THE MOST IMPORTANT QUALITY CRITERIA OF SOME HOME-GROWN BLACK-CURRANT VARIETIES.

II. Dry matter, pectin, acid content, colour and formol value.

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In this work, study of the quality of some home-grown varieties of black-currant was continued; the results concerning the ascorbic acid content have been reported in part I of this series (18).

Methods

Dry matter was assayed by direct drying with sand in vacuum at 70°C in accordance with the directions given by AOAC (22).

Acid content and pH were determined electrometrically, with pH 8.2 as the end-point of titration, applying the method of AOAC (22).

The alcohol-insoluble dry matter was assayed by precipitation of the berry homogenate with acid alcohol; the method of GEE et al. was used with slight modifications (7). From the air-dry powder obtained in this way, containing not only pectin but also cellulose and other alcohol-insoluble materials, an assay of the pectin proper was made by means of the acid titration method of the above-mentioned authors (7), and also by the carbazole method according to MCCREADY & MCCOMB (20). The degree of esterification was calculated from the values of the acid titration method.

The colour strength was measured at the absorption maximum (520 mμ), and the results were in all cases calculated for the same dilution 2.5 g/100 ml.

The formol value was arrived at by application of the method of WYLER (26).

Dry matter

Table 1 gives the results of analyses for the 3 years, and the general averages, in diminishing order of the latter values. The values for 1962 are from frozen samples,

Table 1. Averages of dry matter assays of black-currant varieties in 1962—1964, and the general averages.

	1962	1963	1964	Average
Westwick Choice	28.7	—	—	28.7
Boskoop	28.2	—	—	28.2
Wellington XXX	27.9	19.7	20.7	22.7
Silvergieter	27.2	17.5	—	22.3
Wellington X	23.3	19.0	24.5	22.3
Åström	—	22.2	—	22.2
Gerby	21.7	—	20.6	21.2
Roodknop	21.1	—	—	21.1
Goliath	24.2	17.4	21.2	20.9
Brödtorp	23.5	19.9	19.2	20.9
Janslunda	24.4	18.9	19.0	20.8
Black of Lepaa	22.3	20.2	18.7	20.4

as the corresponding values for fresh berries seemed to be somewhat unreliable. The other values relate to fresh berries. The results are given as percentages of the fresh weight.

Fig. 1 illustrates the sequence of the varieties and the dissimilarities between the different years. The varieties differ to a rather small extent; for instance, the

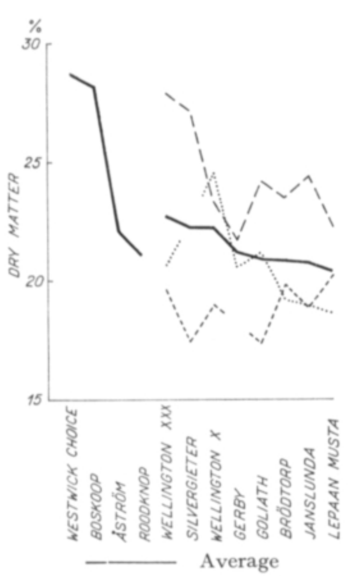

Fig. 1. Dry matter content of black-currant varieties of the 3 years investigated, and general averages.

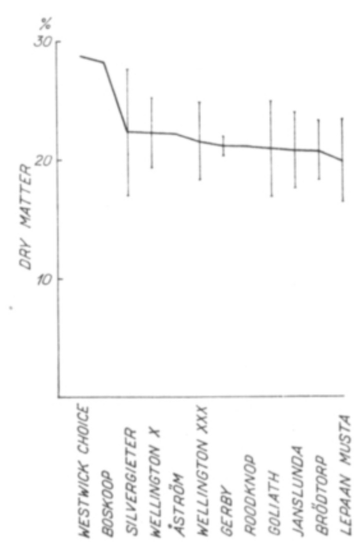

Fig. 2. Dry matter averages and standard deviations of black-currant varieties.

value of Westwick Choice and Boskoop is probably too high in the same way as the other values of these varieties in that year (1962) are above average. In general the values are lowest in respect of 1963. The order of the varieties deviates considerably in the different years.

Statistical treatment was effected in the same way as earlier with the ascorbic acid values. In Table 2, there is given for each variety the average, the standard deviation, the number of samples (n) and the limits of variation calculated from the above results (average ± standard deviation), along with the limits of variation observed.

Table 2. Statistical testing of the reliability of the dry matter averages.

	Average	St. D.	n	Limits of variation calculated	Limits of variation observed
Westwick Choice	28.7		1		
Boskoop	28.2		1		
Silvergieter	22.33	± 5.25	2	17.08—27.58	17.45—27.2
Wellington X	22.3	± 2.9	3	19.4 —25.2	19.0 —24.5
Åström	22.2		1		
Wellington XXX	21.54	± 3.26	12	18.28—24.80	18.34—29.54
Gerby	21.15	± 0.78	2	20.37—21.93	20.6 —21.7
Roodknop	21.1		1		
Goliath	20.92	± 4.02	3	16.90—24.94	17.35—24.20
Janslunda	20.75	± 3.16	3	17.59—23.91	18.85—24.40
Brödtorp	20.72	± 2.55	16	18.17—23.27	17.65—25.31
Black of Lepaa	19.85	± 3.44	9	16.41—23.29	16.54—28.03

Fig. 2 indicates the differences between the varieties. Standard deviations are shown as vertical segments. It may be seen that the varieties diverge relatively little in respect to the dry matter. For Westwick Choice and Boskoop, which are highest, the value relates to one single sample; it seems improbable that they would in fact be so much higher than those of the other samples. The significance of the differences between the other varieties was studied statistically by means of the t-test. Here the value of Black of Lepaa, which was lowest, was compared with Silvergieter and Wellington XXX, among the highest. The probability that the difference discovered is not attributable purely to chance is 70 % for Wellington XXX and 60 % for Silvergieter. The significance of the differences is thus not very great.

The effect of weather conditions on the dry matter may be studied by comparing the series for the different years. In general, the dry matter was largest in 1962, when the temperature was lowest, and smallest in 1963, when the temperature was highest. It is likely that high temperature favours the general metabolism, which would lead to a loss of dry matter (cf. 4). As regards precipitation, it was thought possible that abundant precipitation in the ripening phase of the berries would increase the water content, and thus diminish the dry matter. However, no such relationship is observable when a comparison is made between the dry matter content of any variety and the corresponding amount of precipitation in the summer months or in August. It thus seems that abundant precipitation does not induce a direct diminution in the dry matter content of berries.

The locality of cultivation does not seem to exert a significant influence upon the dry matter values.

The literature contains but scanty detailed information on the dry matter of black-currant. In their table, Turpeinen & Roine (25) give 20 %; according to Beythien & Linzel (cf. 12) the dry matter content is 21 %. Jacobs (13) reports an average of 19.44 %, a minimum of 15.93 % and a maximum of 24.43 % (according to Lampitt & Hughes, 1928, cf. 13, p. 317), and as an average 19.00 %, as a minimum 13.7 % and as a maximum 24.4 % (according to Hughes & Maunsell, 1934, cf. 13, p. 318). Souci, Fachmann & Kraut (23) give for black-currant (edible portion) av average of 82.2 g water/ 100 g, i.e. 17.8 % dry matter; the variation limits given are 15.3 — 21.0 %. For the different varieties, 19.5 % for Boskoop Riesen and 18.5 % for Goliath have been reported by Maurer (19). Groven (11) presents the following values as averages for 4 years: Westwick Choice 20.5 %, Wellington XXX 19.9 %, Boskoop Giant 19.7 %, Brödtorp 18.4 %, Roodknop 18.3 % and Silvergieter 17.7 %. In the present series, the average of all samples was 21.24 %, rather higher than the figures put forward in the literature. The value of dry matter may depend in part upon the method used in the assay. If drying is effected at 100°C, volatile substances other than water may be removed simultaneously. In the present series, the drying was done at 70°C in vacuum to avoid secondary changes. For the variety Noir de Bourgogne, grown in France, Gouny & Vangheesdaele (10) report dry matter values, arrived at by the same method as here; they found the maximum value (19.6 %) at picking time; subsequently the value diminishes slightly (19.3 % after a week). In general, published reports do not specify the method of assay, but if the drying has been effected at 100°C,

Table 3. Values of alcohol-insoluble dry matter and pectin assayed by the carbazole method for the 3 years, and general averages in diminishing order of the former averages.

	Alcohol-insoluble dry matter				Pectin by carbazole method			
	1962	1963	1964	Average	1962	1963	1964	Average
Wellington XXX	8.9	8.2	9.6	8.9	1.99	1.44	1.69	1.65
Wellington X	7.3	9.2	9.9	8.8	1.50	1.61	1.93	1.68
Åström	—	8.7	—	8.7	—	1.41	—	1.41
Gerby	7.3	—	9.4	8.4	1.08	—	1.83	1.46
Silvergieter	9.2	6.2	—	7.7	2.25	0.96	—	1.61
Boskoop	7.7	—	—	7.7	2.34	—	—	2.34
Brödtorp	7.5	7.4	8.0	7.6	1.17	1.21	1.33	1.24
Black of Lepaa	6.9	8.0	7.9	7.6	0.97	1.26	1.39	1.21
Goliath	8.0	6.4	8.1	7.5	1.88	0.94	1.84	1.56
Westwick Choice	7.3	—	—	7.3	1.43	—	—	1.43
Janslunda	7.3	6.7	7.4	7.1	1.61	1.27	1.50	1.46
Roodknop	5.9	—	—	5.9	1.29	—	—	1.29

Table 4. Values for pectin assayed by the acid titration method, and the degree of esterification for the 3 years, and general averages in the same order as in Table 3.

	Pectin by acid titration method				Degree of esterification %			
	1962	1963	1964	Average	1962	1963	1964	Average
Wellington XXX	2.30	1.83	2.15	2.09	55.7	60.5	54.9	57.0
Wellington X	2.14	2.22	2.21	2.19	62.9	62.9	65.4	63.7
Åström	—	2.27	—	2.27	—	64.8	—	64.8
Gerby	2.52	—	2.10	2.31	47.9	—	58.9	53.4
Silvergieter	2.45	1.37	—	1.91	56.3	60.4	—	58.4
Boskoop	2.53	—	—	2.53	68.2	—	—	68.2
Brödtorp	2.25	1.72	2.01	1.99	53.6	59.0	45.4	52.9
Black of Lepaa	1.50	1.97	1.92	1.80	56.3	64.5	49.1	56.6
Goliath	2.38	1.36	2.09	1.94	65.0	60.8	66.9	64.3
Westwick Choice	2.49	—	—	2.49	49.2	—	—	49.2
Janslunda	1.92	1.42	1.79	1.71	66.4	64.7	67.2	66.1
Roodknop	1.89	—	—	1.89	51.6	—	—	51.6

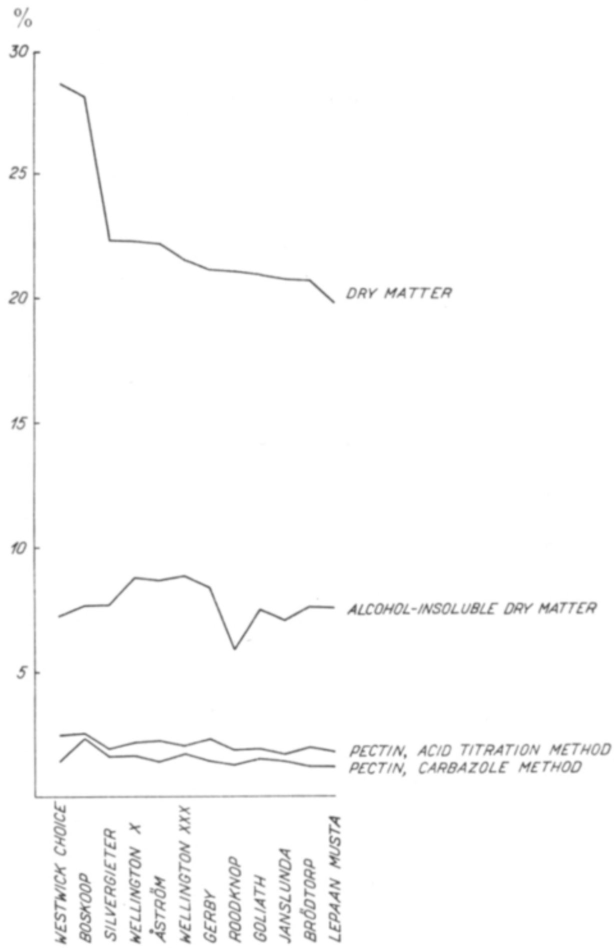

Fig. 3. Pectin, assayed by the acid-titration and carbazole methods, alcohol-insoluble dry matter and dry matter of black-currant varieties as averages of 3 years.

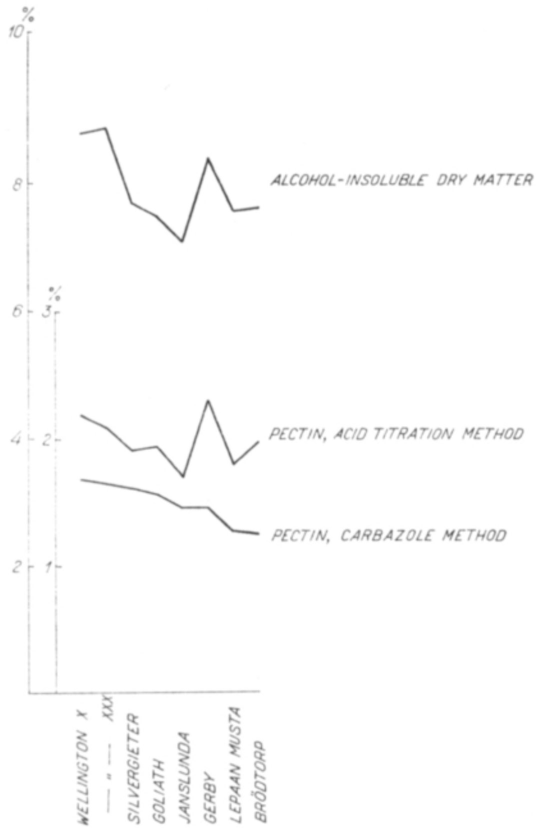

Fig. 4. Pectin, assayed by the acid-titration and carbazole methods, and alcohol-insoluble dry matter as averages of values obtained from at least 2 years' results.

lower values are found. It might be that a cool climate favours higher dry matter values, as has been hinted at in consideration of the effect of weather conditions on the dry matter. The findings cited in literature relate to countries warmer than Finland.

Alcohol-insoluble dry matter, pectin assayed by the carbazole and the acid titration methods, and degree of esterification of pectin

The alcohol-insoluble dry matter was isolated from fresh or frozen berries, and stored as air-dry powder until the pectin assays. The results are calculated in g/100 g fresh weight. From the assay of pectin by acid titration, a calculation was made of the degree of esterification to obtain a picture of the type of pectin: the higher the degree of esterification, the more native is the pectin, whereas a low degree of esterification indicates an enzymatic breakdown of pectin. Tables 3 and 4 present the results of these assays.

Figures 3—5 illustrate the results arrived at. First, an examination is made of the way in which alcohol-insoluble dry matter and pectin assayed by acid titration

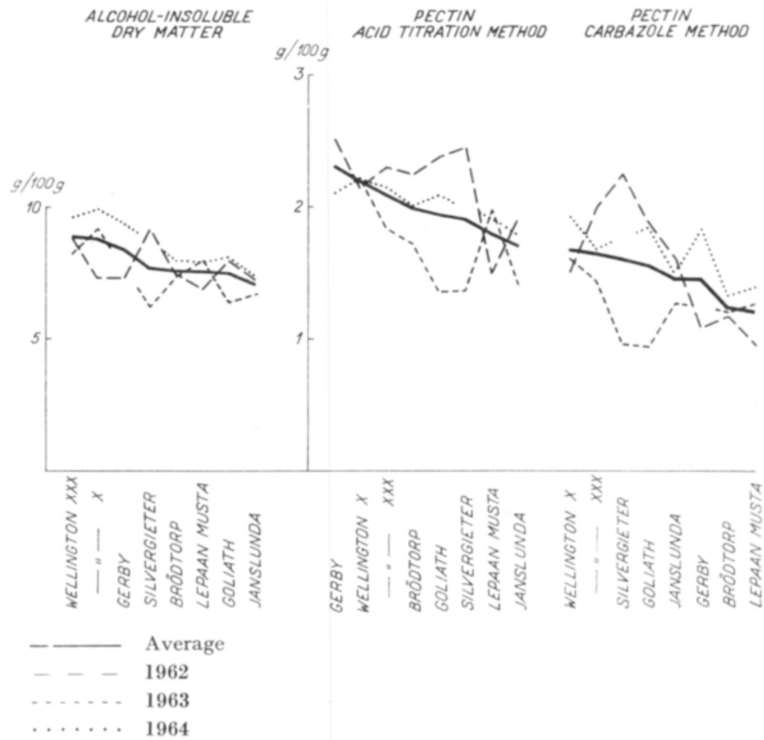

Fig. 5. Alcohol-insoluble dry matter and pectin, assayed by the acid titration and carbazole methods, of black-currant varieties in the different years investigated as compared with the averages.

and carbazole method are changed if the varieties are arranged in diminishing order of the dry matter, and all the values are given the same scale (Fig. 3). It seems that when this scale is employed, the differences in pectin content between the varieties are comparatively small, and the order does not follow that of the dry matter (it is well known that the bulk of dry matter is sugar, which is soluble). In this figure, all the varieties have been taken into account and their averages compared. The picture may be more reliable if the only varieties included are those for which values with respect to more than one year are available. Fig. 4 contains the average values of 8 such varieties, arranged according to the pectin assayed by the carbazole method. Here, it is seen that pectin assayed by the acid titration closely follows the same declining line, with a slight deviation in only the last part of the line. The course of the alcohol-insoluble dry matter is very similar to this line. In Fig. 5 there is a comparison of the values for the different years for the 8 varieties above. This establishes that in 1964, the pectin assayed by the carbazole method was regularly higher than average, whereas in 1963 it was lower than average. Pectin assayed by titration behaved in a similar way and so did alcohol-insoluble dry matter. The findings for 1962 are in line with those for 1964, but the variability is greater.

In an examination of the results obtained in these pectin analyses, it is advisable to bear in mind that many different factors may influence the amount of pectin. It is generally known that changes take place in pectin during the ripening of fruits and berries. Particularly in the case of black-currant, it is known that an early crop is suitable for the making of jam and jelly, since at this phase the berries contain an abundance of pectin. By contrast, late crop, in which the pectin is more or less decomposed, is suitable for juice production, where the removal of pectin is essential.

In these present studies, the clearly unripe berries were removed before analysis, the degree of maturity having been evaluated on the basis of colour. Thus the samples do not contain distinctly unripe berries, although the limit between ripe and over-ripe berries is more difficult to assess. The only indications which could be taken as signs of overripeness are the macroscopically evaluated condition of the berries and, perhaps, a high aroma number.

In one case, where the sample contained a particular abundance of unripe berries, separate studies were made of the ripe and unripe parts (sample of Black of Lepaa from Piikkiö, 1963). The following results were obtained:

	Dry matter %	Alcohol-insoluble dry matter %	Pectin carbaz.	Pectin acid titr.	Degree of esterifica-tion
Unripe sample	17.55	9.0	1.282	2.175	62.05
Ripe sample	18.4	7.5	1.013	1.688	63.9

Accordingly, during maturation there occurs an increase in the dry matter (i.e. the sugar content), whereas the alcohol-insoluble dry matter and pectin diminish (cf. 10). By contrast, in the degree of esterification of the pectin there is no more than a slight change. As the amount of pectin is substantially dependent upon the degree of maturity, and exact definition of this is difficult, it is to be assumed that this fact would impose obstacles to study of the possible differences between the varieties. In Tables 3 — 4, there were presented the pectin values for the different varieties, and from these results it is evident that the values obtained by the carbazole method are systematically lower than those obtained by acid titration. The significance of the differences obtained may be tested statistically. Here it is best to compare the varieties Wellington XXX and Black of Lepaa, where the number of samples was large and where the former evidenced almost the highest value, and the latter almost the lowest. This check gave the following result:

	n	Carbazole method Average	Carbazole method St. D.	Acid titration method Average	Acid titration method St. D.
Wellington XXX	11	1.652	± 0.289	2.061	± 0.279
Black of Lepaa	9	1.269	± 0.250	1.839	± 0.360
Degree of freedom: 18					
P		99 %		80 %	

Thus the difference between these varieties is very significant if the carbazole method is applied. When using the acid titration method the difference lies in the same direction, although its significance is less. In cases where the difference between the varieties is less than here, and there are fewer samples, the significance of the difference is also less, of course.

Nevertheless, the above result gives reason to believe that differences do in fact exist between the varieties with respect to the amount of pectin. This fact is interesting from the standpoint of the utilization of black-currant, as a large amount of pectin is advantageous when jam or jelly is being produced, whereas a small amount of pectin is preferable for juice. The largest amount of pectin is found in both Wellington types, whereas Brödtorp, Black of Lepaa, Roodknop and Janslunda contain less pectin.

If a comparison is made of the values for the different years, the following results are obtained for the averages of all varieties of the same year:

	1962	1963	1964	General average
Alcohol-insoluble dry matter	7.58	7.69	8.54	7.97
Pectin assayed by carbazole method	1.498	1.295	1.534	1.448
Pectin assayed by acid titration method	2.181	1.789	2.032	2.002
Degree of esterification	56.44	65.33	53.96	58.13

The year 1963 was the warmest; then the amount of pectin, as determined by both the carbazole and the acid titration method, was lowest. As for the alcohol-insoluble dry matter, a similar difference is observable between the years 1963 and 1964, but the 1962 value deviates from the series. The value for the degree of esterification is highest in 1963.

In these results, the values arrived at by the carbazole method should be considered most reliable. Consequently the differences between the years, using this assay, were tested statistically by the t-test, and the results were as follows:

Year	Average	St. D.
1962	1.498	± 0.500
1963	1.295	± 0.254
1964	1.534	± 0.259

	Degree of Freedom	P
Difference between 1962—1963	30	80 %
—»— 1963—1964	33	99 %

The differences between the general averages of the different years may thus be considered rather well-defined.

The averages calculated in this instance also include varieties of which only a single sample from one year and locality was available. If an examination is made of the series in which the same variety was studied in the same locality during the 3 successive years, it is found that the general rule stated above holds good to a great extent. Thus, a high summer temperature seems to diminish the amount of pectin, although its degree of esterification simultaneously remains high. It might be mentioned that, according to Biale (4), apart from sugar, pectin may also serve in the respiration as substrate during fruit storage.

On the basis of the above, the assumption might be made that the degree of north latitude of the place of growth could exercise a similar influence on the pectin values, so that in more southern localities the amount of pectin would be less, and the degree of esterification higher than in those further to the north.

To check this assumption, there are presented below the values of pectin obtained for the different localities:

	Piikkiö	Pälkäne	Laukaa	Ylistaro	Maaninka	Rovaniemi
Pectin by carbazole method	1.508	1.386	1.541	1.527	1.310	1.094
Pectin by acid titration method	1.910	1.785	2.173	2.305	2.023	1.913
Degree of esterification	63.67	60.14	54.91	48.64	48.76	57.1
Alcohol-insoluble dry matter	7.76	8.0	8.61	8.85	7.54	7.35

The above values indicate the non-validity of the assumption as such. When assayed by the carbazole method, the amount of pectin is of the same order in Piikkiö, Laukaa and Ylistaro, lower in Pälkäne and Maaninka and lowest in Rovaniemi. On assay by the acid titration method, the values are highest in Laukaa, Ylistaro and Maaninka, next come Piikkiö and Rovaniemi, and in Pälkäne the value is lowest. The alcohol-insoluble dry matter is highest in Laukaa and Ylistaro, and diminishes progressively towards the south, but also towards the north (Maaninka and Rovaniemi) the values are lowered. A clear-cut distribution in accord with the degree of north latitude is thus not discernible. In contrast a more distinct tendency is noted in the degree of esterification; the values diminish towards the north, and only the northernmost part deviates somewhat, with the value of Rovaniemi in particular being again higher.

If the question is studied, and there are taken into account the values for a single variety in different localities in the same summer (for this, the series in 1964 provide the best fit), it is noted that as regards Wellington XXX a clear-cut increasing tendency towards the north occurs in the pectin values assayed by the carbazole method. A similar tendency, with slight deviations, is to be noted in the corresponding values obtained by acid titration. In Black of Lepaa, the results are similar (with Maaninka, the sample of which was overripe, providing an exception). In Brödtorp, too, a corresponding tendency is observable (exceptions being samples of Ylistaro and Maaninka, which suffered from prolonged transport). In the degree of esterification, the same samples show a tendency to diminish towards the north, although the series are somewhat uneven. It might be mentioned that the diminution in the degree of esterification may take place relatively rapidly, so that unevenness in these results is easily brought about.

In literature, information on the pectin content of black-currant is rather scanty. Nehring & Krause (21) state only that the pectin content of black-currant is high. Jacobs (13), according to the table of Lampitt & Hughes, (cf. 13. p. 317) give the average of 1.52 % for pectin content, with a maximum value of 1.79 %, and a minimum of 1.37 %. Kertesz (14) refers to the same table, mentioning that the value is the average of 4 assays made by application of the Ca-pectate method. According to MAURER (19), the pectin values of 7 varieties vary between 0.7 — 2.22 %. Of the varieties, only Boskoop and Goliath were useful for comparison with the present results, and according to MAURER their order differs from that obtained here: for Boskoop, assay by the carbazole method 2.34 %, by acid titration 2.53 %, whereas MAURER finds 1.77 %; for Goliath, assay by the carbazole method 1.56 %, by the acid titration method 1.94 %, according to MAURER 2.22 %. TRESSLER & JOSLYN (22, p. 728) report values of BOGDANSKI et al. (5) for Russian berries varying between 0.69—3.15 %. Correspondingly, values for English berries are reported, varying between 0.90 — 1.25 % (15) or between 0.68 — 1.45 % (probably according to CHARLEY, cf. 24, p. 728). The Ca-pectate assay method was probably used.

It may be that the scantiness of information in literature concerning the pectin content of black-currant can be ascribed to the fact that the industry utilizing black-currant is little interested in the amount of pectin in black-currant, as the main product is juice, and in juice production, pectin has to be removed in any case. In the British method, as referred to by TRESSLER & JOSLYN (24), pectin is completely removed to obtain juice of which the stability is fully guaranteed. In contrast, the German method allows of the retention of some pectin in the juice; for instance, in the tables of KOCH & ZEYEN (17), the pectin content in pure juice is 0.41 g, in pomace extract 0.07 g and in the blend 0.35 g/100 ml. This pectin remaining in the juice is rather highly esterified, and makes the juice rather viscous; KOCH considers this to be important from the point of view of aroma, when juice of the »Süssmost» type is being produced.

Again, those engaged in horticultural studies evidently do not consider the pectin content important from the point of view of plant-breeding, and thus little attention has been paid to the pectin content by these investigators.

Table 5. Acid content of black-currant varieties according to analyses during 3 years, and the general averages.

	Fresh weight				Dry matter			
	1962	1963	1964	Average	1962	1963	1964	Average
Boskoop	708			708	2511			2511
Roodknop	674			674	3200			3200
Åström	—	628	—	628	2829			2829
Janslunda	632	626	555	604	2586	3320	2921	2942
Westwick Choice	574	—	—	574	1997	—	—	1997
Gerby	640	—	500	570	2946	—	2427	2687
Black of Lepaa	634	564	510	569	3051	2824	2728	2868
Brödtorp	620	561	504	562	2589	2886	2625	2700
Wellington XXX	611	547	481	546	2184	2794	2328	2435
Goliath	562	498	477	512	2327	2870	2250	2482
Silvergieter	530	487	—	509	1696	2791	—	2244
Wellington X	546	471	412	474	2348	2479	2117	2315

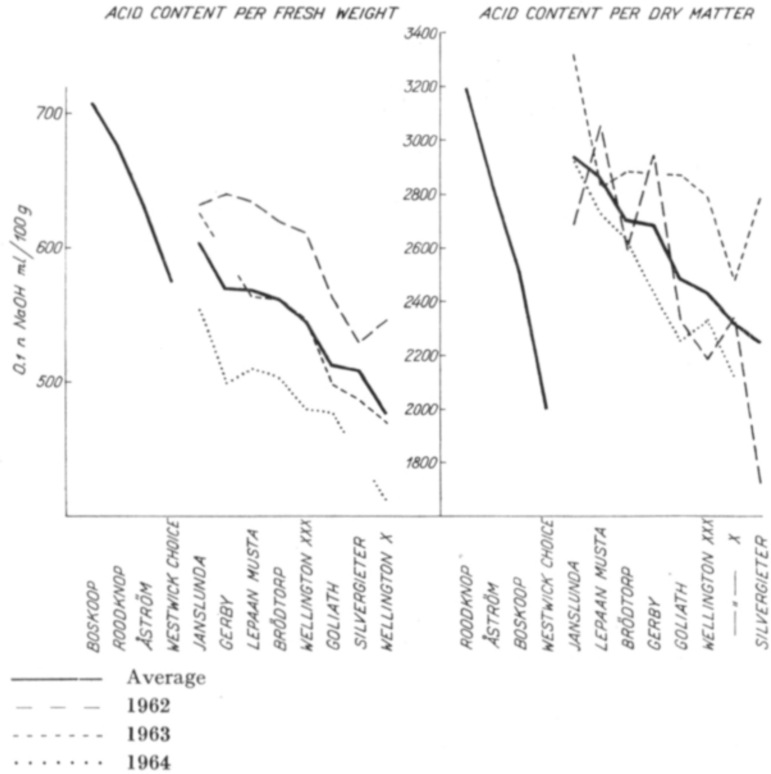

Fig. 6. Acid content of black-currant varieties, on fresh weight and on dry matter, in the 3 years investigated, and general averages.

Table 6. Statistical testing of the reliability of averages of acid content.

	Average	St. D.	n	Limits of variation calculated	Limits of variation observed
Boskoop	708		1		
Roodknop	674		1		
Åström	628		1		
Janslunda	604	± 43	3	571—647	555—632
Westwick Choice	574		1		
Gerby	570	± 99	2	471—669	500—640
Brödtorp	560	± 64	16	496—624	462—670
Black of Lepaa	550	± 56	9	494—606	475—636
Wellington XXX	525	± 62	12	463—587	431—662
Goliath	512	± 44	3	468—556	477—562
Silvergieter	509	± 30	2	479—539	487—530
Wellington X	476	± 67	3	409—543	412—546

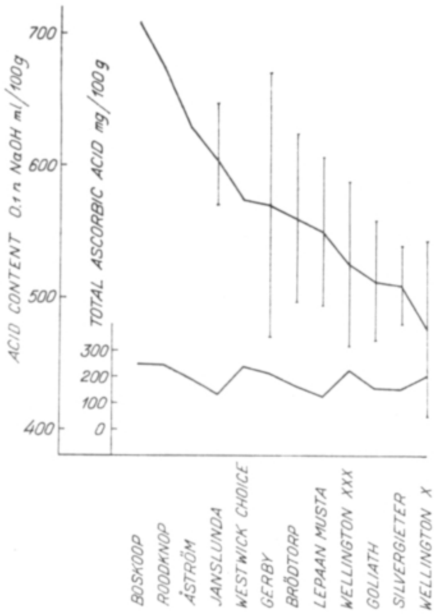

Fig. 7. Acid content averages and standard deviations of black-currant varieties, and corresponding total ascorbic acid values.

Acid content and pH

Table 5 presents the acid titration values for the varieties in the 3 years, and the general averages are presented in diminishing order. For 1962, the values relate to frozen berries, and the others to fresh ones: in the former case the values from the fresh berries were not wholly reliable. The values are given in ml 0.1 n NaOH/100 g of berries, and acid content is calculated both on fresh weight and on dry matter.

Fig. 6 illustrates the sequence of the varieties, and the divergences between the different years. The values of the varieties ot which only one sample was studied are shown in the left hand corner of the diagram. It may be seen that the acid content, fresh weight, was in 1962 higher than average, and in 1964 lower than average. Calculated on dry matter, the values were highest in 1963, when the dry matter values were lowest, and lowest in 1964. In 1962, both the acid content and the dry matter were high, and thus the acid content, dry matter, remains generally low. The order of the varieties varies but little between the different years.

Statistical checking of the reliability of the averages was carried out in the same way as before. In Table 6, there are given the average, standard deviation and number of samples (n) for each variety, along with the calculated and observed limits of variation.

Fig. 7 visualizes the differences between the varieties. The standard deviations are indicated as vertical segments. Particularly as regards Gerby, the deviation is large. The ranges of acid content for the different varieties in many cases markedly overlap, so that their order may easily be reversed in other series of analyses.

The figure also contains the corresponding values of total ascorbic acid, with a view to checking whether any correlation exists between acid content and amount

Table 7. The pH values of black-currant varieties for the 3 years, and the general averages.

	1962	1963	1964	Average
Wellington XXX	3.57	3.36	3.03	3.22
Janslunda	3.40	3.38	2.95	3.24
Black of Lepaa	3.46	3.34	3.12	3.24
Gerby	3.49	—	3.05	3.27
Brödtorp	3.47	3.39	3.10	3.30
Åström	—	3.30	—	3.30
Goliath	3.43	3.40	3.10	3.31
Wellington X	3.41	3.55	3.25	3.40
Roodknop	3.45	—	—	3.45
Silvergieter	3.41	3.50	—	3.46
Boskoop	3.50	—	—	3.50
Westwick Choice	3.60	—	—	3.60

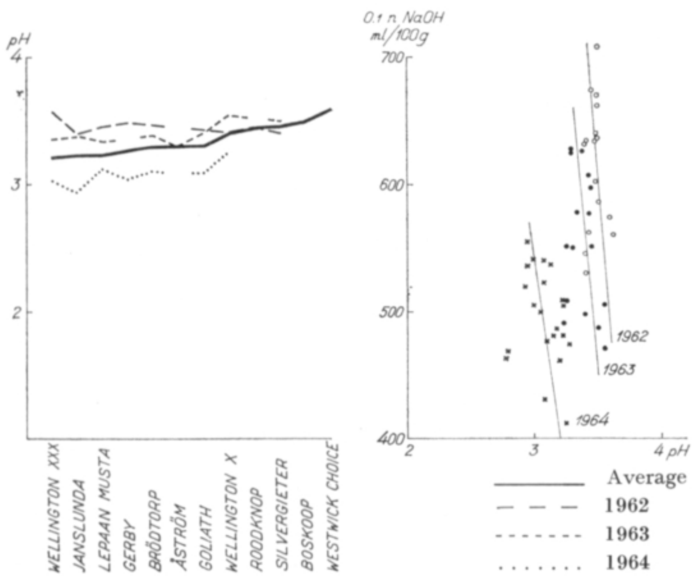

Fig. 8. Values of pH of black-currant varieties. On the left: values for the different years and general averages. On the right: correlation of acid content and pH in the different years.

of ascorbic acid, as has been assumed (cf. 6). No perfect correlation is noted, but some parallelism seems to occur.

In respect of pH, the values among the different varieties vary but little. In Table 7, the variety average of the different years and the general averages are given in the order of the latter.

Fig. 8 provides a comparison of the different years. On the left it is observable that in 1964 the values were systematically lower than average, whereas in 1962 and 1963 the values were in general higher than average. Nevertheless, the differences are only small. In the diagram, in the right hand corner, there is indicated the correlation between the acid content and pH. Each year, a higher acid content corresponds to a lower pH, but the change in pH is much smaller than that in acid content. In all, the different years are slightly dissimilar, so that the diminution in pH due to acid content was least in 1962, and most marked in 1964.

It has been suggested (9) that in the Far North the currants would contain more acid and less sugar than those further south. If a study is made of how far the temperature of summer influences the acid content, some correlation is found when acid content and the cumulative total of heat of a sample are compared, although the variety, the degree of maturity and other factors may induce variability. Precipitation does not seem to exercise a systematic influence. By contrast, the amount of sunshine appears to be important. In 1962, when the acid content was highest, the least sunshine was recorded, whereas both 1963 and 1964 were sunny years. When the acid content and the totals of hours of sunshine were compared, with respect to all the samples, a comparatively clear-cut negative correlation was observed, i.e. the less the total of sunshine, the higher is the acid content.

Comparison of the acid content values obtained here with those reported in literature shows that the former are regularly higher than, for instance, those given

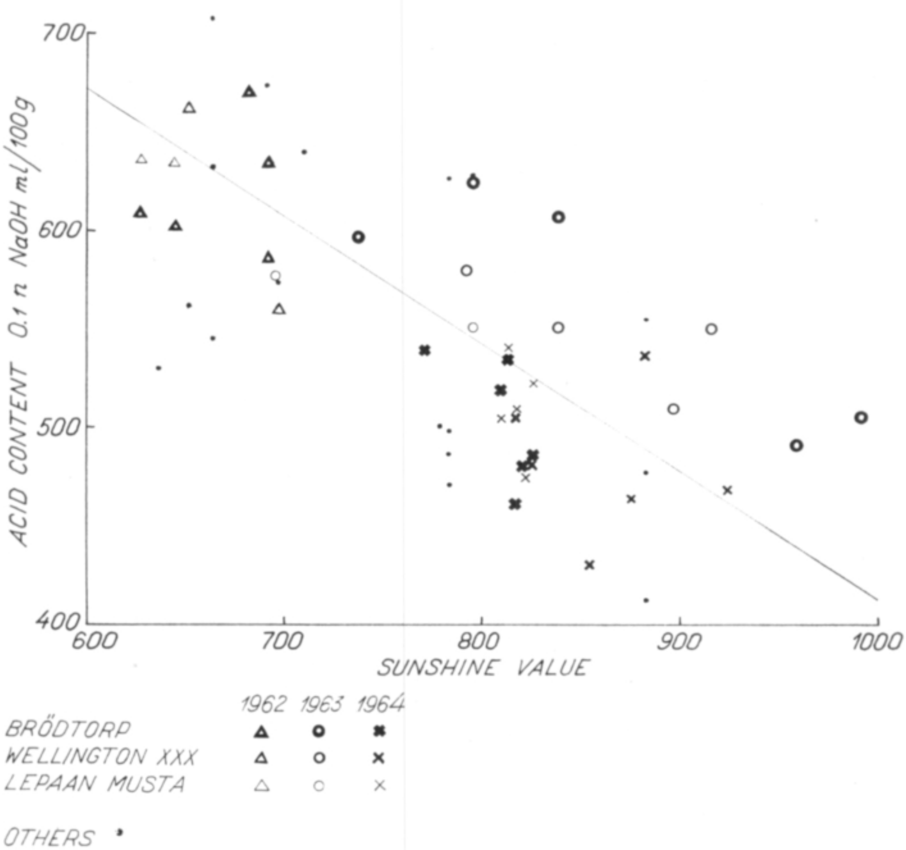

Fig. 9. Correlation between acid content and corresponding sunshine values.

by JACOBS (13): maximum 622, average 499, and minimum 121 ml 0.1 n NaOH/100 g; the variety is not quoted. BAUMANN (2) reports an acid content of 3 %, which if calculated as citric acid corresponds to 469 ml 0.1 n acid/100 g. As a general rule, it seems that Finnish-grown black-currant contains more acid than that of Central Europe. SOUCI (23) gives for black-currant 3.03 g citric acid/100 g and 0.4 g malic acid/100 g, which would together mean 533 ml 0.1 n NaOH/100 g. This is higher than the above-mentioned values given in literature. For the different varieties, BAUMANN (3) gives values representing g total acid per litre of juice. Comparison of the varieties studied with the present results shows that the sequence is nearly the same in both cases; BAUMANN emphasizes that lack of sunshine increases the acid content. Further, KOCH & BRETTHAUER (16) and GROVEN (11) report acid content values for jüices pressed from different varieties. GROVENS values are comparatively low, and the differences between the varieties small. The results of KOCH correspond approximately to the results of BAUMANN, and also to the present values.

Table 8. Values for colour strength of black-currant varieties during the 3 years, and the general averages, in diminishing order of the latter.

	1962	1963	1964	Average
Boskoop	988	–	–	988
Åström	–	890	–	890
Silvergieter	522	872	–	697
Wellington X	490	889	668	682
Janslunda	633	930	401	655
Roodknop	591	–	–	591
Brödtorp	598	651	496	582
Goliath	571	700	392	554
Black of Lepaa	528	655	370	518
Wellington XXX	471	647	389	503
Westwick Choice	486	–	–	486
Gerby	519	–	371	445

Colour strength

In Table 8, there are compiled the values for the 3 years and the general averages, in the order of the latter. In 1962, the values were obtained from frozen samples and the others from fresh ones. The absorption readings have been calculated for the dilution of 2.5 g/100 ml, and measurement was made at 520 mμ, in general the maximum point.

Fig. 10 illustrates the results. It is observable that the values were highest in 1963 and lowest in 1964. The order of the varieties in the different years shows considerable variation.

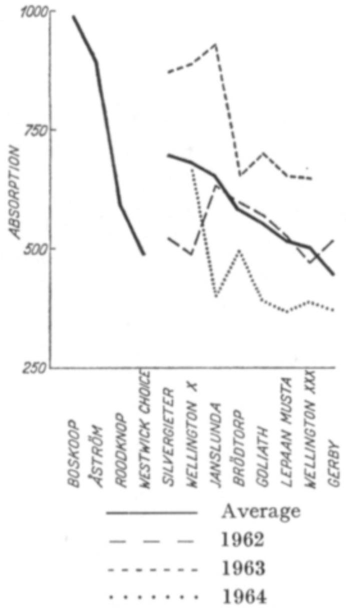

Fig. 10. Colour strength of black-currant varieties in the different years investigated, compared with the average.

Statistical testing of the reliability of the differences found between the varieties is in this case less useful, since there is relatively little mutual deviation in the values of those varieties where the number of samples is greatest. However, a tentative calculation was made of the significance of the difference between varieties Wellington X and Wellington XXX, of which the former is No. 4 in the sequence, and the latter No. 10. The following result was obtained:

				Limits of variation	
	Average	St. D.	n	calculated	observed
Wellington X	682	± 200	3	482—882	490—889
Wellington XXX	499	± 175	11	324—674	308—821

Degree of freedom: 12
P 80 %

Thus the differences between the varieties may in fact be assumed to possess some significance, although not very much.

The effect of the summer temperature was already observable in Figure 10, which shows that the colour strength was greatest when the temperature was highest. This is also indicated in the comparison of mean values of all samples for each year, presented in the following:

				Limits of variation	
	Average	St. D.	n	calculated	observed
1962	574	± 147	16	427—721	380—988
1963	715	± 175	16	540—890	410—930
1964	430	± 130	20	300—560	282—810

		Degree of freedom	P
Difference between	1962—1963	30	95 %
» »	1963—1964	34	99 %

Thus in 1963, when the summer was warmest, the colour strength was significantly greater than in both the other summers. Against this, the warm summer diminished the dry matter, so that the greater colour strength is not connected with increased dry matter; even if the summer temperature is high, the water content of these berries is not diminished, by virtue of the protecting wax coating of the berry surface; the loss of dry matter again is probably attributable to increased metabolism caused by higher temperature. An increase of colour strength may be connected with the fact that high temperature (or abundant sunshine) favours the synthesis of anthocyanins: it might also be that in a warm summer the berries remain smaller than in a cool one, whereby the relative proportion of the skin is increased; the anthocyanins are localized in the skin part.

The size of the berries was measured only in 1964, by weighing 100 of them. This material was used as a basis for a study of the correlation between the size of the berries and the colour strength, as shown in Fig. 11. Is seems that a slight

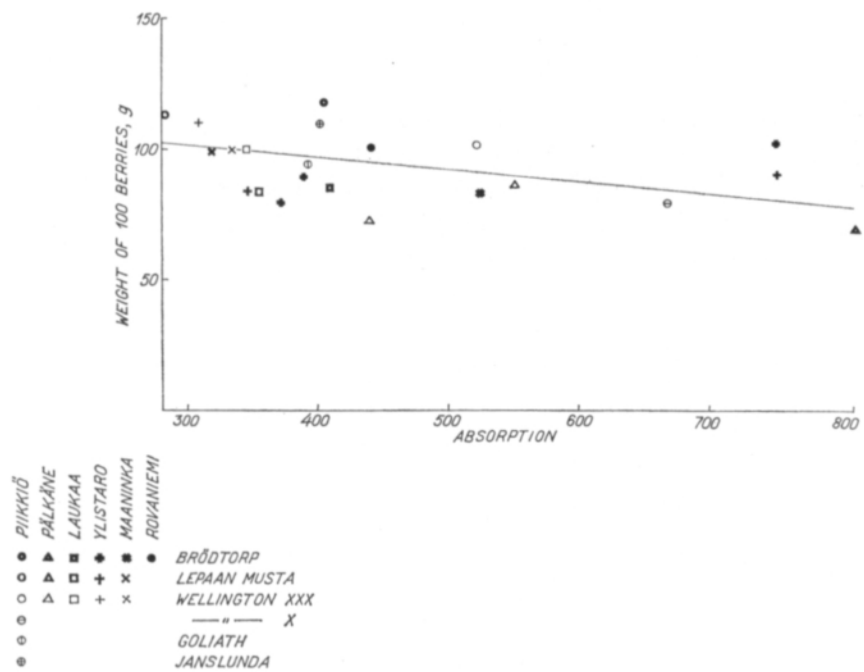

Fig. 11. Correlation between the berry size and colour strength according to results obtained in 1964.

negative correlation is observable. In the figure, the effect of variety and the locality of growing are detectable. No very clear-cut differences are present. Strong colour is observable in Wellington X; in Brödtorp, the colour is stronger than in Wellington XXX and Black of Lepaa. It seems, as regards the various localities, that berries from Piikkiö are large, those from Pälkäne and Laukaa again relatively small. Furthermore, in 1962, although the size was not measured, Boskoop was observed to be a particularly small-sized berry, and correspondingly the colour was very strong. It is regrettable that the berry size was not measured in 1962 and 1963, as it is not possible to establish whether high summer temperature had reduced the berry size.

A study may also be made whether a more southern latitude of the growing locality has an effect corresponding to high summer temperature. For this purpose, the averages of all samples for each locality have been compared. This comparison is presented below.

	Average	n	Limits of variation
Piikkiö	626	21	282—988
Pälkäne	660	5	438—810
Laukaa	591	7	344—890
Ylistaro	411	6	308—531
Maaninka	484	10	317—716
Rovaniemi	450	3	410—499

It can be seen that a slightly increasing trend towards the south occurs, although this is not very clear-cut. However, there is no increase to be found between Pälkäne and Piikkiö, and the values for Ylistaro are low (in this case, changes attributable to transport were perhaps partly responsible). A very marked influence of the degree of southern latitude is, in fact, not to be expected, since the local micro-climate may here as well signify more than the actual latitude of the place.

The possible effect of the amount of sunshine can also be considered on the basis of the present material. It has been established that light is essential for the formation of anthocyanins (cf. 7), and thus a study was made whether a correlation exists between the colour strength and the corresponding totals of hours of sunshine, or cumulative totals of heat. In this connexion it was found that there existed a comparatively clear correlation with respect to the totals of heat; in the case of hours of sunshine, some correlation was also present, although it was less distinct. In both cases, the type of deviation led to the assumption that from some point onwards increasing heat or light no longer increased the colour strength. It is probable that light in particular was in excess, so that it did not form a limiting factor.

Literature contains relatively little information concerning the colour strength of black-currant varieties. Baumann (3), when comparing different varieties, mentions that differences between the varieties are inessential. From the point of view of quality he considers vitamin C most important, and as regards cultivation, also the yield. In his opinion, acid content, colour strength and aroma are less important, and accordingly no values are given for these properties. Ayres, Charley & Swindells (1) give some values for juices pressed from different varieties, and show that colour strength is lowest for early crop, higher in the middle of season, and even somewhat higher in the late season. Of the varieties studied, only a few were the same as here; thus the colour strength of Wellington XXX was greater than of Westwick Choice, which agrees with the average obtained here (it is true that the difference is only slight, and in 1962 the result is the reverse). Koch & Bretthauer (16) found the amount of anthocyanins in Boskoop and Silvergieter

Table 9. Formol values of black-currant varieties during the 3 years, and the general averages.

	1962	1963	1964	Average
Westwick Choice	24	–	–	24
Black of Lepaa	20	24	19	21
Wellington XXX	18	17	17	17
Brödtorp	15	16.5	17.5	16
Roodknop	16	–	–	16
Boskoop	16	–	–	16
Silvergieter	14	14	–	14
Åström	–	14	–	14
Goliath	14	11.5	11	12
Gerby	14	–	9	12
Janslunda	18	1	9	9
Wellington X	12	2.5	11	8.5

to be greater than in Roodknop and Wellington 30, a result which resembles that obtained here. GLEISBERG & AUMANN (8) report for black-currant (variety Silvergieter) 76.0 mg anthocyanin/100 ml as colour strength; however, it is difficult to compare this finding with the present results.

Formol value

Table 9 presents the averages of varieties during the 3 years, the general averages being arranged in their diminishing order. Some of the assays were made with fresh berries, and in part frozen material was used.

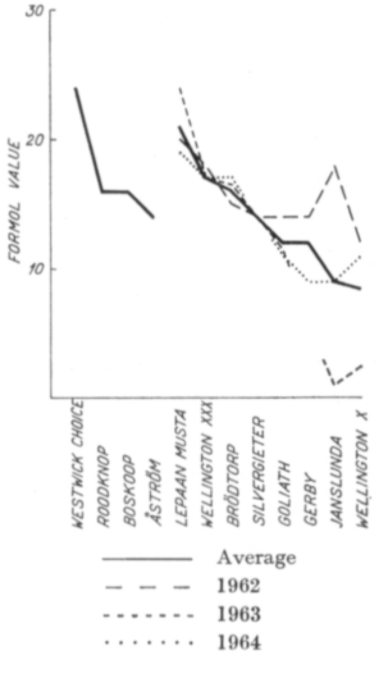

Fig. 12. Formol value of black-currant varieties in the different years investigated, compared with the averages.

Fig. 12 illustrates the results. It can be observed that for most of the varieties the differences between the years are rather small, the effect of the different years being very slight is seen only in the fact that some exceptionally low values were noted in 1963. This might be connected with formol values being high in unripe berries (cf. 26); thus the berries would be most definitely ripe in 1963, when the temperature was high. It general, however, the values are higher than those for 1963, remaining in the range 8—24. WYLER (26) gives for black-currant the values 25 (unripe) and 20 (ripe). Other literature values are found in AYRES, CHARLEY & SWINDELLS (1): for early crop 13.75, middle season 17.2 and late season 16.82. As regards the varieties corresponding to those here, there are Wellington XXX: 14.9, and Westwick Choice: 21.05. The order is the same as here, although the British values are somewhat lower than the present ones.

A comparison of the averages of the different years is shown below.

	1962	1963	1964	All together
No.	17	16	21	54
Average	16.5	15.0	16.1	15.9
Limits of variation	12—24	1—33	9—25	1—33

In 1962, which was the coolest year, the average was the highest, and in 1963, which was the warmest, the average was the lowest, although the difference is not very great.

Correspondingly, the values for the different localities are given in the following:

	n	Average	Limits of variation
Piikkiö	21	15.2	1—33
Pälkäne	5	12.7	8—19
Laukaa	7	16.9	14—20
Ylistaro	6	14.7	9—19
Maaninka	11	17.1	11.5—25
Rovaniemi	4	20.5	16—25

In the values, a slightly increasing tendency towards the north is noted, probably connected with the slower achievement of maturity there. On the other hand, low formol values may indicate overripeness, and possible changes induced by adverse transport conditions.

Summary

The quality properties of black-currant have been investigated in respect of 12 home-grown varieties. Samples were obtained from 6 localities over a period of 3 years. The properties studied were dry matter, pectin and its degree of esterification, acid content, colour strength, and formol value.

As regards dry matter, the differences between the varieties were small. A high summer temperature diminished the dry matter values.

Some variations existed between the varieties in respect of pectin. Thus Wellington XXX and X contained an abundant amount of pectin, whereas Brödtorp

and Black of Lepaa contained little. A high summer temperature lowered the pectin content, but the degree of its esterification remained high. A corresponding effect was noted as a consequence of the degree of north latitude of the place of growth: the amount of pectin was increased and its degree of esterification was lowered towards the north.

With respect to the acid content, differences were remarked among the varieties, corresponding approximately to results reported earlier in literature. As a rule, the acid content of the home-grown varieties is higher than the values so reported. Of weather factors, sunshine seems to exercise most influence on the acid content, the acid being increased by a lack of it.

Similarly, differences among the varieties were found in colour strength. This property seems to bear a negative correlation to the berry size, since the colouring compounds are localized in the skin part of the berry. The colour strength depends markedly upon the summer temperature, as is evidenced by both the comparison of the different years, and that of the different localities.

Slight differences in the formol value were noted between the varieties. However, this value depends substantially upon the degree of maturity; it falls during ripening, a fact which renders comparison difficult.

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SELOSTUS:

MUSTAHERUKAN TÄRKEIMMISTÄ LAATUOMINAISUUKSISTA ERÄILLÄ KOTIMAASSA VILJELLYILLÄ LAJIKKEILLA

II. Kuiva-aine, pektiini, happopitoisuus, väri ja formoliarvo.

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Mustaherukan laatuominaisuuksia tutkittiin 12 kotimaassa viljellyllä lajikkeella; näytteitä saatiin 6 eri paikkakunnalta 3 vuoden aikana. Tutkimuksen kohteina oli kuiva-aine, pektiini ja sen esteröitymisaste, happopitoisuus, värinvoimakkuus ja formoliarvo.

Kuiva-aineeseen nähden lajikkeet poikkesivat toisistaan melko vähän. Korkea kesälämpötila vaikutti kuiva-ainetta alentavasti.

Pektiiniin nähden esiintyi jonkin verran eroja eri lajikkeiden välillä; mm. Wellingtonit sisälsivät runsaasti pektiiniä, Brödtorp ja Lepaan musta taas vähän. Korkea kesälämpötila alensi pektiinin määrää, mutta esteröitymisaste oli tällöin korkea. Vastaava vaikutus oli kasvatuspaikan pohjoisuudella: pektiinin määrä suureni ja sen esteröitymisaste aleni pohjoiseen päin.

Happopitoisuuteen nähden esiintyi lajikkeiden kesken eroja, jotka suunnilleen vastaavat kirjallisuudessa aikaisemmin esitettyjä. Hapon määrä oli kotimaisilla lajikkeilla korkeahko kirjallisuuteen verrattuna. Sääolosuhteista vaikuttanee happopitoisuuteen eniten aurinkoisuus siten, että auringonpaisteen puute suurentaa happomäärää.

Värinvoimakkuuteen nähden esiintyy samoin lajikkeiden keskisiä eroja. Värinvoimakkuus lienee negatiivisessa korrelaatiossa marjan kokoon, koska väriaineet ovat marjan kuoriosaan lokalisoituneet. Värinvoimakkuus on kesän lämpötilasta suuresti riippuvainen. Tämä ilmenee sekä eri vuosien että eri paikkakuntien vertailusta.

Formoliarvossa esiintyy vähäisiä eroja eri lajikkeiden välillä. Formoliarvo on kuitenkin suuresti kypsyysasteesta riippuvainen alentuen kypsymisen aikana, mikä vaikeuttaa vertailua.