October 1951

HOP QUALITY STUDIES

1950 Crop

Oregon Agricultural Experiment Station

in cooperation with

Grain Branch, Production and Marketing Administration, U.S.D.A.

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by

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INTRODUCTION

The 1950 hop quality studies were made with funds as provided for a similar study of the 1949 crop. The four main objectives of the study were: (1) to sample a cross section of the crop, to subject these samples to detailed physical and chemical analyses, and to establish, if possible, the interrelationships between physical and chemical factors of quality; (2) to further investigate and/or devise rapid methods for chemical evaluation of hops; (3) to study and test devices for moisture determination which might be adapted to drier or warehouse use; and (4) to begin preliminary work on hop oil.

The Division of Tobacco, Medicinal and Special Crops, Bureau of Plant Industry, Soils and Agricultural Engineering, assigned G. R. Hoerner, Agent (Plant Pathologist) to assist representatives of the Pacific Coast Headquarters of the Grain Branch, Production and Marketing Administration, in making the physical analyses.

The Department of Agricultural Chemistry, Oregon State College, made the chemical analyses, by or under the direction of D. E. Bullis.

The statistical analyses were made under the direction of Dr. Jerome C. R. Li, Biometrician, Oregon Experiment Station.

The data were analyzed, the results interpreted jointly, and the final report prepared by G. R. Hoerner and D. E. Bullis.

METHODS OF STUDY

The 198 samples used were obtained through cooperation of the Federal-State Hop Inspection Departments of California, Idaho, Oregon and Washington. Samples were drawn from lots at random throughout the season in an effort to obtain a representative cross section of the crop.

Just as in the 1949 crop study, this year's work included a possible 24 classifications. And, as in last year's work, actually there were enough samples in only nine of the 24 classifications for statistical analysis. In three of the nine, a larger number of samples would have been preferable. The following table shows the number and distribution of the hop samples in the several classifications.

DISTRIBUTION OF 1950 CROP COMMERCIAL HOP SAMPLES BY CLASSIFICATION

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS		TOTAL
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND	
CALIFORNIA					64		64
IDAHO					7		7
OREGON	19	6	2		34	18	79
WASHINGTON			26		18		44
TOTALS	19	6	28		123	18	194

In addition to the 194 samples classified in the above table, chemical and physical analyses were made on one sample of hand-picked Idaho Late Clusters, one sample of machine-picked Oregon Brewer's Gold and two samples of machine-picked Oregon Red Vine hops. These data are not included in the statistical analyses for the obvious reason that there were too few samples in those classifications to give significance to the values obtained from them.

The experience on the 1949 crop indicated that the repeated handlings involved in the methods used were responsible for considerable breakage. Preliminary trials on that crop showed an increase in breakage from the core sampler, from the sieving, and from the divider. The cumulative increase in breakage from these items was in the neighborhood of 20 percent. For a further check on this source of error additional trials were run on the 1950 crop.

The following table illustrates the amount of cones broken by mechanical sieving.

AVERAGE PERCENTAGE OF WHOLE CONES

No. Samples	Number of times through sieve			
	1	2	3	4
20	66.2	63.1	60.9	58.8

To eliminate this source of possible error, special three-core samples were drawn from each lot selected. These samples were placed intact in individual polyethylene bags and forwarded immediately to Pacific Coast Headquarters of the Grain Branch, Portland, Oregon, where they were numbered and placed in cold storage for later examination and analysis.

The cutting edge of the core sampler will break some of the cones as it is forced into the bale. To eliminate as much as possible of this error, only the two-inch center lengthwise portion of each core was used in determining the whole cone percentage.

The following table illustrates the difference in the amount of whole cones between the inside and outside core samples.

AVERAGE PERCENTAGE OF WHOLE CONES

No. Samples	Center of Core	Outside of Core
25	64.6	60.1

The three center sections representing each lot were weighed and carefully separated by hand, and then sieved over a 30/64 inch round hole sieve. The hops remaining on top of the sieve were considered as whole cones.

The whole and broken portions were then placed in individual containers and forwarded to D. E. Bullis at Oregon State College, where the chemical analyses were made.

The portions of the cores not used for the whole cone determinations were divided by means of the Bates hop divider into two equal parts. One-half was used for the analyses of leaf and stem, and seed content; the other one-half was used for the physical analyses. The percentages of leaf and stem, and seed were determined by the official Federal-State analytical method at Pacific Coast Headquarters of the Grain Branch.

The other physical analyses were performed in a manner similar to last year, with some changes that will be noted in the discussion immediately following.

PHYSICAL ANALYSES

Physical analyses were made for: percentages of leaf and stem, seed, and whole cones; total discoloration and general appearance; size of cones; color of cones and brilliance of color; damage; amount of lupulin; color and condition of lupulin. Aroma was not considered.

In determining total discoloration and general appearance, damage, amount of lupulin and color and condition of lupulin, an arbitrary descending numerical scale of 1, 2, 3, and 4 was used.

It should be noted that analytical procedure differed in certain particulars from that employed on the 1949 crop, in that each factor was considered separately and that amount of lupulin was determined on a scale of 1 to 4 rather than 0 to 9. It was thought this would simplify and unify procedure and render it more readily applicable by field inspectors.

In making ratings in accordance with the numerical scale referred to above, each sample was roughly divided into two parts so that, in effect, duplicate determinations were made of each sample to determine whether these factors could be applied with a reasonable degree of accuracy.

Since the deviations were never greater than 1, in rating duplicate samples for the physical factors considered, the statistical data are not included in the Appendix of this report.

Summaries of information obtained by physical analyses of the several factors of hop quality under consideration are presented in Text Tables 1 to 21 inclusive.

Table 1, page 11. Two varieties, Fuggles in Oregon and Late Clusters in both Idaho and Oregon, were picked both by hand and machine. The average percent of leaf and stem is shown for each method of picking as well as for each variety regardless of method of picking.

In both states and for both varieties machine-picked samples, on the average, had lower percentages of leaf and stem than hand-picked samples.

Regardless of state of origin or method of picking, the average percent leaf and stem content for the five varieties listed was: Brewer's Gold-2.7, Early Clusters-3.7, Late Clusters-5.4, Red Vines-5.6, and Fuggles-6.0. The average of all varieties for all states was 5.2 percent.

By states, regardless of variety or method of picking, the average leaf and stem content was: Idaho-3.3, Washington-3.6, California-5.2, and Oregon-6.3 percent.

Table 2, page 12. The percentages of samples classified as seedless, semi-seedless and seeded are shown by state and for all states, regardless of variety or method of picking.

The percentages of samples containing 6 percent or less leaf and stem content, which serves as the customary basis of contracts with growers, can readily be determined for individual states and for all states.

Tables 3 to 5 inclusive, page 13, present, in more detail, some of the data shown in Table 1.

Table 6, page 14. The data presented are self-explanatory. They are a summary of all samples, regardless of state of origin, variety or method of picking. Data on the leaf and stem content of samples of the 1949 crop were presented in different form so that direct comparisons are not possible.

Table 7, page 15. Two varieties, Fuggles in Oregon and Late Clusters in both Idaho and Oregon, were picked both by hand and machine. The average percent of seed is shown for each method of picking as well as for each variety, regardless of method of picking.

In Oregon, for both varieties, machine-picked samples had lower average percentages of seed. In Idaho the one hand-picked sample of Late Clusters had an appreciably lower percentage of seed than the seven machine-picked samples.

Regardless of state of origin or method of picking, the average percent seed content for the five varieties listed was: Early Clusters-6.4, Late Clusters-8.2, Red Vines-9.9, Fuggles-17.4, Brewer's Gold-19.3. The average of all varieties for all states was 12.4 percent.

By states, regardless of variety or method of picking, the average seed content was: Idaho-1.8, California-5.3, Washington-6.2, and Oregon-14.6 percent.

Table 8, page 16. A partial summary of seed content by areas of origin in California and Oregon shows the areas from which seedless, semi-seedless and seeded samples were obtained.

A comparison of the average percentages of these three classifications by states as shown by samples used in these studies, with average percentages as shown by the Inspection Service records, indicates that the samples used in the study were reasonably representative.

Numerical ratings, on a descending scale, are indicated as follows:

STATE	SEEDLESS		SEMI-SEEDLESS		SEEDED	
	Q.S.*	I.S.R.*	Q.S.	I.S.R.	Q.S.	I.S.R.
CALIFORNIA	2	1	3	3	2	3
IDAHO	1	2	2	1	4	4
OREGON	4	4	4	4	1	1
WASHINGTON	3	3	1	2	3	2
TOTALS %	30.8	32.4	7.1	10.3	62.1	57.2

* Q.S. refers to Quality Studies data, I.S.R. to Inspection Service records.

The numerical ratings, on the basis of quality studies data of the four states with respect to percentages of the type of hops produced in 1950 as compared with 1949, are indicated as follows:

STATE	SEEDLESS		SEMI-SEEDLESS		SEEDED	
	1949	1950	1949	1950	1949	1950
CALIFORNIA	3	2	4	3	2	2
IDAHO	1	1	1	2	4	4
OREGON	4	4	3	4	1	1
WASHINGTON	2	3	2	1	3	3
TOTALS %	48.9	30.8	7.8	7.1	43.3	62.1

An appreciable increase in the percentages of seeded hops in 1950, as compared with 1949, in all states except California may have been due to more favorable weather for pollination during 1950, which resulted in the formation of more seeds. Comparisons from quality studies data are presented herewith:

STATE	PERCENTAGES OF SEEDED HOPS	
	1949	1950
CALIFORNIA	42.7	42.2
IDAHO	4.8	12.5
OREGON	80.7	95.1
WASHINGTON	15.1	38.6
TOTALS	43.3	62.1

Methods of handling samples in the laboratory make the data on percentages of whole cones more reliable than was the case on the 1949 crop.

Table 9, page 17, shows that in the case of Late Clusters in both Idaho and Oregon a higher percentage of whole cones was obtained in hand-picked samples. The differences, however, were not as great as might be expected. In the case of Oregon Fuggles, however, the larger percentage of whole cones was obtained from machine-picked samples.

The percentage of whole cones, as shown by samples, probably does not accurately represent differences due to method of picking because in instances where breakage due to machine-picking occurs, a considerable amount of the broken portions of the cones never enters the drier. The percentage of whole cones, as shown by samples, probably does, however, represent care in handling after picking.

By states, regardless of variety or method of picking, the average percentages of whole cones were as follows: Washington-69.5, California-68.9, Idaho-65.6, and Oregon-59.9.

By varieties, regardless of state of origin or method of picking, the average percentages of whole cones of the common varieties were as follows: Early Clusters-72.2, Late Clusters-65.5, Fuggles-55.9, and all varieties combined-65.2.

Table 10, page 18, shows in more detail some of the data shown in Table 9.

Table 11, page 18, shows the effect of clean picking (freedom from leaves and stems) on the percentage of whole cones.

Samples with 50 percent or more whole cones compared to leaf and stem content were as follows: 3 percent or less-100 percent of the samples; 4 to 6 percent-91.4 percent of the samples; 7 percent or more-83.5 percent of the samples.

Tables 12 and 13, pages 19 and 20. General appearance was influenced, primarily, by partial discoloration brought about by climatic conditions, such as sunburn and wind whip, resulting in a reddish color of the bracts. Red spider may have been responsible for some reddening of the bracts but no attempt was made to assign definitely the specific cause of the condition, i.e., whether it was due to pests, climatic, or mechanical factors.

Lack of brilliance in cone color adversely affected general appearance. Downy mildew and sooty mould were present in only minor amounts in a very few samples and did not affect total discoloration and general appearance materially. The dull hue may have been due, in part, to methods of handling after picking.

Table 14, page 21. It will be noted that downy mildew was evident only on Late Clusters from Oregon. Sooty mould was evident on samples of Early Clusters from Washington, and on Late Clusters from California, Oregon and Washington.

Table 15, page 22. The data presented are self-explanatory.

Table 16 and 17, pages 23 and 24, pertain to damage, which was slight, regardless of state of origin, variety or method of picking. A comparison with 1949, based on hop quality studies data and expressed in percentages, follows:

STATE	RATING							
	1949				1950			
	1	2	3	4	1	2	3	4
CALIFORNIA	78.0	18.0	3.3	0.7	92.2	6.3	1.5	
IDAHO	100.0				87.5	12.5		
OREGON	92.0	7.4		0.6	95.1	4.9		
WASHINGTON	91.9	5.2	1.7	1.2	97.7	2.3		
TOTALS	88.7	9.0	1.5	0.8	94.4	5.1	0.5	

Tables 18 and 19, pages 25 and 26, pertain to amount of lupulin. The scale of 0 to 9, as used on the 1949 crop, was abandoned and no attempt was made to justify use of the terms "thin" and "fat". As was the case on the 1949 crop, all samples examined showed a considerable amount of lupulin had shaken out and not, in all probability, in equal amount in all samples. Ratings were made upon examination of whole cones and considered relatively representative.

When comparisons are possible, machine-picking seems to have reduced the amount of lupulin as reflected by the comparative percentages of samples in the number 1 rating. It will be of interest to compare the ratings of varieties, regardless of state of origin or method of picking. The ratings of samples by states of origin, regardless of variety or method of picking, are of interest also. Oregon's relatively unfavorable position is due in part to the high percentage of Fuggles and their noticeably low rating in amount of lupulin.

Table 19, page 26, shows in more detail some of the data shown in Table 18. The relatively unfavorable position of samples from the Grants Pass area may be due to immaturity at harvest.

Adequate comparison with 1949 ratings are not possible.

Table 20, page 27. It will be noted a higher rating for color and condition of lupulin of Early Clusters from Washington was given than for samples from Oregon. In the case of Late Clusters ranking by states of origin was: (1) Oregon, (2) Washington, (3) California and Idaho.

By variety, regardless of state of origin, the ranking was: (1) Brewer's Gold, Fuggles and Red Vines, (2) Late Clusters, (3) Early Clusters.

Table 21, page 28, shows the ranking for color and condition of lupulin by areas of origin, regardless of variety, in the states of California and Oregon. Samples from Sacramento were ranked higher than those from Santa Rosa. In Oregon, the order was: (1) Grants Pass, (2) Willamette Valley, (3) Eastern Oregon. The ranking for all areas in the two states was: (1) Grants Pass, (2) Willamette Valley, (3) Sacramento, (4) Santa Rosa, (5) Eastern Oregon.

SUMMARY OF LEAF AND STEM CONTENT

Table 1.

STATE	VARIETY	NO. SAMPLES	HOW PICKED	RANGE IN %	AVERAGE %	ALL SAMPLES AVERAGE %
CALIFORNIA	LATE CLUSTERS	64	MACHINE	1.0 to 12.3	5.2	
IDAHO	LATE CLUSTERS	1	HAND		4.8	
	" "	7	MACHINE	1.6 to 5.8	3.1	
	ALL VARIETIES	8				3.3
OREGON	BREWER'S GOLD	1	MACHINE		2.7	
	EARLY CLUSTERS	2	"	2.3 to 4.3	3.3	
	FUGGLES	6	HAND	5.7 to 8.8	7.2	
	"	19	MACHINE	2.7 to 11.5	5.6	6.0
	LATE CLUSTERS	18	HAND	4.0 to 9.8	7.5	
	" "	34	MACHINE	3.2 to 9.9	6.1	6.6
	RED VINES	2	"	4.6 to 6.6	5.6	
	ALL VARIETIES	82				6.3
WASHINGTON	EARLY CLUSTERS	26	MACHINE	1.6 to 8.2	3.7	
	LATE CLUSTERS	18	"	1.2 to 7.3	3.5	
	ALL VARIETIES	44		1.2 to 8.2		3.6
ALL STATES	BREWER'S GOLD	1	MACHINE		2.7	
	EARLY CLUSTERS	28	"	1.6 to 8.2	3.7	
	FUGGLES	6	HAND	5.7 to 8.8	7.2	
	"	19	MACHINE	2.7 to 11.5	5.6	6.0
	LATE CLUSTERS	19	HAND	4.0 to 9.8	7.4	
	" "	123	MACHINE	1.0 to 12.3	5.1	5.4
	RED VINES	2	"	4.6 to 6.6	5.6	
	ALL VARIETIES	198		1.0 to 12.3		5.2

LEAF AND STEM CONTENT OF SEEDLESS, SEMI-SEEDLESS AND SEEDED HOPS

Table 2.

STATE	TYPE	TOTAL SAMPLES		2% OR LESS		3%		4%		5%		6%		7%		8%		9%		10% OR MORE	
		NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
CALIFORNIA	SEEDLESS	34	53.1	9	26.5	13	38.2	7	20.6			2	5.9	2	5.9			1	2.9		
	SEMI	3	4.7			1	33.3	1	33.3	1	33.3										
	SEEDED	27	42.2	1	3.7	1	3.7	4	14.8	5	18.5	4	14.8	7	26.0	1	3.7	1	3.7	3	11.1
	TOTALS	64		10	15.6	15	23.4	12	18.8	6	9.4	6	9.4	9	14.1	1	1.6	2	3.1	3	4.7
IDAHO	SEEDLESS	6	75.0	2	33.3	2	33.3	1	16.7	1	16.7										
	SEMI	1	12.5	1	100.0																
	SEEDED	1	12.5			1	100.0														
	TOTALS	8		3	37.5	3	37.5	1	12.5	1	12.5										
OREGON	SEEDLESS	3	3.7			1	33.3			2	66.7										
	SEMI	1	1.2									1	100.0								
	SEEDED	78	95.1	4	5.1	4	5.1	10	12.8	15	19.2	14	18.0	18	23.1	6	7.7	6	7.7	1	1.3
	TOTALS	82		4	4.9	5	6.1	10	12.2	17	20.7	15	18.3	18	22.0	6	7.3	6	7.3	1	1.2
WASHINGTON	SEEDLESS	18	40.9	5	27.8	7	38.9	2	11.1	1	5.6	2	11.1	1	5.6						
	SEMI	9	20.5	7	77.8			1	11.1	1	11.1										
	SEEDED	17	38.6	3	17.6	8	47.1	2	11.8	2	11.8	1	5.9			1	5.9				
	TOTALS	44		15	34.1	15	34.1	5	11.4	4	9.1	3	6.8	1	2.3	1	2.3				
ALL STATES	SEEDLESS	61	30.8	16	26.2	23	37.7	10	16.4	4	6.6	4	6.6	3	4.9			1	1.6		
	SEMI	14	7.1	8	57.1	1	7.1	2	14.3	2	14.3	1	7.1								
	SEEDED	123	62.1	8	6.5	14	11.4	16	13.0	22	17.9	19	15.4	25	20.3	8	6.5	7	5.7	4	3.3
	TOTALS	198		32	16.2	38	19.2	28	14.1	28	14.1	24	12.1	28	14.1	8	4.0	8	4.0	4	2.0

METHOD OF PICKING IN RELATION TO LEAF AND STEM CONTENT OF OREGON HOPS

Table 3.

HOW PICKED	SAMPLES		2% OR LESS		3%		4%		5%		6%		7%		8%		9%		10% OR MORE	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
HAND	24	29.3					1	4.2	2	8.3	4	16.7	8	33.3	6	25.0	3	12.5		
MACHINE	58	70.7	4	6.9	5	8.6	9	15.5	15	25.9	11	19.0	10	17.2			2	3.4	2	3.4
TOTALS	82		4	4.9	5	6.1	10	12.2	17	20.7	15	18.3	18	22.0	6	7.3	5	6.1	2	2.4

LEAF AND STEM CONTENT OF OREGON FUGGLES AND LATE CLUSTERS HOPS

Table 4.

VARIETY	SAMPLES		2% OR LESS		3%		4%		5%		6%		7%		8%		9%		10% OR MORE	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
FUGGLES	25	32.5	2	8.0	2	8.0	3	12.0	6	24.0	3	12.0	6	24.0	2	8.0			1	4.0
LATE CLUSTERS	52	67.5			2	3.8	6	11.5	11	21.2	11	21.2	12	23.2	4	7.7	6	11.5		
TOTALS	77		2	2.6	4	5.2	9	11.7	17	22.1	14	18.2	18	23.4	6	7.8	6	7.8	1	1.3

SUMMARY OF LEAF AND STEM CONTENT OF OREGON HOPS BY AREAS OF ORIGIN

Table 5.

AREA	SAMPLES	2% OR LESS	3%	4%	5%	6%	7%	8%	9%	10% OR MORE
EASTERN OREGON	6	1	1		3		1			
GRANTS PASS	11		1	4	4	1		1		
WILLAMETTE VALLEY	65	3	3	6	10	14	16	5	6	2
TOTALS	82	4	5	10	17	15	17	6	6	2

Table 6.

SIZE OF LOTS, IN BALES, IN RELATION TO LEAF AND STEM CONTENT*

PERCENTAGE LEAF AND STEM	SAMPLES		1 TO 49		50 TO 99		100 TO 149		150 TO 199		200 TO 249		250 TO 299		300 TO 349		350 TO 399		400 AND OVER	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
1 TO 2	372	21.2	35	9.4	59	15.9	42	11.3	135	36.3	34	9.1	12	3.2	16	4.3	10	2.7	29	8.0
3 TO 4	675	38.5	122	18.1	135	20.0	110	16.3	139	20.6	64	9.5	24	3.6	18	2.7	15	2.2	48	7.1
5 TO 6	504	28.7	105	20.8	132	26.2	73	14.5	104	20.6	25	5.0	21	4.2	17	3.4	12	2.4	15	3.0
7 AND OVER	203	11.6	50	24.6	50	24.6	30	14.8	32	15.8	19	9.4	8	4.0			4	2.0	10	4.9
TOTALS	1754		312	17.8	376	21.4	255	14.5	410	23.4	142	8.1	65	3.7	51	2.9	41	2.3	102	5.8

* Data based on Hop Inspection Service records of the entire 1950 crop.

Table 7.

SUMMARY OF SEED CONTENT*

STATE	VARIETY	NO. SAMPLES	HOW PICKED	RANGE IN %	AVERAGE %	ALL SAMPLES AVERAGE %
CALIFORNIA	LATE CLUSTERS	64	MACHINE	0.1 to 15.0	5.3	
IDAHO	LATE CLUSTERS	1	HAND		0.3	
	" "	7	MACHINE	0.7 to 7.7	3.3	
	ALL VARIETIES	8				1.8
OREGON	BREWER'S GOLD	1	MACHINE		19.3	
	EARLY CLUSTERS	2	"	10.0 to 13.3	11.7	
	FUGGLES	6	HAND	14.7 to 22.3	18.2	
	"	19	MACHINE	7.3 to 21.0	16.6	17.4
	LATE CLUSTERS	18	HAND	9.0 to 18.0	13.6	
	" "	34	MACHINE	0.5 to 24.6	12.8	13.2
	RED VINES	2	"	8.0 to 11.7	9.9	
	ALL VARIETIES	82				14.6
WASHINGTON	EARLY CLUSTERS	26	MACHINE	0.3 to 19.3	5.9	
	LATE CLUSTERS	18	"	0.5 to 16.8	6.4	
	ALL VARIETIES	44				6.2
ALL STATES	BREWER'S GOLD	1	MACHINE		19.3	
	EARLY CLUSTERS	28	"	0.3 to 19.3	6.4	
	FUGGLES	6	HAND	14.7 to 22.3	18.2	
	"	19	MACHINE	7.3 to 21.0	16.6	17.4
	LATE CLUSTERS	19	HAND	0.3 to 18.0	12.9	
	" "	123	MACHINE	0.1 to 24.6	7.4	8.2
	RED VINES	2	"		9.9	
	ALL VARIETIES	198		0.1 to 24.6		12.4

* Seedless - 3%; Semi-seedless - 6%; Seeded - over 6%

Table 8.

SUMMARY OF SEED CONTENT BY AREAS OF ORIGIN*

STATE	AREA	SAMPLES NO.	SAMPLES %	SEEDLESS NO.	SEEDLESS %	SEMI-SEEDLESS NO.	SEMI-SEEDLESS %	SEEDED NO.	SEEDED %
CALIFORNIA	SACRAMENTO	36	56.3	30	83.3	2	5.6	4	11.1
	SANTA ROSA	28	43.7	4	14.3	1	3.6	23	82.1
OREGON	EASTERN OREGON	6	7.3	3	50.0			3	50.0
	GRANTS PASS	11	13.4					11	100.0
	WILLAMETTE VALLEY	65	79.3			1	1.5	64	98.5
ALL STATES (HOP QUALITY STUDIES)	CALIFORNIA	64	32.3	34	53.1	3	4.7	27	42.2
	IDAHO	8	4.0	6	75.0	1	12.5	1	12.5
	OREGON	82	41.4	3	3.7	1	1.2	78	95.1
	WASHINGTON	44	22.3	18	40.9	9	20.5	17	38.6
	TOTALS	198		61	30.8	14	7.1	123	62.1
ALL STATES (INSPECTION SERVICE)	CALIFORNIA	416	23.7	240	57.7	20	4.8	156	37.5
	IDAHO	36	2.1	18	50.0	16	44.4	2	5.6
	OREGON	568	32.4	13	2.3	14	2.5	541	95.2
	WASHINGTON	734	41.8	298	40.6	131	17.8	305	41.6
	TOTALS	1754		569	32.4	181	10.3	1004	57.2

* Data based on Hop Inspection Service records of the entire 1950 crop

Table 9.

SUMMARY OF WHOLE CONES

STATE	VARIETY	NO. SAMPLES	HOW PICKED	RANGE IN %	AVERAGE %	ALL SAMPLES AVERAGE %
CALIFORNIA	LATE CLUSTERS	64	MACHINE	41 to 86	68.9	
IDAHO	LATE CLUSTERS	1	HAND		78.0	
	" "	7	MACHINE	52 to 78	63.9	
	ALL VARIETIES	8				65.6
OREGON	BREWER'S GOLD	1	MACHINE		80.0	
	EARLY CLUSTERS	2	"	67 to 82	74.5	
	FUGGLES	6	HAND	39 to 66	54.2	
	"	19	MACHINE	36 to 78	56.5	55.9
	LATE CLUSTERS	18	HAND	50 to 74	63.2	
	" "	34	MACHINE	31 to 91	60.2	61.3
	RED VINES	2	"	49 to 52	50.5	
	ALL VARIETIES	82				59.9
WASHINGTON	EARLY CLUSTERS	26	MACHINE	55 to 90	72.0	
	LATE CLUSTERS	18	"	56 to 78	65.9	
	ALL VARIEITIES	44		55 to 90		69.5
ALL STATES	BREWER'S GOLD	1	MACHINE		80.0	
	EARLY CLUSTERS	28	"	55 to 90	72.2	
	FUGGLES	6	HAND	39 to 66	54.2	
	"	19	MACHINE	36 to 78	56.5	55.9
	LATE CLUSTERS	19	HAND	50 to 78	63.9	
	" "	123	MACHINE	31 to 91	65.7	65.5
	RED VINES	2	"	49 to 52	50.5	
	ALL VARIETIES	198		31 to 91		65.2

SUMMARY OF PERCENTAGE OF WHOLE CONES

Table 10.

STATE	SAMPLES		30-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90-94	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
CALIFORNIA	64	32.3					1	1.6	1	1.6	5	7.8	3	4.7	7	10.9	11	17.2	15	23.4	13	20.3	6	9.4	2	3.1		
IDAHO	8	4.0									1	12.5	2	25.0	1	12.5	1	12.5	1	12.5	2	25.0						
OREGON	82	41.4	1	1.2	2	2.4	2	2.4	8	9.8	13	15.9	12	14.6	18	21.9	12	14.6	5	6.1	6	7.3	2	2.4			1	1.2
WASHINGTON	44	22.2											6	13.7	7	15.9	9	20.5	10	22.7	8	18.2	2	4.5	1	2.3	1	2.3
ALL STATES	198		1		2		3		9		19		23		33		33		31		29		10		3		2	

SUMMARY OF EFFECT OF CLEAN PICKING ON WHOLE CONES

Table 11.

PERCENTAGE LEAF AND STEM	SAMPLES		30 TO 39		40 TO 49		50 TO 59		60 TO 69		70 TO 79		80 TO 89		90 TO 99	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
3% OR LESS	69	34.8					10	14.5	22	31.9	26	37.7	11	16.0		
4 TO 6%	81	40.9			7	8.6	17	21.0	30	37.0	23	28.4	2	2.5	2	2.5
7% OR MORE	48	24.2	3	6.3	5	10.4	15	31.3	14	29.2	11	23.0				
TOTALS	198		3	1.5	12	6.1	42	21.2	66	33.3	60	30.3	13	6.6	2	1.0

SUMMARY OF TOTAL DISCOLORATION AND GENERAL APPEARANCE

Table 12.

STATE	VARIETY	NO. SAMPLES	HOW PICKED	NUMERICAL RATING: NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4	ALL SAMPLES % 1	2	3	4
CALIFORNIA	LATE CLUSTERS	64	MACHINE	39	18	7		60.9	28.2	10.9					
IDAHO	LATE CLUSTERS	1	HAND		1				100.0						
	" "	7	MACHINE	7				100.0							
	ALL VARIETIES	8		7	1							87.5	12.5		
OREGON	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	2	"		2				100.0						
	FUGGLES	6	HAND	4	2			66.7	33.3						
	"	19	MACHINE	15	4			78.9	21.1			76.0	24.0		
	LATE CLUSTERS	18	HAND	16	2			88.9	11.1						
	" "	34	MACHINE	26	7	1		76.5	20.6	2.9		80.8	17.3	1.9	
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	82		64	17	1				1.2		78.0	20.8	1.2	
WASHINGTON	EARLY CLUSTERS	26	MACHINE	18	8			69.2	30.8						
	LATE CLUSTERS	18	"	12	6			66.7	33.3						
	ALL VARIETIES	44		30	14							68.2	31.8		
ALL STATES	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	28	"	18	10			64.3	35.7						
	FUGGLES	6	HAND	4	2			66.7	33.3						
	"	19	MACHINE	15	4			78.9	21.1			76.0	24.0		
	LATE CLUSTERS	19	HAND	16	3			84.2	15.8						
	" "	123	MACHINE	84	31	8		68.3	25.2	6.5		70.4	23.9	5.7	
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	198		140	50	8						70.7	25.3	4.0	

Table 13. SUMMARY OF TOTAL DISCOLORATION AND GENERAL APPEARANCE BY AREAS OF ORIGIN

STATE	AREA	NO. SAMPLES	NUMERICAL RATING NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4
CALIFORNIA	SACRAMENTO	36	21	12	3		58.3	33.3	8.3	
	SANTA ROSA	28	18	6	4		64.3	21.4	14.3	
OREGON	EASTERN OREGON	6	5	1			83.3	16.7		
	GRANTS PASS	11	8	3			72.7	27.3		
	WILLAMETTE VALLEY	65	50	14	1		76.9	21.5	1.5	
ALL STATES (HOP QUALITY STUDIES)	CALIFORNIA	64	39	18	7		60.9	28.0		
	IDAHO	8	7	1			87.5	12.5		
	OREGON	82	64	17	1		78.0	20.8	1.2	
	WASHINGTON	44	30	14			68.2	31.8		
	TOTALS	198	140	50	8		70.7	25.3	4.0	

Table 14.

SUMMARY OF CAUSES OF DISCOLORATION

STATE	VARIETY	NO. SAMPLES	HOW PICKED	PERCENT SAMPLES MISCL.*	PERCENT SAMPLES DOWNY MILDEW	PERCENT SAMPLES SOOTY MOULD
CALIFORNIA	LATE CLUSTERS	64	MACHINE	37.5		4.7
IDAHO	LATE CLUSTERS	1	HAND	100.0		
	" "	7	MACHINE			
OREGON	BREWER'S GOLD	1	MACHINE			
	EARLY CLUSTERS	2	"	100.0		
	FUGGLES	6	HAND	33.3		
	"	19	MACHINE	26.3		
	LATE CLUSTERS	18	HAND	5.6	11.1	
	" "	34	MACHINE	32.4	5.9	2.9
	RED VINES	2	"			
WASHINGTON	EARLY CLUSTERS	26	MACHINE			7.7
	LATE CLUSTERS	18	"			22.2
ALL STATES	BREWER'S GOLD	1	MACHINE			
	EARLY CLUSTERS	28	"	71.4		7.1
	FUGGLES	6	HAND	33.3		
	"	19	MACHINE	26.3		
	LATE CLUSTERS	19	HAND	10.5	10.5	
	" "	123	MACHINE	28.5	1.6	6.5
	RED VINES	2	"			

* Reddish discoloration due to climatic conditions, mechanical factors and possibly including some red spider damage.

SUMMARY OF SIZE AND COLOR OF CONES

Table 15.

STATE	VARIETY	NO. SAMPLES	PERCENT SAMPLES: SIZE			PERCENT SAMPLES: COLOR			PERCENT SAMPLES: BRILLIANCE	
			SMALL	MEDIUM	LARGE	GREEN	YELLOW	YELLOW GREEN	DULL	BRIGHT
CALIFORNIA	LATE CLUSTERS	64	14.1	76.5	9.4	50.0	4.7	45.3	57.8	42.2
IDAHO	LATE CLUSTERS	8	12.5	87.5		25.0		75.0	12.5	87.5
OREGON	BREWER'S GOLD	1			100.0			100.0	100.0	
	EARLY CLUSTERS	2		50.0	50.0		50.0	50.0	50.0	50.0
	FUGGLES	25		80.0	20.0	36.0		64.0	76.0	24.0
	LATE CLUSTERS	52	9.6	82.7	7.7	11.5	11.5	76.9	28.8	71.2
	RED VINES	2		100.0				100.0		100.0
WASHINGTON	EARLY CLUSTERS	26	3.8	73.1	23.1	34.6		65.4	26.9	73.1
	LATE CLUSTERS	18	5.6	94.4		44.4		55.6	44.4	55.6
ALL STATES	BREWER'S GOLD	1			100.0			100.0	100.0	
	EARLY CLUSTERS	28	3.6	71.4	25.0	32.1	3.6	64.3	28.6	71.4
	FUGGLES	25		80.0	20.0	36.0		64.0	76.0	24.0
	LATE CLUSTERS	142	11.3	81.7	7.0	33.8	6.3	59.9	42.9	57.1
	RED VINES	2		100.0				100.0		100.0

SUMMARY OF DAMAGE

Table 16.

STATE	VARIETY	NO. SAMPLES	HOW PICKED	NUMERICAL RATING: NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4	ALL SAMPLES % 1	2	3	4
CALIFORNIA	LATE CLUSTERS	64	MACHINE	59	4	1		92.2	6.3	1.5					
	ALL VARIETIES	64		59	4	1						92.2	6.3	1.5	
IDAHO	LATE CLUSTERS	1	HAND		1				100.0						
	" "	7	MACHINE	7				100.0							
	ALL VARIETIES	8		7	1							87.5	12.5		
OREGON	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	2	"	1	1			50.0	50.0						
	FUGGLES	6	HAND	6				100.0							
	"	19	MACHINE	18	1			94.7	5.3			96.0	4.0		
	LATE CLUSTERS	18	HAND	18				100.0							
	" "	34	MACHINE	32	2			94.1	5.9			96.2	3.8		
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	82		78	4							95.1	4.9		
WASHINGTON	EARLY CLUSTERS	26	MACHINE	26				100.0							
	LATE CLUSTERS	18	"	17	1			94.4	5.6						
	ALL VARIETIES	44		43	1							97.7	2.3		
ALL STATES	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	28	"	27	1			96.4	3.6						
	FUGGLES	6	HAND	6				100.0							
	"	19	MACHINE	18	1			94.7	5.3			96.0	4.0		
	LATE CLUSTERS	19	HAND	18	1			94.7	5.3						
	" "	123	MACHINE	115	7	1		93.5	5.7	0.8		93.7	5.6	0.7	
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	198		187	10	1						94.4	5.1	0.5	

SUMMARY OF DAMAGE BY AREAS OF ORIGIN

Table 17.

STATE	AREA	NO. SAMPLES	NUMERICAL RATING NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4
CALIFORNIA	SACRAMENTO	36	35	1			97.2	2.8		
	SANTA ROSA	28	24	3	1		85.7	10.7	3.6	
OREGON	EASTERN OREGON	6	5	1			83.3	16.7		
	GRANTS PASS	11	11				100.0			
	WILLAMETTE VALLEY	65	62	3			95.4	4.6		
ALL STATES (HOP QUALITY STUDIES)	CALIFORNIA	64	59	4	1		92.2	6.3	1.5	
	IDAHO	8	7	1			87.5	12.5		
	OREGON	82	78	4			95.1	4.9		
	WASHINGTON	44	43	1			97.7	2.3		
	TOTALS	198	187	10	1		94.4	5.1	0.5	

SUMMARY OF AMOUNT OF LUPULIN

Table 18.

STATE	VARIETY	NO. SAMPLES	HOW PICKED	NUMERICAL RATING: NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4	ALL SAMPLES % 1	2	3	4
CALIFORNIA	LATE CLUSTERS	64	MACHINE	8	56			12.5	87.5						
	ALL VARIETIES	64		8	56							12.5	87.5		
IDAHO	LATE CLUSTERS	1	HAND	1				100.0							
	" "	7	MACHINE	5	2			71.4		28.6					
	ALL VARIETIES	8		6	2							75.0	25.0		
OREGON	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	2	"	1	1			50.0	50.0						
	FUGGLES	6	HAND		1	5			16.7	83.3					
	"	19	MACHINE		3	16			15.8	84.2			16.0	84.0	
	LATE CLUSTERS	18	HAND	5	12	1		27.8	66.7	5.5					
	" "	34	MACHINE	4	30			11.8	88.2			17.3	80.8	1.9	
	RED VINES	2	"			2				100.0					
	ALL VARIETIES	82		11	47	24						13.4	57.3	29.3	
WASHINGTON	EARLY CLUSTERS	26	MACHINE	5	18	3		19.2	69.2	11.5					
	LATE CLUSTERS	18	"	4	14			22.2	77.8						
	ALL VARIETIES	44		9	32	3						20.5	72.7	6.8	
ALL STATES	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	28	"	6	19	3		21.4	67.9	10.7					
	FUGGLES	6	HAND		1	5			16.7	83.3					
	"	19	MACHINE		3	16			15.8	84.2		16.0	84.0		
	LATE CLUSTERS	19	HAND	6	12	1		31.6	63.2	5.2					
	" "	123	MACHINE	21	102			17.1	82.9			19.0	80.3	0.7	
	RED VINES	2	"			2				100.0					
	ALL VARIETIES	198		34	137	27						17.2	69.2	13.6	

Table 19. SUMMARY OF AMOUNT OF LUPULIN BY AREAS OF ORIGIN

STATE	AREA	NO. SAMPLES	NUMERICAL RATING: NO. SAMPLES				NUMERICAL RATING: % SAMPLES			
			1	2	3	4	1	2	3	4
CALIFORNIA	SACRAMENTO	36	4	32			11.1	88.9		
	SANTA ROSA	28	4	24			14.3	85.7		
OREGON	EASTERN OREGON	6	2	3	1		33.3	50.0	16.7	
	GRANTS PASS	11	1	8	2		9.1	72.7	18.2	
	WILLAMETTE VALLEY	65	8	36	21		12.3	55.4	32.3	
ALL STATES (HOP QUALITY STUDIES)	CALIFORNIA	64	8	56			12.5	87.5		
	IDAHO	8	6	2			75.0	25.0		
	OREGON	82	11	47	24		13.4	57.3	29.3	
	WASHINGTON	44	9	32	3		20.5	72.7	6.8	
	TOTALS	198	34	137	27		17.2	69.2	13.6	

SUMMARY OF COLOR AND CONDITION OF LUPULIN

Table 20.

STATE	VARIETY	NO. SAMPLES	HOW PICKED	NUMERICAL RATING: NO. SAMPLES 1	2	3	4	% SAMPLES 1	2	3	4	ALL SAMPLES % 1	2	3	4
CALIFORNIA	LATE CLUSTERS	64	MACHINE	49	15			76.6	23.4						
IDAHO	LATE CLUSTERS	1	HAND		1				100.0						
	" "	7	MACHINE	6	1			85.7	14.3						
	ALL VARIETIES	8		6	2							75.0	25.0		
OREGON	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	2	"	1	1			50.0	50.0						
	FUGGLES	6	HAND	6				100.0							
	"	19	MACHINE	19				100.0				100.0			
	LATE CLUSTERS	18	HAND	18				100.0							
	" "	34	MACHINE	30	4			88.2	11.8			92.3	7.7		
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	82		77	5							93.9	6.1		
WASHINGTON	EARLY CLUSTERS	26	MACHINE	21	5			80.8	19.2						
	LATE CLUSTERS	18	"	16	2			88.9	11.1						
	ALL VARIETIES	44		37	7							84.1	15.9		
ALL STATES	BREWER'S GOLD	1	MACHINE	1				100.0							
	EARLY CLUSTERS	28	"	22	6			78.6	21.4						
	FUGGLES	6	HAND	6				100.0							
	"	19	MACHINE	19				100.0				100.0			
	LATE CLUSTERS	19	HAND	18	1			94.7	5.3						
	" "	123	MACHINE	101	22			82.1	17.9			83.8	16.2		
	RED VINES	2	"	2				100.0							
	ALL VARIETIES	198		169	29							85.4	14.6		

Table 21. SUMMARY OF COLOR AND CONDITION OF LUPULIN BY AREAS OF ORIGIN

STATE	AREA	NO. SAMPLES	NUMERICAL RATING NO. SAMPLES 1	2	3	4	NUMERICAL RATING % SAMPLES 1	2	3	4
CALIFORNIA	SACRAMENTO	36	28	8			77.8	22.2		
	SANTA ROSA	28	21	7			75.0	25.0		
OREGON	EASTERN OREGON	6	4	2			66.7	33.3		
	GRANTS PASS	11	11				100.0			
	WILLAMETTE VALLEY	65	62	3			95.4	4.6		
ALL STATES (HOP QUALITY STUDIES)	CALIFORNIA	64	49	15			76.6	23.4		
	IDAHO	8	6	2			75.0	25.0		
	OREGON	82	77	5			93.9	6.1		
	WASHINGTON	44	37	7			84.1	15.9		
	TOTALS	198	169	29			85.4	14.6		

A comparison of the effects of hand- and machine-picking is made possible by selecting certain lots of both Fuggles and Late Clusters from Oregon for both 1949 and 1950. Some of the data from the 1949 report is incorporated with certain data from Tables 1, 7, and 9 in the following table. Generally, the percentages of leaf and stem, seed, and whole cones are higher for the hand-picked material, although there are individual exceptions.

Certain other data in these two reports provide additional information on other characters. These cannot be tabulated, however, because of a different method of evaluation in the two years. Regardless of the method used, it is clear that the amount of lupulin is usually higher in the hand-picked samples. On the other hand, the color and condition of lupulin does not appear to be influenced by the method of picking.

COMPARISON OF HAND & MACHINE PICKING AS SHOWN BY ANALYSIS FOR CERTAIN CHARACTERS. FUGGLES AND LATE CLUSTERS HOPS FROM OREGON

1949 -- 1950

	FUGGLES		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND
LEAF & STEM				
1949	8.1 (16)*	6.6 (37)	6.0 (42)	7.1 (61)
1950	5.6 (19)	7.2 (6)	6.1 (34)	7.5 (18)
SEED				
1949	12.0 (16)	12.7 (37)	8.2 (42)	9.1 (61)
1950	16.6 (19)	18.2 (6)	12.8 (34)	13.6 (18)
WHOLE CONES				
1949	20.1 (16)	23.6 (37)	34.5 (42)	40.8 (61)
1950	56.5 (19)	54.2 (6)	60.2 (34)	63.2 (18)

* Numbers of observations in parentheses.

Several comparisons between the 1949 and 1950 crops are presented in the following table. These include leaf and stem, seed, and damage. Some variations in leaf and stem and seed content are shown but, on the whole, the data for the two years agree fairly well. Less damage was shown for the 1950 than for the 1949 crop.

RESULTS OF HOP ANALYSES FOR CERTAIN CHARACTERS
DURING TWO CROP YEARS -- 1949 & 1950

CHARACTER ANALYZED AND SUB-DIVISIONS		PERCENT OF SAMPLES BY STATES			
		OREGON	WASHINGTON	CALIFORNIA	IDAHO
LEAF & STEM:					
5% OR LESS	1949	36.3	93.6	84.6	100.0
	1950	43.9	88.6	67.2	100.0
6% - 8%	1949	55.7	5.2	13.4	
	1950	47.6	11.4	25.0	
OVER 9%	1949	8.0		2.0	
	1950	8.5		7.8	
SEED CONTENT:					
SEEDLESS	1949	13.0	75.1	51.3	83.3
	1950	3.7	40.9	53.1	75.0
SEMI-SEEDLESS	1949	6.3	9.8	6.0	11.9
	1950	1.2	20.5	4.7	12.5
SEEDED	1949	80.7	15.1	42.7	4.8
	1950	95.1	38.6	42.2	12.5
DAMAGE RATING:					
1.	1949	92.0	91.9	78.0	100.0
	1950	95.1	97.7	92.2	87.5
2.	1949	7.4	5.2	18.0	
	1950	4.9	2.3	6.3	12.5
3.	1949	0.0	1.7	3.3	
	1950	0.0		1.5	
4.	1949	0.6	1.2	1.5	
	1950	0.0		0.7	

Other comparisons include whole cones, amount of lupulin, and color and condition of lupulin. Comparisons for these characters cannot be shown in tabular form because different systems of evaluation were used in the two years. The data show fewer broken hops and a better color and condition rating for the lupulin for 1950 than for 1949. This is not surprising as it was thought that the 1949 crop was unusual for these two factors and so indicated in the report covering the 1949 crop. The amount of lupulin for the two years showed little variation.

MOISTURE DETERMINATIONS

It is quite generally accepted that hops should contain under 12 per-cent moisture for best storage life. On the other hand, very low moisture content promotes excessive cone breakage during handling and baling. While laboratory moisture methods are accurate, in general, they are not rapid enough to be suitable for control use in the drier. Likewise, they are not adapted to rapid examination of baled hops. Therefore, a study of instruments for moisture determination suitable for use in the drier was started last year. Two instruments were described and discussed in last year's report.* Two more instruments, both of which operate on the electrical conductivity principle, have been tested this year. They are the "Megger" Insulation Tester manufactured by the James G. Biddle Co., 1316 Arch Street, Philadelphia 7, Pennsylvania, and the TAG-Heppenstall Moisture Meter with tobacco attachment made by the Tagliabue Instruments Division of Weston Electrical Instrument Corporation, Newark 5, New Jersey.

The "Megger" Tester was developed for testing electrical insulation and in its present form is not flexible enough to cover the moisture range

* Hop Quality Studies, 1949 Crop. June 1950. J. D. Sather, D. E. Bullis, D. D. Hill, B. W. Whitlock and W. T. Wisbeck.

of hops, particularly low moisture values. Also there is no means of using the instrument for loose hops. For use with baled hops a probe was constructed consisting of two metal rod electrodes rigidly fastened through a fiber block. This probe could be inserted through the baling cloth at any point in the bale where a moisture content determination was desired.

The TAG-Heppenstall machine was originally developed for grain moisture, but now includes models for tobacco, wood, plaster, and other materials. The older models such as used in this work consist of a meter box having several fixed resistances which may be switched into the circuit independently, plus a variable resistance with a dial. Thus a combination of total resistances may be placed in the circuit, depending on the conductivity (moisture content) of the material under test. The instrument scale does not read directly in percent moisture, so for each material it is necessary to prepare a calibration chart using a series of samples of known moisture content. These are prepared to cover the desired range, and moisture content is then determined by a standard laboratory method. These values can then be charted against instrument readings for the same samples.

For baled hops the probe described above was used with the TAG-Heppenstall machine. For loose hops an auxiliary device made for use with cigarette tobacco was employed. This consists of a circular plastic base from which two electrodes extend. The electrodes in the base are connected to the standard TAG-Heppenstall meter box. Over the base fits a removable plastic cylinder into which the loose hops are placed. A hand-operated screw forces a piston down into the cylinder until the hops are compressed to the desired pressure as indicated on a gauge (150 pounds per square inch in the case of hops) and then the reading of the meter is taken.

Our tests this season indicate that the old model will consistently show moisture differences as low as 1/2 percent, which should be amply sensitive for drier use.

Results with this instrument from both baled and loose hops were quite quickly obtained and reproducibility of readings was good. However, the instrument used in these tests would not work on hops much below 8 percent moisture. Tagliabue engineers are working to remedy this defect and it is hoped the newer models may be used for hop moisture as low as 4 or 5 percent. The newer models work on the principle of electrical capacity instead of conductivity and are said to be much more sensitive. It is hoped that one of the new instruments will be available for next season so that some tests may be made in the driers and storage warehouses.

Average moisture content for the states follows exactly the same relationship as observed last year. Oregon had the highest, followed in order by California, Washington, and Idaho. Average moisture values for the 1950 crop are lower than for 1949. This difference, however, is probably more apparent than actual as some of the 1949 samples absorbed moisture in storage due to defective containers which tended to raise the averages for that year. It is thought that less cone breakage would result if more moisture were left in the cured hops. Probably an average of about 9 percent would be more desirable than the values now generally found.

CHEMICAL ANALYSES

Chemical analysis studies of the 1950 commercial hop samples followed essentially the same pattern as that of the previous season. In fact, one of the primary reasons for continuing the work was to re-check some of the 1949 crop results. In addition to the whole and broken cone analysis, light absorption studies on petroleum ether extracts from about 200 samples were carried out to determine the usefulness of a spectrophotometric method for rapid estimation of hop soft resins.

A few preliminary tests were made relative to the effect of maturity on yield of hop oil and on losses of oil which may take place during drying. The colorimetric method* for soft resins used last year was also studied further.

On the basis of soft resin content, California and Oregon Clusters are similar to last year's crops. Oregon Fuggles and Washington Clusters are somewhat better than a year ago and Idaho Clusters are much improved, probably due to a big reduction in cone breakage observed in this year's Idaho samples over those of 1949. These comparisons may be more easily seen in the following table of total soft resin averages for both years.

AVERAGE TOTAL SOFT RESIN

STATE	VARIETY	1949	1950
		%	%
CALIFORNIA	CLUSTERS	16.90	16.96
IDAHO	CLUSTERS	15.64	17.66
OREGON	FUGGLES	14.11	15.41
OREGON	CLUSTERS	17.08	17.09
WASHINGTON	CLUSTERS	15.62	16.67

It should be remembered that for purposes of comparison, figures given in the above table have been converted to a moisture-free basis. Average values for the samples as received would be about one-thirteenth lower than those given above.

If average values for total soft resins in the following table are compared with the 1950 column in the preceding table, an idea may be had of the difference obtained by the two bases of calculation.

* "A New Approach to the Estimation of Hop Soft Resins" by D. E. Bullis and Gordon Alderton. Wallerstein Laboratories Communications 8, No. 24, p. 118-127. Aug. 1945.

TOTAL SOFT RESIN AVERAGE AND RANGE OF 1950 EXPERIMENTAL SAMPLES AS RECEIVED

		CALIFORNIA CLUSTERS(64)*	IDAHO CLUSTERS(8)	OREGON FUGGLES(25)	OREGON CLUSTERS(57)	WASHINGTON CLUSTERS(44)
		%	%	%	%	%
ALPHA RESIN	MINIMUM	4.58	5.68	3.78	3.71	4.51
	AVERAGE	5.93	6.67	4.66	5.58	6.09
	MAXIMUM	8.18	8.14	5.96	7.56	7.53
BETA RESIN	MINIMUM	7.51	8.98	7.42	8.16	8.42
	AVERAGE	9.76	9.52	9.50	10.20	9.37
	MAXIMUM	12.30	10.32	11.22	13.25	10.54
TOTALS SOFT RESIN	MINIMUM	12.09	14.83	12.52	12.74	12.92
	AVERAGE	15.70	16.43	15.08	15.79	15.44
	MAXIMUM	20.00	18.47	17.18	20.69	17.38

* Numbers of observations shown in parentheses.

Gravimetric versus Colorimetric Method for Hop Soft Resins

Data from three crop years have now been accumulated from which to assess speed and accuracy and hence usefulness of the colorimetric method (loc. cit.) of hop analysis. The number of commercial lots used in the tests is given in the following table.

NUMBER OF SAMPLES

STATE	1941 CROP	1949 CROP	1950 CROP
CALIFORNIA	33	52	64
IDAHO	--	29	8
NEW YORK	11	--	--
OREGON	44	53	82
WASHINGTON	44	52	44
TOTALS	132	186	198

The following table shows a comparison of average alpha and beta resin obtained by the official gravimetric method and by the 1941 and 1949 colorimetric equations. (See 1950 report.) The 1950 equations would give mean values identical with 1950 gravimetric values since they were derived from those gravimetric data, so they are not included in the table. These data are calculated to a moisture-free basis.

COMPARISON OF ANALYTICAL METHODS

STATE	GRAVIMETRIC		1941 COLORIMETRIC		1949 COLORIMETRIC	
	A** %	B** %	A %	B %	A %	B %
CALIFORNIA (64)*	6.96	11.02	7.12	11.58	7.19	11.30
IDAHO (8)	8.61	10.72	7.80	11.82	7.98	11.25
OREGON (82)	6.67	11.05	6.60	11.74	6.46	11.72
WASHINGTON (44)	7.10	10.02	6.95	11.06	7.19	10.67
ALL SAMPLES (198)	6.94	10.80	6.89	11.54	6.92	11.33

* Numbers of observations in parentheses.

** A = Alpha resin. B = Beta resin.

The above data were obtained from the whole cone fractions of the samples and so do not agree with the figures given on page 35, which were from analyses of the samples as received, that is, including both whole and broken portions.

Agreement between procedures for alpha resin content is very good in all cases except for the Idaho lots where gravimetric alpha is somewhat higher than given by the colorimetric method. Beta resin is somewhat lower by gravimetric analysis in all cases but is in good agreement between the two sets of colorimetric equations.

Regression equations calculated from the 1950 crop data are:

$$\text{Alpha} = -0.0435S + 0.0359T + 0.7259$$

$$\text{Beta} = 0.6620S - 0.0154T + 1.7587$$

S = Percent of petroleum ether solubles

T = Klett colorimeter reading

These equations vary slightly from season to season (see Hop Quality Studies, June 1950 report). However, the variations do not appear to be large enough to affect the usefulness of the colorimetric procedure as a rapid analytical method.

Spectrophotometric Method for Soft Resin Determination

The same petroleum ether extracts of the samples used in the colorimetric method study were employed in this study. The procedure followed was essentially that reported by Lewis and co-workers in mimeographed publication AIC-231 from the Western Regional Research Laboratory, Albany, California.

Method: Two grams of ground hops were shaken 20 minutes with 100 ml. of Skelly-solve F (petroleum ether), centrifuged and 1 ml. of clear extract placed in a 200 ml. volumetric flask. Two drops of 6 N NaOH were added and the flask filled to the mark with methanol. Optical density of the solution was read at 325 mu, 332 mu and 355 mu wave lengths with a Model B Beckman Spectrophotometer. Corex cells were used.

The resulting data were subjected to statistical analysis to determine if alpha or beta resins or both might be determined from the observed optical density values of the hop extracts. The statistical analysis showed that alpha resin can be quite accurately determined by use of the optical density values obtained at 332 mu and 355 mu wave lengths. The equation is $\text{alpha} = 15.656\ (O.D._{332}) - 6.008\ (O.D._{355}) + 1.303$. ($O.D._{332}$ = optical density at 332 mu and $O.D._{355}$ = optical density at 355 mu.) This equation will give values for alpha resin within 0.5 percent of gravimetric values in 65 percent of the samples tested. In the other 35 percent of the samples the error will be greater than 0.5 percent. The greatest difference observed was 2.15 percent. This procedure would thus appear to give about the same degree of accuracy as the colorimetric method for alpha resin; however, none of the Idaho samples gave good alpha agreements between the two methods.

For beta resin the only optical density reading of statistical significance was taken at 355 mu wave length. The agreement with gravimetric values was not nearly as close as in the case of alpha resin. The equation is:

beta resin = 6.504 (O.D.$_{355}$) ≠ 6.621. The divergence from gravimetric values will not be greater than 1.05 percent in 65 percent of the samples tested and above that on the remaining 35 percent. The greatest difference observed was 2.79 percent. For beta resin this method is somewhat less accurate than the colorimetric method. The cost of laboratory equipment is somewhat higher for the spectrophotometric procedure, but it requires less time to complete an analysis than by the colorimetric method. However, the spectrophotometric method should receive further study before it can be recommended for general acceptance.

Hop Oil

Only a few tests of a preliminary nature were undertaken on hop oil the past season. They were concerned with the relationship of maturity of hops to yield of oil and with loss of oil in the drying process. The samples were Late Clusters from the Oregon Agricultural Experiment Station yard. The following table gives the pertinent data from the test in percentages.

HOP OIL

PICKING	GREEN HOPS		CURED HOPS	
DATE	AS PICKED	MOISTURE-FREE BASIS	AS TAKEN FROM DRIER	MOISTURE-FREE BASIS
9- 7-50	.11	.60	.49	.54
9-12-50	.20	.88	.66	.72
9-15-50	.19	.84	.49	.53
9-18-50	.27	1.01	.79	.84

From the figures in column 3 it appears that there may be an increase of about 65 percent in oil yield if picking is delayed 12 days. Comparing column 3 with column 5 indicates a possible average loss of about 20 percent of the oil content of green hops in the drying process. These values should be considered as indicating trends rather than exact differences, since time did not permit replication of the experiments. More detailed studies are planned for the coming season.

RELATIONSHIP OF PHYSICAL TO CHEMICAL FACTORS

Moisture

No significant moisture difference was found in machine-picked Late Clusters hops from the four states. (See Appendix, Table 2.) Last year a difference was observed but, as noted on page 33 of the 1949 crop report, it was thought that the differences were due to moisture absorption by some samples while in storage.

MEAN MOISTURE OF 1950 MACHINE-PICKED LATE CLUSTERS

CALIFORNIA	IDAHO	OREGON	WASHINGTON
%	%	%	%
7.49 (64)*	7.07 (7)	7.68 (34)	7.44 (18)

* Numbers of observations in parentheses.

There was, however, a significant moisture difference between varieties of machine-picked Oregon hops. (See Appendix, Table 3.)

MEAN MOISTURE OF MACHINE-PICKED OREGON VARIETIES

FUGGLES	EARLY CLUSTERS	LATE CLUSTERS
%	%	%
8.21 (19)*	7.10 (2)	7.68 (34)

* Numbers of observations in parentheses.

The over-all average moisture content and the range observed are shown below. In this tabulation both hand- and machine-picked samples are included.

MOISTURE AVERAGE AND RANGE FOR ALL 1950 CROP EXPERIMENTAL SAMPLES

	CALIFORNIA	IDAHO	OREGON		WASHINGTON
	CLUSTERS(64)*	CLUSTERS(8)	FUGGLES(25)	CLUSTERS(57)	CLUSTERS(44)
	%	%	%	%	%
MINIMUM	6.25	5.73	6.85	6.68	6.15
AVERAGE	7.49	6.94	8.12	7.69	7.26
MAXIMUM	9.65	8.19	8.85	8.88	8.76

* Numbers of observations in parentheses.

Cone Breakage

Just as noted on the 1949 crop, the amount of whole cones in 1950 commercial hop samples was found to vary significantly between the states. (See Appendix, Table 4.) In order of decreasing percent of whole cones the states were Washington, California, Idaho, and Oregon. In the 1949 crop, the order was the same except that Oregon was third and Idaho lowest in whole cone percent. All states had a better record this year than last, particularly Idaho. The following figures are from all samples analyzed.

WHOLE CONES BY STATES

	CALIFORNIA	IDAHO	OREGON		WASHINGTON
	CLUSTERS(64)*	CLUSTERS(8)	FUGGLES(25)	CLUSTERS(57)	CLUSTERS(44)
	%	%	%	%	%
MINIMUM	41.0	52.0	36.0	31.0	55.0
AVERAGE	68.9	65.6	55.9	61.6	69.5
MAXIMUM	86.0	78.0	78.0	91.0	90.0

* Numbers of observations in parentheses.

Variety was not a factor in cone breakage in the 1950 crop as it was in the 1949 crop. (See Appendix, Table 5.) Although the average whole cone percent for Early Clusters is higher than for the other varieties in the following table, the fact that only two samples of Early Clusters were included in this test reduces the significance of this difference. Machine-picked Oregon hops were used in this test.

MEAN WHOLE CONES BY VARIETY

FUGGLES	EARLY CLUSTERS	LATE CLUSTERS
%	%	%
56.5 (19)*	74.5 (2)	60.1 (34)

* Numbers of observations in parentheses.

Alpha and Beta Resin Content of Whole and Broken Cones

Alpha and beta resin content is very definitely affected by breakage of hop cones. The magnitude of the difference in soft resin content of the whole and broken fractions varies with variety and with state where grown but is not significantly affected by the type of picking (hand or machine). The averages for alpha and beta resin content of whole and broken cones and the average differences in alpha and beta resin content between whole and broken cones are given in the next four tables. (See also Appendix, Tables 6, 7, 8, and 9.)

MEANS OF ALPHA RESIN CONTENT

WHOLE CONE PORTIONS

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					7.19(64)	
IDAHO					7.86(7)	
OREGON	5.69(19)*	5.41(6)	6.26(2)		6.72(34)	7.02(18)
WASHINGTON			7.03(26)		7.41(18)	

BROKEN CONE PORTIONS

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					4.76(64)	
IDAHO					5.61(7)	
OREGON	4.33(19)*	4.43(6)	4.93(2)		4.66(34)	4.94(18)
WASHINGTON			5.06(26)		5.26(18)	

* Numbers of observations in parentheses.

MEAN ALPHA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					2.43(64)	
IDAHO					2.25(7)	
OREGON	1.36(19)*	0.98(6)	1.33(2)		2.06(34)	2.08(18)
WASHINGTON			1.97(26)		2.15(18)	

* Numbers of observations in parentheses.

MEANS OF BETA RESIN CONTENT

WHOLE CONE PORTION

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					11.30(64)	
IDAHO					11.16(7)	
OREGON	10.98(19)*	11.09(6)	10.11(2)		11.93(34)	12.29(18)
WASHINGTON			10.41(26)		11.05(18)	

BROKEN CONE PORTION

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					8.83(64)	
IDAHO					9.05(7)	
OREGON	9.32(19)*	9.96(6)	8.23(2)		9.36(34)	9.52(18)
WASHINGTON			8.54(26)		9.06(18)	

* Numbers of observations in parentheses.

MEAN BETA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES

PICKING / STATE	FUGGLES		EARLY CLUSTERS		LATE CLUSTERS	
	MACHINE	HAND	MACHINE	HAND	MACHINE	HAND
	%	%	%	%	%	%
CALIFORNIA					2.47(64)	
IDAHO					2.11(7)	
OREGON	1.66(19)*	1.13(6)	1.88(2)		2.57(34)	2.77(18)
WASHINGTON			1.87(26)		1.99(18)	

* Numbers of observations in parentheses.

Alpha and Beta Resin Content of Commercial Samples as Received

Machine-picked Late Clusters commercial samples as received (before separation into whole and broken cone fractions) showed a definite relationship between alpha resin content and the state of origin. (See also Appendix, Table 10.) This relationship was also observed in 1949 crop studies. However, the 1950 crop showed no relationship between beta resin and state of origin; whereas, the 1949 crop did exhibit a significant beta resin-state of origin correlation. (See also Appendix, Table 11.) Consistency of the alpha resin relationship for both years of the study is probably more important than the inconsistency of the beta resin relationship because in recent years alpha resin is receiving more and more consideration as the important soft resin in hop evaluation.

MEANS OF ALPHA AND BETA RESIN CONTENT OF MACHINE-PICKED LATE CLUSTERS

RESIN \ STATE	CALIFORNIA	IDAHO	OREGON	WASHINGTON
	%	%	%	%
ALPHA	6.41(64)*	7.05(7)	5.90(34)	6.70(18)
BETA	10.55(64)	10.41(7)	10.95(34)	10.39(18)

* Numbers of observations in parentheses.

When classified according to variety it was found that there is a significant variation in both alpha and beta resin content. (See also Appendix, Tables 12 and 13.) Last year's observations showed the same relationship to be true of the 1949 crop. In this case the data came from Oregon machine-picked hops since samples of no other state included all the common commercial varieties.

MEANS OF ALPHA AND BETA RESIN CONTENT OF MACHINE-PICKED OREGON HOP VARIETIES

RESIN \ VARIETY	FUGGLES	EARLY CLUSTERS	LATE CLUSTERS
	%	%	%
ALPHA	5.69(19)*	6.26(2)	6.72(34)
BETA	10.98(19)	10.11(2)	11.93(34)

* Numbers of observations in parentheses.

Relationships Between the Soft Resins and Certain Physical Factors

Most of the relationships between chemical and physical factors observed in last year's study have been confirmed and some additional correlations have been noted. Brief comment on some of these relationships follows. (See Appendix, Table 14, for correlation data.)

Alpha resin content of the 1950 crop, as of the 1949 crop, decreased as leaf and stem content of the hops increased. Beta resin appeared to increase with increases in leaf and stem; whereas, last year the reverse relationship was observed. Therefore, it cannot be concluded as yet whether a definite relationship exists between beta resin and leaf and stem content.

The relationship between percent whole cones and moisture content when all samples are considered together is not quite as positive as it appeared in last year's study. However, when taken by individual classes (e.g., variety, method of picking, state of origin) there is a decided relationship between the moisture content and the amount of breakage. The relationship between percent whole cones and alpha resin content is again very positive. Beta resin content does not appear to vary with whole cone percentage, although in the previous study some correlation was observed.

The whole cone percentage and amount of lupulin show a fair degree of correlation, but not nearly to the extent that alpha resin and total soft resin appear to be related to amount of lupulin. In the latter two factors their relationships to lupulin are particularly definite, as they also were in last year's study.

No correlation whatever was found between alpha resin or total soft resin and color and condition of lupulin.

In both seasons' hops it has been observed that when correlations exist between physical factors versus alpha and beta resins, the relationships, as a rule, are much more positive in respect to alpha resin than to beta resin. The reason for this difference is obscure but it is fortunate that the more important soft resin constituent is the one which shows generally the best correlation with the various physical factors.

Soft resin values for the four states were quite similar to those of the 1949 crop. Within a variety alpha, but not beta, resin varies with the state where produced. Both alpha and beta resin vary with variety within a state.

For those who may be interested, further detailed statistical data may be found in Tables 1 to 15 in the Appendix section of this report.

SUMMARY OF TWO-YEAR STUDY

The following points summarize very briefly the results of two years' investigations of the physical and chemical factors which might be relevant to the evaluation of hop quality. The studies were made jointly by the Pacific Coast Headquarters of the Grain Branch, Production and Marketing Administration, U.S.D.A., and the Oregon Agricultural Experiment Station. The samples used for the study were from commercial lots from the states of California, Idaho, Oregon, and Washington. They were, as nearly as possible, taken so as to represent a cross section of the commercial crops for the years 1949 and 1950 and were collected by the Federal-State hop inspection officials of the four states. The 1949 crop was represented by 520 samples and the 1950 crop by 198 samples.

Physical Factors

1. Machine-picked samples had lower percentages of leaf and stem than hand-picked samples of the same variety.

The average percent of leaf and stem varied by varieties, by state of origin, and by areas of origin within a state. The relative position of the four states was the same in both years. In order of increasing percentage the ranking was: Idaho, Washington, California, and Oregon.

2. The average percent of seed varied by varieties, by state of origin, and by areas of origin within a state. In order of increasing percentage the ranking in 1950 was: Idaho, California, Washington, and Oregon. In 1949 California had less seedless hops than Washington. There was an appreciable increase in the percentages of seeded hops in 1950, in all states except California.

3. The average percent of whole cones varied both by variety and by state of origin.

The percentage of whole cones increased as leaf and stem content was reduced. This situation may not represent what actually occurs in the field, particularly as regards machine-picked hops.

Broken portions of the cones, in most cases, would not reach the drier and consequently would not be present in the bales from which the samples were taken.

4. The ratings for total discoloration and general appearance varied by varieties, by states of origin, and by areas of origin within states.

Considered as a whole, samples from all states in both years showed relatively little discoloration, from all causes, and the general appearance was good.

5. Observations on damage were similar to those regarding total discoloration and general appearance.

6. The ratings for amount of lupulin varied by varieties, by states of origin, and by areas of origin within states.

The amount of lupulin was less in machine- than in hand-picked samples of the same varieties. Amounts of lupulin were estimated from examinations of whole cones and may not, in all instances, constitute a fair appraisal since considerable lupulin, and in varying amounts, had been shaken out in the course of handling the samples in the laboratory.

7. Ratings for color and condition of lupulin varied by varieties, by states of origin, and by areas of origin within states. Rankings for all four states were higher in 1950 than in 1949.

Chemical Factors

1. There was little difference in the moisture content of hops from the four states.

2. In general, all samples had too low a moisture content and quality would be improved by an additional 2 percent to 3 percent of moisture.

3. Of the moisture instruments tested, the Dietert Moisture Teller and the TAG-Heppenstall Moisture Meter were the best. The Dietert can be used only for loose hops. The TAG-Heppenstall with the addition of probe electrodes can be used either for loose or baled hops but will require some factory modification if moisture values below 7 percent are to be determined.

4. Regression equations, by which the soft resins are determined in the colorimetric method of analysis (loc. cit.), have been calculated from three seasons' data. While the equations vary slightly from season to season, the difference is not enough to impair the value of the procedure as a means of rapid estimation of hop soft resins.

5. Studies of 1950 crop samples indicate some possibility of developing a spectrophotometric method for estimating alpha but not beta resin in petroleum ether extracts of hops. Further work is required before conclusions can be drawn as to the value of such a procedure.

6. Hop oil yields increase markedly with maturity of the hops. About one-fifth of the oil content of green hops may be lost during drying.

Relationship of Physical to Chemical Factors

1. Alpha and beta resins varied with percentage of whole cones in the 1949 crop samples, whereas in the 1950 samples only alpha resin varied with the whole cone percentage.

2. In both years the proportion of the alpha resin was higher in the soft resins of whole cones than in the soft resins of broken cones. In other words, the quality of soft resins was better in whole cones than in broken cones.

3. In both 1949 and 1950 crops alpha and beta resins were higher in whole cones than in broken cones.

4. In both years the difference in alpha and beta resin between whole and broken cones was related to the state of origin and to the variety, and much less positively to the method of picking.

5. In the 1949 crop samples both alpha and beta resin increased with decrease in leaf and stem content. In the 1950 crop samples alpha resin showed the same trend but beta resin seemed to increase with increase in leaf and stem content.

6. In both years alpha and beta resins were higher in samples with the higher estimated lupulin content.

7. In both seasons' samples, there appeared to be no relationship between the alpha and beta resin content and the color and condition of lupulin.

CONCLUSIONS

From the foregoing summarization, several conclusions of practical importance may be drawn:

A number of physical factors used for many years by the trade to judge hop quality are little or not at all indicative of the soft resin content of the hops. These include: (1) discoloration and general appearance and damage, except where due to downy mildew or sooty mould. Reddish- or yellowish-colored hops, when the color is due to stage of maturity may be, and in many cases are, far richer in soft resins than green-colored hops; (2) color and condition of lupulin, likewise, are not indices of soft resin content.

Several physical factors are shown by this study to be definitely related to hop quality. (1) Leaf and stem content is apparently inversely related to alpha resin content; the higher the leaf and stem content, the lower the alpha resin content. (2) Broken hops, which in the past have been given scant consideration in hop quality evaluation, appear to be of major importance and a factor related to quality. The results of this two-year study show conclusively that whole hops contain more soft resins and of a better quality than do broken hops. (3) Moisture content affects the amount of broken hops and is therefore related to quality. Commercial samples may advantageously contain a moisture content several percent higher than those dealt with in this study. (4) Amount of lupulin, as estimated physically, was directly indicative of the total soft resin content.

Of the physical factors which have been considered, the inclusion of (1) broken cones, (2) moisture content, and (3) estimated amount of lupulin are items which could, if desired by the industry, be undertaken to supplement the present inspection of leaf and stem and seed content.

Should future interest in evaluation of chemical factors of quality be desired, the colorimetric procedure offers a rapid and relatively inexpensive means of soft resin determination.

APPENDIX

The following tables are included for readers of this report who may have a knowledge of statistics and thus will be familiar with the terms employed in them. For those who may not have a background in statistics an explanation of the terms "significant at 5 percent level" and "significant at 1 percent level" may be helpful. If a value is significant at the 5 percent level it means that the value would occur strictly by chance only 5 times in 100. If a value is significant at the 1 percent level the odds are only 1 in 100 that the observed differences are due to chance.

PERCENT LEAF AND STEM BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 1. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	108.9271	3	36.3090	9.10**	SIGNIFICANT
ERROR	474.9389	119	3.9911		AT 1%
TOTAL	583.8660	122			LEVEL

PERCENT MOISTURE BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 2. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	2.4303	3	0.8101	2.25	NOT
ERROR	42.7920	119	0.3596		SIGNIFICANT
TOTAL	45.2223	122			

PERCENT MOISTURE BY VARIETY, OREGON, MACHINE PICKED

Table 3. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
VARIETY	4.5175	2	2.2587	8.59**	SIGNIFICANT
ERROR	13.6761	52	0.2630		AT 1%
TOTAL	18.1936	54			LEVEL

PERCENT WHOLE CONES BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 4. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	1,745.2117	3	581.7372	6.23**	SIGNIFICANT
ERROR	11,118.2518	119	93.4307		AT 1%
TOTAL	12,863.4635	122			LEVEL

PERCENT WHOLE CONES BY VARIETY, OREGON, MACHINE PICKED

Table 5. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
VARIETY	633.3172	2	316.6586	2.49	NOT
ERROR	6,617.1192	52	127.2523		SIGNIFICANT
TOTAL	7,250.4364	54			

** Significant at the 1 percent level.

ALPHA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 6. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	3.5694	3	1.1898	4.65**	SIGNIFICANT
ERROR	30.4421	119	0.2558		AT 1%
TOTAL	34.0115	122			LEVEL

ALPHA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES BY VARIETY AND PICKING METHOD, OREGON HOPS

Table 7. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
					SIGNIFICANT
VARIETY	10.8713	1	10.8713	56.56**	AT 1% LEVEL
PICKING	0.1278	1	0.1278	0.66	NOT
INTERACTION	0.5245	1	0.5245	2.73	SIGNIFICANT
ERROR	14.0298	73	0.1922		

BETA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 8. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	4.8977	3	1.6326	3.63*	SIGNIFICANT
ERROR	53.4639	119	0.4493		AT 5%
TOTAL	58.3616	122			LEVEL

BETA RESIN DIFFERENCE BETWEEN WHOLE AND BROKEN CONES BY VARIETY AND PICKING METHOD, OREGON HOPS

Table 9. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
					SIGNIFICANT
VARIETY	20.3433	1	20.3433	39.02**	AT 1% LEVEL
PICKING	0.0006	1	0.0006	0.001	NOT
INTERACTION	1.8551	1	1.8551	3.56	SIGNIFICANT
ERROR	38.0530	73	0.5213		

* Significant at the 5 percent level.

** Significant at the 1 percent level.

PERCENT ALPHA RESIN BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 10. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	12.7240	3	4.2413	6.19**	SIGNIFICANT
ERROR	81.5573	119	0.6854		AT 1%
TOTAL	94.2813	122			LEVEL

PERCENT ALPHA RESIN BY VARIETY, OREGON, MACHINE PICKED

Table 11. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
VARIETY	12.9828	2	6.4914	10.46**	SIGNIFICANT
ERROR	32.2797	52	0.6208		AT 1%
TOTAL	45.2625	54			LEVEL

PERCENT BETA RESIN BY STATE, LATE CLUSTERS, MACHINE PICKED

Table 12. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
STATE	5.4106	3	1.8035	1.65	NOT
ERROR	130.2802	119	1.0948		SIGNIFICANT
TOTAL	135.6908	122			

PERCENT BETA RESIN BY VARIETY, OREGON, MACHINE PICKED

Table 13. ANALYSIS OF VARIANCE

VARIATION DUE TO	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	REMARKS
VARIETY	15.1441	2	7.5721	11.13**	SIGNIFICANT
ERROR	35.3637	52	0.6801		AT 1%
TOTAL	50.5078	54			LEVEL

** Significant at the 1 percent level.

SIMPLE CORRELATION COEFFICIENTS (r)
BETWEEN CERTAIN CHEMICAL AND PHYSICAL FACTORS

Table 14. TABLE OF r

VARIABLES \ ANALYSIS USED	CORRECTED BY CLASSIFICATION	IGNORING CLASSIFICATION
RESIN A AND % LEAF AND STEM	-0.1878*	-0.3060**
RESIN B AND % LEAF AND STEM	0.1217	0.2686**
H_2O OVEN AND % WHOLE CONE	0.2670**	0.0166
RESIN A AND % WHOLE CONE	0.3245**	0.4504**
RESIN B AND % WHOLE CONE	0.0092	-0.0824
% WHOLE CONE AND LUPULIN(1)	-0.0684	-0.2353**
RESIN A AND LUPULIN(1)	-0.2961**	-0.5112**
TOTAL SOFT RESIN AND LUPULIN(1)	-0.2921**	-0.4317**
RESIN A AND COLOR AND CONDITION	-0.0242	-0.0667
TOTAL SOFT RESIN AND COLOR AND CONDITION OF LUPULIN	0.0064	0.0297

(1) These correlation coefficients are negative because the ratings for lupulin were 1, 2, 3, 4 in order of decreasing amount of lupulin. Actually whole cones, A resin and total soft resin, increase with lupulin increase.

* Significant at the 5 percent level.

** Significant at the 1 percent level.