste was rather sharp and astringent ("metallic"). Treatment with certain charcoals was effective in improving the organoleptic quality of this brandy. The hot and woody aroma was often reduced, and the taste was less astringent.

REMOVAL OF HIGHER ALCOHOLS

The generally unsatisfactory results of removing fusel oils with 0.5 gram per 100 ml. of charcoal led to further tests using larger amounts of charcoal, different temperatures, and other methods of treatment (Tables II and IV). Increasing the amount of charcoal from 0.5 to 3.0 or 4.0 grams per 100 ml. increased the percentage absorption in most cases, but still the fusel-oil removal was not great enough to be profitable.

Zaharia, Angelescu, and Motoc (*23*) obtained better absorption of fusel oil at lower concentrations of ethyl alcohol; and Amiot (*1*) reported that ethyl alcohol only slightly influenced the absorption of the alcohols by animal charcoal. In this study, increasing the percentage of ethyl alcohol in which the fusel oil was dissolved from 50 to 94 per cent reduced the fusel oil absorption except with four charcoals, where the absorption was small. Little difference in absorption was noted between 0° and 22° C., but raising the temperature to 70° C. reduced the absorption in all cases, except one. Running the hot distillate directly through charcoal filters will therefore probably be less effective in removing higher alcohols than cooling and cutting with water before filtering. Increasing the period of contact to 2 hours, with continuous mechanical shaking, did not materially change the percentage absorption of fusel oils except with charcoal 24.

The tests with larger amounts of charcoal were repeated on the high fusel oil brandy 1 (Tables III and IV). Some increases in the absorption were obtained in all but one case, and the taste scores were also improved. Charcoals 5, 13, 21, and 25 used in these large amounts communicated pronounced off-tastes of unknown source to the brandy.

Considerably more fusel oil was removed from the brandy than from the isoamyl-isobutyl alcohol standards. A much larger percentage of higher alcohol was removed from a hexyl alcohol standard than from an isoamyl-isobutyl standard. Fusel oil removal from brandy by charcoals, therefore, appears subject to variation, depending on the type of higher alcohols present.

COMMERCIAL APPLICATION

In purchasing charcoal for treating brandy, the distiller should be guided by preliminary tests with several charcoals on the particular lot of brandy to be treated. A more expensive charcoal may be the least expensive if its efficiency is greater. Treatment of a spirit for fusel oil removal alone is likely to be impractical, as better results can be obtained more economically by careful separation of the tails during distillation. The same is true of color where one can carefully control the addition of caramel sirup. If, however, the brandy picks up a green or dark coloration, perhaps owing to contamination with metals, then charcoal treatment has a definite value. Charcoal may also improve harsh or rough brandies by removing some of the tannin and furfural. The removal of these constituents from normal brandy is undesirable, since they impart character and body.

In general these results agree with Dietrich (*10*) who found that the quantities of acids, esters, higher alcohols, furfural, and aldehydes should be controlled by proper distillation. However, the charcoal treatments are valuable in improving the organoleptic character of brandies that have woody, metallic, or other obnoxious tastes. Charcoal should always be used in the smallest possible amounts, particularly on aged brandies. Excessive amounts of charcoal either remove too much flavor or produce oxidized or off-tastes.

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