Diploma in Oenology Thesis

This is the fourth of a series of papers written by Students of Roseworthy Agricultural College, South Australia.
They are selected from a number of papers submitted and are considered to be most valuable contributions to investigations of the wine industry.
The series will appear exclusively in this Journal, and the publication will extend over several months.

The Influence of Distillation Methods on Brandy Composition

By W. O. Graham, R.D.Oen.

Note: Mr. Graham was awarded the Karl Weidenhofer Prize for the best individual study or project submitted by the Diploma Class for 1939. At the request of the Federal Viticultural Council, the following paper was prepared from the original thesis for presentation before the Viticultural Conference, Adelaide, which was abandoned owing to war conditions.

Introduction.

IN the course for the Diploma of Oenology inaugurated some three years ago at Roseworthy Agricultural College, a very important section of the syllabus is the independent study or research into some problem that the student himself selects. "The main object of these studies"—we are told—"is to encourage and assist students to develop initiative and originality, and essentially to give them practice in the applicaton and practice of technique."

For my study the problem chosen was the effect of modifying methods of distillation on the composition of brandy. I wish to emphasise that pot-still distillation only is dealt with, as no other method produces **genuine** brandy. The composition of successive fractions was determined and compared with that of commercial brandies; also the effects of altering the rate of distillation, and the strength of the wine distilled, were studied.

I am told that various members of the industry who have seen some of the papers prepared by students, as well as the authorities at the college, have thought that this Conference would be interested to hear one of them, and this honour has fallen to me. The actual thesis presented was much too long for this purpose, and what I now have the privilege of placing before you is, in fact, a summary of the essentials of the work done and the conclusions arrived at.

The importance of the export trade to the wine industry is well recognised. The overseas market is, however, already saturated, and the present crisis has tended to make winemakers look for other avenues as brandy making to relieve the situation. The production of brandy has been increasing rapidly during the last few years, and it will probably continue to do so while markets can be found for it.

Though certain relationships between composition and quality must exist, little is known regarding them, and it was hoped that this study might throw some light on them. A second consideration of practical importance is that certain importing countries require a brandy containing not less than 60 parts of esters as ethyl acetate per 100,000 parts of absolute alcohol. This is, of course, doubtful proof of maturity, but it is a definite requirement and demands consideration. It was with these facts in mind that the problem was chosen for study.

It is necessary at the outset to emphasise that the investigations concern methods of distillation only, that is, to study the changes brought about by different distillation procedures with the object of obtaining the best brandy from a given wine. It might also be mentioned that the time available for this study is limited and the work had to be restricted accordingly. While it is believed that the secondary alcohols have an important influence on the quality of brandy, their analytical estimation is a matter of considerable uncertainty; the determinations are time-consuming and the methods available give sometimes conflicting results. It was therefore regretfully decided to omit this determination and confine attention to those secondary constituents whose estimation could be carried out with reasonable accuracy and in the time available.

Literature.

From an extensive survey of the literature detailed in the original paper the following points might be mentioned as they bear directly on the work done.

First, French brandy is distilled at a considerably lower strength than ours, viz., at approximately 20 O.P., whereas Australian brandies are distilled at 35 to 40 O.P. This is due mainly to a lower original wine strength in France, but also to differences in the methods of distillation and the construction of the still. It is well known that low strength distillation produces brandies containing more secondary constituents.

Second, the rate of distillation is much slower in France. According to authorities, a still having a capacity of 220 gallons requires 16-18 hours for complete distillation, whereas under Australian conditions a 2,000 gallon charge takes only 30 to 40 hours. It is generally accepted (1) that slow distillation gives a more selective separation of the secondary constituents. The distribution of these constituents is, in fact, governed by two principal factors:—(a) their respective volatilities, and (b) their respective miscibilities in water-alcohol mixtures of different strengths, a factor that varies with the percentage of alcohol in the distillate. The importance of this second factor is not sufficiently appreciated; (2) it accounts not only for wide differences in the amounts of secondary constituents in spirits distilled at different strengths, but also in their nature or composition. Unfortunately, as mentioned above, suitable analytical methods for examining these differences are not available.

Third, the practice followed in separating the heads and tails is the most important factor governing the final composition of the brandy, and in this regard French distillers operate on very different lines. In Australia a comparatively large head fraction, representing as much as 20 per cent. of the brandy running, is allowed, whereas in France a very small head fraction representing about 5 per cent. of the brandy running is separated (3). Further, heads are mixed with the following charge of low wines or brouillis, although I have been informed that, in the distillation of Cognac, this is not always the case. The strength of the brandy run is about 40 O.P. at the beginning and falls to a little below 10 U.P. before separating the tail fraction, and the resulting brandy varies from about 15 to 26 O.P. According to Rocques (3) the tail fraction is generally mixed with the wine distilled later. However, when the wine is rich in alcohol, many distillers divide it into fractions—the part showing from about 10 U.P. to 65 U.P. is mixed with the low wines or brouillis, and the part showing 65 U.P. to 100 U.P., with the next charge of the wine to be distilled. Such a procedure of returning, in whole or in part, the head and tail fractions to the following charge of wine or low wines must have a very marked effect on the composition of the distillate. The exact time at which changes are made depends to some extent upon the judgment of the distiller—nose and palate being the accepted guides—but according to Rocques (3), French distillers usually begin the separation of the tail fraction at a strength of about 50 per cent. alcohol by volume or slightly higher, that is, at about 10 U.P.

The direct-fired pot stills used so widely in France are also reported to increase the quantity of secondary constituents, though some authorities doubt this. Another factor bearing on final composition is the changes that occur during storage, and which it is generally stated in the literature, consist of an increase in esters, aldehydes and acids (both fixed and volatile) while such substances as resins, gums and tannins are extracted from the wood, and are in part responsible for the improvement and mellowing of the spirit.

However, whatever the modifications in the composition of the brandy occurring during maturation, there must be in the newly-distilled spirit some optimum amount of secondary constituents which will give a final product of highest quality for the type of wine from which it was distilled, and it is important to know how to modify the composition, and the effects of variations in distillation procedure.

In the college laboratory records there are results of analysis of about 50 Australian brandies, and these show that groups of samples of apparently the same origin contain similar quantities of secondary constituents. This further shows that the method of distillation has a very important bearing upon the composition of the distillate, and that, with systematised distillation methods, standards of composition to give the highest quality product should be able to be laid down.

Experimental.

In view of the foregoing, which represents a summary of an extensive literature review the experimental work was planned as follows:—

Part I.—The Composition of Representative Commercial Brandies.

Part II.—A Study of the Variations in the Composition of Brandies made under selected experimental conditions.

Part I.

Twelve commercial brandies were kindly supplied by different distillers and these were analysed for esters, aldehydes, volatile and total acids. The results are shown in Table I.

Table I.—Composition of Commercial Brandies.

Sample No.	Age (Years).	Strength.	Esters as Grms. Ethyl acetate 100,000 Parts Abs.	Aldehydes as Grms. Acet aldehyde 100,000 Parts Abs.	Vol. Acids as G. acetic acid 100,000 Parts Abs. Alc.	Total Acids as grs. acetic acid 100,000 Parts Abs. Alc.
1	1	35.6 O.P.	37.4	7.5	9.0	9.1
2	3	34.3 O.P.	30.5	9.8	34.6	41.9
3	5	32.5 O.P.	47.5	33.4	25.2	37.7
4	1	27.7 O.P.	45.0	5.2	15.1	15.2
5	5	23.5 U.P.	58.5	22.0	64.0	102.9
6	2	10.0 O.P.	34.5	79.2	36.0	218
7	7	17.0 U.P.	74.0	15.0	61.7	97.3
8	20 av	17.5 U.P.	94.0	20.4	79.2	127
9	1	4.2 O.P.	22.0	13.7	19.2	32.3
10	4	5.5 O.P.	38.0	18.0	44.8	66.1
11	3	33.0 U.P.	163.0	26.4	110.6	175
12	(Cognac)	21.9 U.P.	90.0	24.7	74.1	117

Discussion:

It is to be noted that there is a very marked variation in composition, and this variation is to some extent proportional to age. The young brandies are very low in esters, which increase due to the esterification of acids and alcohols, the latter also being oxidised to aldehyde, which increases with age. Volatile acids also increase due to the further oxidation of the aldehydes to acids. Total acids increase due to the substances extracted from the wood, as well as to the increased volatile acidity. It is to be noticed that the total acidity of the young brandies is practically the same as the volatile acidity, that is, the whole of the acidity is volatile acidity. In the older samples the total acidity is very much greater due to substances extracted from the wood, and as a rule the older the brandy the greater this acidity. There also appears to be some relationship between the ester content and the volatile acidity, those samples having a relatively high volatile acidity are also high in esters.

There are marked differences in nose and palate, samples Nos. 8 and 12 being by far the best quality brandies. It is significant that both have a large quantity of secondary constituents and that they occur in approximately the same proportions. However, both are old brandies, and their composition cannot be very well compared with that of the young brandies. Sample No. 11 has an abnormal volatile acidity which suggests that the wine from which it was distilled was slightly pricked. Samples 1, 2 and 3, low in secondary constituents, were of poor quality and definitely lacked character. Of the remainder Nos. 9 and 10 were of quite good quality but very neutral, and would not benefit by age as had Nos. 8 and 12. The average results, omitting Nos. 8, 11, and 12 for the reasons given above, are given in Table II., and may be regarded, for the purposes of comparison, as representative of average Australian brandy.

Table II.—Average Composition of Brandies.
(Expressed in parts per 100,000 of absolute alcohol.)

Esters.	Aldehydes.	Volatile Acids.
42.7	15.6	34.4

Comparison of these figures with published analyses of French brandies (5, 6) shows that the latter contain a greater proportion of secondary constituents and this is doubtless an important factor governing their improvement in quality during ageing.

Definite conclusions cannot be drawn, but the results show that the average Australian brandy is low in secondary constituents, especially esters.

(TO BE CONTINUED)

Australian Wine Shipments in War-Time

Uncertainty of Future Shipments.

IN an article in a British trade newspaper, H. E. Laffer (Overseas Representative, Australian Wine Board), says that seaborne traffic must of necessity cause considerable anxiety, not to say difficulty, so long as the present war lasts, while non-essential commodities must concede priority to those upon which the safety and food of the people of Great Britain depend. From Australia will come vast stores of wheat, wool, meat, butter, etc., representing foodstuffs and textiles, while additionally, munitions of war will occupy a great deal of the shipping space available.

Wine is not among the commodities in the list of priority issued by the British Government, and therefore it must take its chance when space may be available from time to time.

At the end of July, the last figures issued by the Board of Trade showed that bonded stock in the United Kingdom totalled 2,729,000 gallons, of which only 700,000 gallons was held by shippers' agents—the balance being in the hands of merchants. In the early weeks subsequent to the declaration of war with Germany, merchants, naturally anxious to safeguard their supplies, eagerly bought up all stock in agents' hands. Thus, it could be assured that supplies were sufficient for about nine months under normal trading conditions, even if it was impossible to make fresh shipments.

Fortunately the position regarding shipping space in the first months of war was not so difficult as might have been expected. A number of ships with ample space, were available in Australian ports, and every effort has been made to load as much wine as possible. Shipments for the past three months have therefore been greatly in excess of quantities which would normally have been despatched, and approximate to one and three-quarter million gallons.

That the necessities of war determine the port of unloading in the United Kingdom, often far from the intended point, is unfortunate, but so long as wine and other commodities arrive safely, the question of internal transport, even if costly, is a relatively small matter. The question as to who is responsible for the cost of land freight from the point of discharge to the specified port of delivery is a vexed one, and has arisen on several occasions. The responsibility for the deflection of the ships from their normal course is outside the control of either buyer or seller, and may be equally irritating and unfortunate for both parties. Can either gain any advantage by sticking to the strict letter of law or contract? It appears to be a case where mutual agreement to accept the conditions on an amicable basis is the desirable solution.

From approximately the last week in November, no space will be available for wine in ships leaving Australia, that is to say, essential commodities are now filling all holds, and there is no assurance that any more wine will come forward for quite a long time. Stocks in bond, and to arrive, should be sufficient to last at least eighteen months. It should therefore, be clearly understood that the great quantities now on the water are simply an insurance on future requirements, and should be treated as such.

Any shipper or agent who sacrifices stocks just because bonds are full, will probably regret his action later. Every effort will be made to get wine over as and when space may be available, but of this there is no guarantee.

The Australian wine trade in the United Kingdom is in a very different position from that of 1914, when shipments were under three-quarters of a million gallons, but even then it was possible to exert pressure and get space as stocks became depleted.

Wine can be easily stowed, and doubtless some space will be unoccupied from time to time into which a number of casks can be placed. In the meantime, the vital thing is to prosecute the war to a victorious conclusion, and Australia's man-power as well as primary and secondary industries will be devoted to that end in defence of our Empire.

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The Influence of Distillation Methods on Brandy Composition

By W. O. Graham, R.D.Oen.

(Continued from March Issue.)

Part II.

The distillation studies fell into three sections corresponding to the main points raised in the discussion of the literature, viz.,

1. A comparison of the composition of successive fractions obtained during distillation, and the effect of the rate of distillation upon the distribution of the secondary consituents amongst the fractions of the distillate.
2. A comparison of the composition of the "brandy" fraction as obtained by separation of the heads and tails by French methods with that obtained by local methods.
3. Other factors affecting the ester content,—the study of which was an important objective in this work,—were investigated, viz.
   (a) The relationship between the volatile acidity of a wine and the ester content of the spirit distilled from it.
   (b) Changes in ester content during storage.

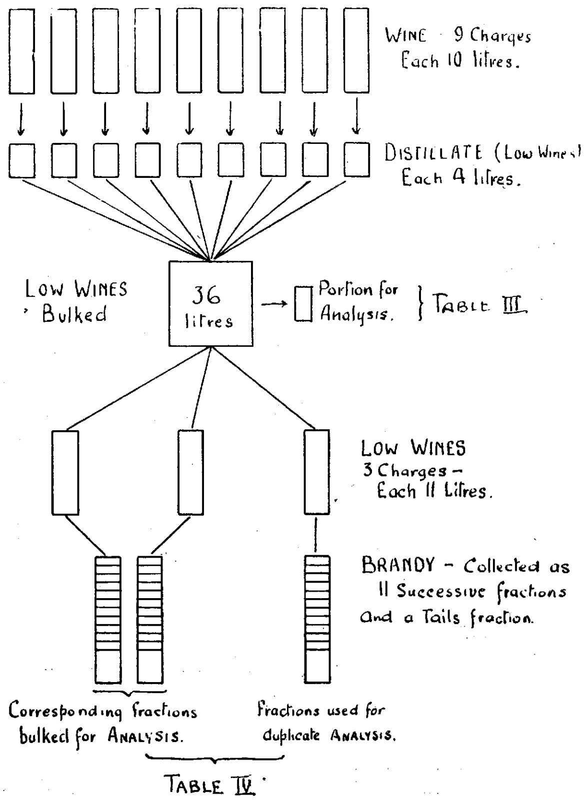
The Still.—The still used was a two-gallon copper pot. It was heated by means of a 3-heat electric element to ensure accurate control and reproducibility, and, in order to show the effects of distillation at different rates, some were made at full heat or "high" and others at low heat or "low."

The Wine.—The wine used was a 1938 Sultana, containing 21.1 per cent. P.S. and having a volatile acidity of 1.2 grms acetic acid/litre.

Section I.—A Comparison of the Composition of Successive Fractions obtained during Distillation, and the Effect of varying the Rate of Distillation.

The plan of the experimental work, for the sake of clarity, is shown diagrammatically.

Low Wines.—Nine distillations were made at a rapid rate (about 2½ hours per charge), the amount of each charge being 10 litres. The wine distillates of 4 litres each were bulked giving 36 litres of low wines. The composition of these and the low wines obtained in a similar



Flow Diagram, showing the Plan of the Distillations of Section I.

way by slow distillation (about 13½ hours per charge), are given in Table III.

Table III.—Composition of Low Wines from High and Low Speed Distillations.

Particulars.	Rapid.	Slow.
Duration of Distillation	2 hours 25 minutes	13 hours 35 minutes
Strength of the Distillate	43.5% P.S.	48.3% P.S.
Analysis of the low wines		
(1) Esters (as grms ethyl acetate /100,000 parts abs. alc.)	182	191
(2) Aldehydes (as grms. acetaldehydes/100,000 parts abs. alc.)	26.3	27.4
(3) Volatile acids (as grms acetic acid/100,000 parts abs. alc.)	27.0	19.2

Brandy.—The 36 litres of low wines, after removal of 3 litres for analysis (Table II.), were divided into 3 charges of 11 litres each, and each was distilled separately, the (brandy) distillate being divided into 11 fractions of 400 mls each, and one large fraction of tails. Corresponding fractions from distillations 1 and 2 were bulked, making 11 fractions of 800 mls each, and one fraction of tails. The third charge was kept separate and treated as a duplicate. The time for each fraction to distil was recorded. Both series of fractions were analysed for esters, aldehydes and volatile acids after determining the alcoholic strength. The results of analysis of the first series only are shown in Table IV. Those of the duplicate series agreed almost exactly with the figures given.

Low Speed Distillations.—For these the same materials were used but

(a) Six distillations (instead of nine as before) were made in a similar manner and

(b) The electric hot-plate was run on "low" instead of "high" to give a slower rate of distillation.

The time for the completion of each distillation was noted. The distillates were bulked, and two charges separated as before, the remainder being analysed as in the previous section. The results of the analysis are shown in Table III. The charges of low wines were redistilled separately, each (brandy) distillate being divided into fractions as before. The results of the analysis of one of the series of fractions are shown in Table IV.

Discussion of Results.

Low Wines.—The ester content of the low wines (Table III.) obtained by slow distillation is significantly higher than that of the distillate obtained by rapid distillation. This is probably due to the formation of esters during the longer boiling in the pot, and the results discussed later in this paper may offer some explanation. The difference between the aldehyde contents is insignificant. The lower volatile acidity of the low wines is explained in a later paragraph.

"Brandy" Distillate.—The difference in the rates of the rapid and slow distillations (Table IV.) is very considerable, being in the ratio of at least 1 : 5, so that any effect on the distribution of secondary constituents due to varying the rate of distillation should be shown by the results. The graphs show the distribution of alcohol, esters, aldehydes, and volatile acids in the fractions of this distillate, and the effect of the rate of distillation on their distribution.

Each constituent is dealt with separately hereunder:—

1. **Alcohol** (V. Graph and Table IV.).—By rapid distillation the strength of the distillate remains fairly constant for the first part of the distillation, but after the 5th fraction, the strength drops gradually in increasing amounts. When distilling slowly the strength falls gradually from beginning to end in increasing amounts. Thus when distilling slowly the temperature in the still will increase gradually, the volatile constituents will distil over more uniformly, and their separation should be more marked. The lower strength of the fractions by the slow distillations is due to the combined effects of the more efficient rectification by the still column and to the lower strength of the wines.

2. **Esters** (V. Graph and Table IV.).—The results obtained here are very striking and explain much of the difference in ester content between Australian and French brandies. By rapid distillation there is a sharp decrease in esters from the first to the fifth fractions, but from the fifth to the tenth fractions, the change is not appreciable.

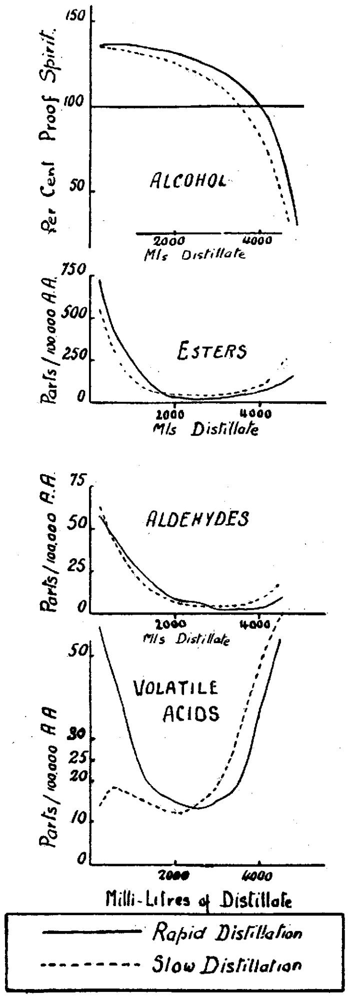
According to Australian methods of separating heads and tails, fractions 1 to 3 and possibly 4 would be separated as heads, while fractions 10 and 11, owing to their low strength, would most probably be included in the tails. This leaves fractions 5 to 9 (inclusive) as representing the "brandy" fraction. The average ester content of this would then be about 37, which is not high enough to satisfy the customs authorities of certain importing countries.

Table IV.—Effect of Rate of Distillation on Composition of Successive Fractions of the Brandy Distillate.

	High Speed Distillation.						Low Speed Distillation.				
Fraction No.	Strength % Proof.	Time to Distil. Minutes.	Esters.	Aldehydes.	Volatile Acids.		Strength % Proof.	Time to Distil. Minutes.	Esters.	Aldehydes.	Volatile Acids.
1	136.0	8	735	57.6	47.7	..	135.1	38	559	64.0	14.0
2	136.8	8	400	44.5	44.4	..	133.8	44	282	41.7	18.4
3	135.9	8	246	31.0	28.9	..	131.7	41	136	25.9	16.4
4	134.4	9	114	19.5	19.7	..	129.5	38	68.4	15.8	14.7
5	131.1	9	53.9	11.7	16.6	..	126.7	42	46.1	8.9	12.7
6	130.0	9	30.5	6.7	14.3	..	123.4	49	36.9	5.9	12.4
7	126.5	8	27.2	6.1	13.5	..	118.5	55	39.9	4.4	15.1
8	122.3	9	29.4	2.1	15.6	..	111.6	60	46.9	3.8	19.0
9	116.1	10	38.8	2.6	18.5	..	102.9	54	58.1	4.4	27.1
10	106.0	11½	52.7	1.9	26.3	..	90.1	61	74.6	5.6	41.4
11	93.7	13	73.5	3.3	43.3	..	73.1	68	102	7.8	68.7
Tails	30.8	126	123	10.3	28.8	..	22.5	10 Hrs.	271	21.9	43.3

Note: Esters are expressed as grams of ethyl acetate, aldehydes as grams of acetaldehyde, and volatile acids as grams of acetic acid, per 100,000 parts of absolute alcohol.

On consulting the results of analysis of commercial brandies in Table I., it is to be noted that the average ester content of the samples (excluding Nos. 8, 11 and 12, none of which are really typical commercial brandies in Australia) is 42.7, while if brandies in Table I. above 4 years old are omitted, the average for young brandies is 34.5. These figures agree very well with the above figure. The above method of separation is probably a fair indication of Australian methods.



Graph, showing Progressive Changes in the Composition of the Brandy Distillates obtained by Slow and Rapid rates of distillation.

The rate of distillation has a considerable influence on the distribution of the esters throughout the distillate. By the slow process the esters distil more evenly, with the result that the first fractions contain a smaller amount, making the decrease less marked. The value for the middle fractions also is not so low, and consequently the ester content of the brandy fraction obtained by the slow distillation will be higher. The actual value is 46 as compared with 37, obtained by a rapid distillation. However, if a smaller heads fraction were taken as in French practice, this figure would be much higher, especially if the heads fraction from the previous distillation were included in the charge. Also, because of the much longer column of Australian pot-stills, it is probable that separation of an equal head fraction would effect a greater reduction of esters in the brandy than would a French pot-still.

3. **Aldehydes** (V. Graph and Table IV.).—As with esters, there is a sharp decrease in the aldehyde content of the first fractions, but this is somewhat more marked in the slow distillations. There is only a slight fall from the 5th to the 9th fractions, when the aldehyde begins to increase again. Here again the mutual solubilities of alcohol and aldehyde have a pronounced modifying influence on their distribution. However, aldehydes are not as important constituents in brandy as are esters, and their elimination receives more attention. It will be observed that any attempt to eliminate aldehydes will have a considerably greater effect in eliminating esters.

4. **Volatile Acids** (V. Graph and Table IV.).—Great differences due to varying the speed of distillation are noted in the distribution of the volatile acids. By rapid distillation the first fractions are comparatively high in volatile acids, there being a sharp decrease from the first to the fourth fractions, when variations become relatively small. The amount gradually decreases until the seventh fraction, when a slight increase in each fraction becomes noticeable. Marked increases are noticeable towards the end of the distillate. By slow distillation the first fractions show only small amounts of volatile acids. There is a significant rise from the first to the second fraction, while variations from then on are small, except for the latter part of the distillate when marked increases occur. The value for the tails fraction for the slow distillation (Table IV.) is very much greater than that for the rapid distillation, and it may be concluded that, by slowing down the rate of distillation, the volatile acids will tend to concentrate in the tail fractions. This is probably the reason for the difference in volatile acidity of the low wines shown in Table III. As regards esters, the greater concentration of acid in the pot during the slow distillation must assist in their formation, and this probably explains the difference in ester content of the low wines (Table III.).

(TO BE CONTINUED)

"Wine opens the heart, it warms the shy poet hidden in the cage of the ribs," says Christopher Morley. "Wine," he continues, "melts the wax in the ears that music may be heard. It takes the terror from the tongue, that truth can be said, or what rhymes marvellously into truth. The soft warm sting on the cheek-bones that a ripe Burgundy gives, is only the thin outward pervasion of a fine heat within, when the cruel secret smoulder of the wit leaps into clear flame; flame that consumes the sorry rubbish of precaution and cajolery. The mind is full of answers. And then, presently, if you have dealt justly with the god, not brutishly, he gives you the most complete answer of all—sleep."

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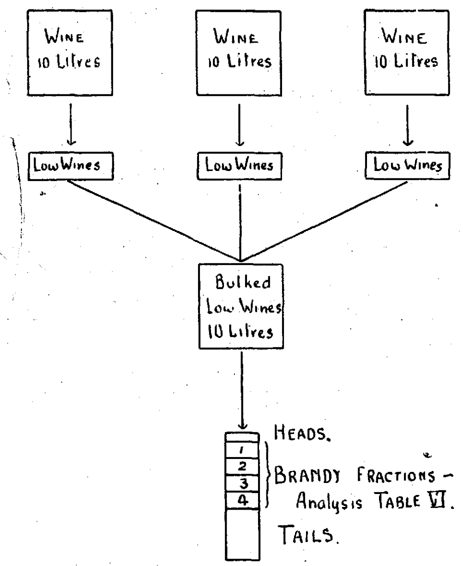
The Influence of Distillation Methods on Brandy Composition

By W. O. Graham, R.D.Oen.

(Continued from April Issue)

Section II.—A Comparison of the Composition of the Brandy Fractions as Obtained by Separation of Heads and Tails According to French Methods with those Obtained by Australian Methods.

The plan of the experimental work is again shown diagrammatically. The same wine was used as in the previous Section (I.), but diluted to a lower strength and left for three weeks to allow the constituents to attain equilibrium.



Flow Diagram, showing the Plan of the Distillations of Section II.

Three distillations of the wine were made, and the low wines were then bulked and redistilled, the distillate being divided into heads, heart and tail fractions according to French procedure as given by Elliott (4). To enable any changes that might occur in the heart or brandy to be followed, it was separated as four successive fractions which were analysed separately.

A comparison of the data given by Elliott and the experimental procedure and results is given in Table V., and from this it may be seen how closely the actual results compare with Elliott's figures, proving that the experimental procedure followed very closely along the lines indicated in the literature.

The results of the analyses of the four fractions into which the brandy or heart was divided are given in Table VI.

Table VI.—Analysis of the Four Brandy Fractions—French Method.

No.	Strength % P.S.	Time to Distil. Minutes.	Esters.	Aldehydes.	Volatile Acids.
1st . .	129.4	80	250	35.2	17.6
2nd . .	121.2	91	42.9	10.9	19.3
3rd . .	106.0	115	46.1	4.0	29.8
4th . .	71.2	150	89.6	5.1	81.8

Note.—Average strength of fractions 1, 2, 3 and 4 is 106.9% P.S.

Average strength of fractions 1, 2 and 3 only is 118.8% P.S.

According to Elliott fractions 1-4 are included in the brandy, but, when this is done, the strength is only 6.9 O.P. instead of 18.6 O.P. (the strength quoted by him). However, by transferring the 4th fraction to tails, the strength

Table V.—French and Australian Methods Compared.

Particulars.	French Method. (Elliott's Data)	Experimental Method. (Actual procedure and results)
Strength of wine	8% A.A. by weight = 17.31% P.S.	17.26% P.S.
Amount of wine distilled	3 charges of 1,000 litres	3 charges of 10 litres (10,000 ml)
Amount of low wines collected from each distillation	300-350 litres	3.33 litres (3,330 ml)
Strength of low wines	20-24% A.A. by weight = 46.90% P.S. (average)	45.6% P.S.
Amount of low wines distilled	1,000 litres	10 litres (10,000 ml)
Amount of heads	3-5 litres	.04 litres (40 ml)
Brandy fraction	360-380 litres	3.7 litres (3,700 ml)
Strength	60% A.A. by weight = 118.6% P.S.	118.8% P.S.
Time to distil spirit fraction	10-11 hrs.	7¼ hrs.
Tails	200-225 litres	2.125 litres (2,125 ml)
Strength of tails	16-20% A.A. by weight = 38.55% P.S. (average)	37.8% P.S.