JOURNAL OF THE AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE

VOLUME 96 SEPTEMBER 1971 NUMBER 5

The *Journal* supersedes the *Proceedings*, which was established in 1903. It is published bimonthly in January, March, May, July, September and November. Volume number is continued without interruption.

Communications in regard to membership in the Society or subscription to the *Journal*, or regarding reprints and advertising, should be sent to the Business and Circulation Manager, Cecil Blackwell, Executive Director, American Society for Horticultural Science, 914 Main Street, St. Joseph, Michigan 49085, USA.

Manuscripts for publication in the *Journal* and all correspondence relating to manuscripts should be sent to the editor, Thomas W. Whitaker, U.S. Horticultural Field Station, P.O. Box 150, La Jolla, California 92037, U.S.A. Because of occasional serious delay in transit, authors and reviewers are urged to send manuscripts and proofs by first class mail.

All members of the Society except Associate and Emeritus Members receive the *Journal* as a part of such membership through the payment of annual dues. The subscription price to nonmembers is $24.00 per year in the USA, Canada and Mexico, and $26.00 per year elsewhere. The back volume price is $26.00 and $28.00, respectively. The single copy (issue) price is $4.75 for nonmembers and $2.75 for members. All prices include postage. Remittances should be made payable (in U.S. dollars) to: American Society for Horticultural Science.

Post Office Entry: Second-class postage is paid at St. Joseph, Michigan 49085.

Postmaster. Please return all undeliverable copies and change of address "Form 3579" to The American Society for Horticultural Science, P.O. Box 109, St. Joseph, Michigan 49085, USA. Return postage guaranteed.

The Effect of the Modified Munson and 4-Arm Kniffin Training Systems on Changes in Pectic Substances of 'Concord' Grapes[1]

C. J. B. Smit and G. A. Couvillon[2]

University of Georgia, Athens

Abstract. 'Concord' grapes were harvested at weekly intervals from vines trained to either the Modified Munson (M.M.) or 4-arm Kniffin (4-A.K.) training systems. Total pectic substances and protopectin increased until about 7-9% soluble solids was reached and then decreased during further maturation. As maturity approached, water and oxalate soluble pectins increased. The M.M. system gave higher values for total pectic substances, protopectin, and water soluble pectins than the 4-arm Kniffin system.

In a recent paper Couvillon and Nakayama (3) showed that 'Concord' grapes, harvested from vines trained to the Modified Munson (M.M.) system, ripened more evenly, contained more anthocyanin pigments and soluble solids, and produced greater yields than 'Concord' grapes trained to the 4-arm Kniffin (4-A.K.) system. These authors suggested that this was due to better leaf exposure with the M. M. training system which resulted in more efficient photosynthesis per unit leaf area. Such differences in composition are important when the fruit is used to manufacture different fruit products such as juice, jams, or jellies.

The pectic substances of fruit have received considerable attention in the past because of the problems they create during the filtration of juice and because of the useful role they play during jam or jelly making. As a result, numerous reports have been published on the pectic substances of a variety of different fruits. Early investigations on grapes by Hopkins and Gourley (4) as well as Mehlitz (6) showed that total pectic substances generally decrease during ripening while there is an increase in the soluble pectic materials at the same time. Mehlitz further pointed out that there is a slight increase in total pectic substances in the early stages of development which is then followed by a continual decrease as the fruit matures. Recently Carter (2) reported on the change in total pectic substances of 'Concord' grapes during a 3-month period prior to harvesting. Here again, it was found that the pectic substances decreased as maturation progressed.

Because of the importance of the amount and the nature of the pectic substances in grapes, a study was undertaken to determine whether differences may exist during maturation when grapes were trained to different systems.

Materials and Methods

The grapes used in this study were obtained from 24 plants (12 plants trained to each system) in an experimental vineyard in which the vines were balanced pruned (30 + 10) and trained to either the M. M. or 4-A. K. training systems. The experimental design was a randomized complete block with 3 replications and 4-plant plots. Berry samples (200 berries per sample) were taken from each plant at weekly intervals

[1]Received for publication July 29, 1970. Journal Series Paper No. 845, University of Georgia, College of Agriculture Experiment Stations, College Station, Athens.

[2]Food Scientist and Assistant Horticulturist respectively. The authors gratefully acknowledge the technical assistance of Fred Reynolds.

[3]Rohm and Haas, Philadelphia, Penna.

[4]Sigma Chem. Co., St. Louis, Mo.

beginning approximately one month before harvest. The samples were blended and stored at -20°C until ready for analysis. To minimize bias, each sample was collected without viewing the clusters.

The frozen samples were allowed to thaw slightly before blending at high speed to break and mix the seed and fruit tissue thoroughly. From each blended sample three 10-g quantities of fruit were weighed into 250 ml stoppered Erlenmeyer flasks. One hundred ml of 78% ethanol was then added to each flask and the mixture was brought to a boil on a hot plate. After slight cooling the flask was shaken on a mechanical shaker for half an hour before filtering through Whatman No. 2 paper. The precipitate was washed 3 times with approximately 50-ml portions of 70% ethanol. The residue and paper were then transferred to a 250-ml Erlenmeyer flask.

Water soluble pectins were extracted from one of the three alcohol precipitates from each sample by adding 150 ml distilled water and shaking vigorously for 1 hr. The slurry was then transferred to a 250-ml volumetric flask, made up to vol, and filtered through Whatman No. 2 paper. A sample of the filtrate was treated with an equal volume of 0.1N sodium hydroxide and left for at least 30 minutes before proceeding with the colorimetric determination for anhydrogalacturonic acid.

Oxalate soluble, together with water soluble, pectins were extracted from a second alcohol precipitated sample by shaking vigorously with 150 ml 0.75% ammonium oxalate for 1 hr before making up to 250 ml with the oxalate solution. This was filtered and treated with alkali in a similar manner to the water soluble fraction described earlier. Oxalate soluble pectin content was then determined by subtraction.

The third alcohol precipitated sample was used to determine total pectic substances according to a modification of the procedure described by McCready and McComb (5). The alcohol precipitate was mixed with 150 ml 0.75% versene solution and adjusted to pH 11.5 with 1N sodium hydroxide. This was vigorously shaken for half an hr before adjusting the pH to 5.0 with 1N acetic acid. The equivalent of 0.03 ml Pectinol 59-L[3] was then added and the mixture was again shaken for 1 hr. It was then made to 500 ml with distilled water and filtered, and 10 ml of the filtrate was diluted to 100 ml with distilled water.

The colorimetric carbazole procedure as described by Bittner and Muir (1) was used for the determination of pectic substances in the 3 fractions. D-Galacturonic acid monohydrate[4] was used as a standard and results were expressed in mg anhydrogalacturonic acid per 100 g of fruit. Soluble solids content was determined in the blended fruit sample with a refractometer and values were corrected to 20°C.

Results and Discussion

The data are given for: (a) total pectic substances; (b) oxalate soluble pectic substances, which are pectic acids or low-methoxyl pectinic acids capable of forming insoluble salts with polyvalent cations; (c) water soluble pectins which have relatively high methoxyl levels; and (d) alkali soluble pectins of protopectin which are high molecular wt, high methoxyl, water insoluble materials. These are the materials which yield soluble pectins on treatment with acid, alkali, or enzymes (7).

Total pectic substances in fruits harvested from both training systems increased with an increase in soluble solids until a soluble solids level of approximately 8 to 10 percent was reached and then began to decline (Fig. 1). This finding agrees with the data of Hopkins and Gourley (4), Mehlitz (6), and Carter (2). The initiation of the decline in total pectic materials occurred at a lower soluble solids level in fruits harvested from 4-A. K. trained vines than in those from M. M. trained plants. Throughout the maturation period, those fruits produced on M. M. trained vines had a greater total pectin content than those harvested from 4-A. K. trained plants. The same was reported (3) for soluble solids and anthocyanin content of fruits produced on plants trained to the M. M. and 4-A. K. trained plants. This difference was probably due to increased photosynthetic efficiency on the M. M. trained vines as a result of better leaf exposure. This would result in a greater carbon pool for the synthesis of various organic compounds.

Protopectins followed the same general curves as did total

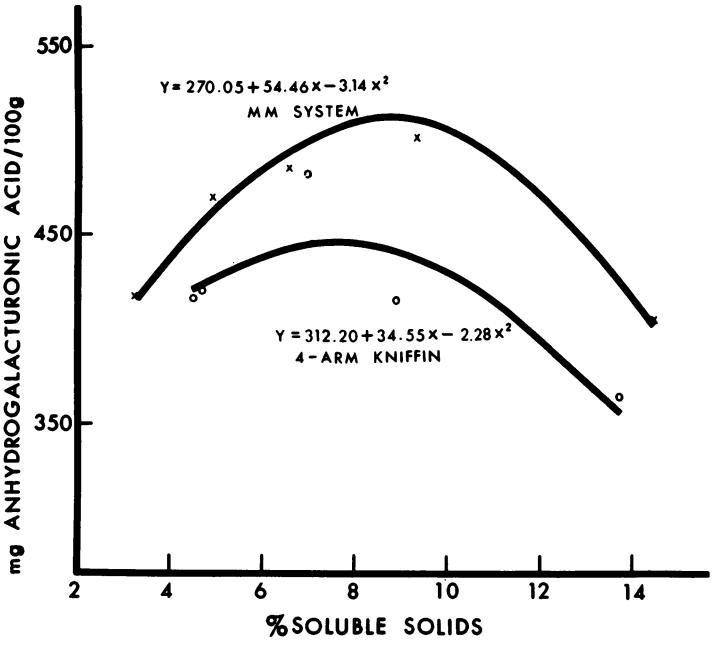

Fig. 1. Influence of the Modified Munson (M.M.) and 4-Arm Kniffin training systems on total pectin content of 'Concord' grapes. The quadratic regression of anhydrogalacturonic acid on % soluble solids was statistically significant at the 5% level of probability.

pectic substances (Fig. 2). There was an increase in protopectins until a soluble solids level of approximately 6 to 7% was reached and this was followed by a rapid decline which continued to harvest. The decline in protopectins occurred at approximately the same soluble level for both training systems. As was the case with total pectins, plants trained to the M. M. system produced fruits with a higher protopectin content than did vines trained to the 4-A. K. system.

Water soluble pectins increased in a linear fashion with an increase in soluble solids (Fig. 3). This rapid increase in water soluble pectins is to be expected since the insoluble pectic substances are converted to the water soluble forms as the fruit matures (4,6). As was the case with protopectin and total pectin substances, fruits harvested from M. M. trained vines contained a higher water soluble pectin content than did those trained to the 4-A. K. system and this difference increased as soluble solids increased.

Oxalate soluble pectin also increased in a linear fashion as the fruit matured (Fig. 4). This increase, however, was not as rapid as was the case with water soluble pectins. Fruits harvested from M. M. trained vines contained a greater oxalate soluble pectin content than did fruit harvested from 4-A. K. trained vines.

From these data it is clear that if fruit were harvested from the M. M. and 4-A. K. training systems at the same soluble solids level, the M. M. system would not only result in higher yields and better color as reported by Couvillon and Nakayama (3), but it would also give fruit with a higher concn of total pectic substances, protopectin, water soluble pectin, and oxalate soluble pectic substances. This latter condition is of particular importance when the fruit is used for jam or jelly making and it may also be a consideration in juice or wine making.

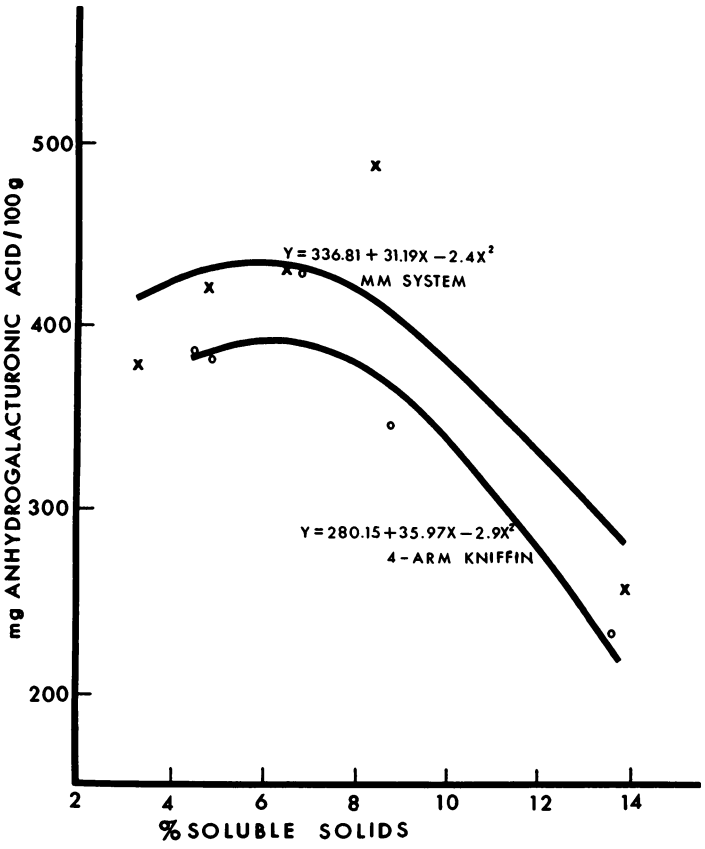

Fig. 2. Influence of the Modified Munson (M.M.) and 4-Arm Kniffin training systems on protopectin content of 'Concord' grapes. The quadratic regression of anhydrogalacturonic acid on % soluble solids was statistically significant at the 5% level of probability.

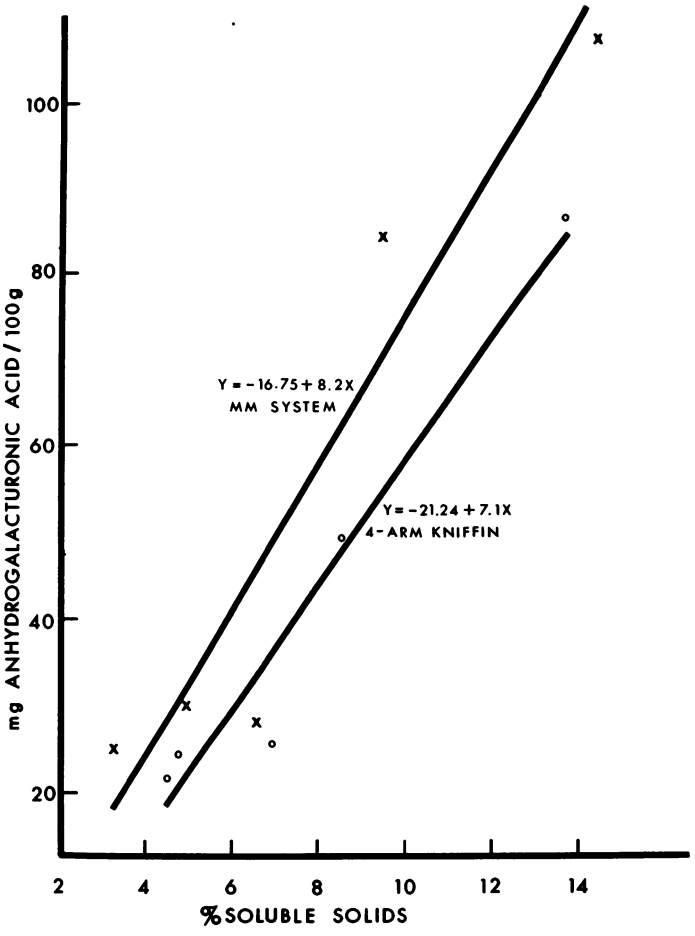

Fig. 3. Influence of the Modified Munson (M.M.) and 4-Arm Kniffin training systems on water soluble pectin content of 'Concord' grapes. The linear regression of anhydrogalacturonic acid on % soluble solids was statistically significant at the 5% level of probability.

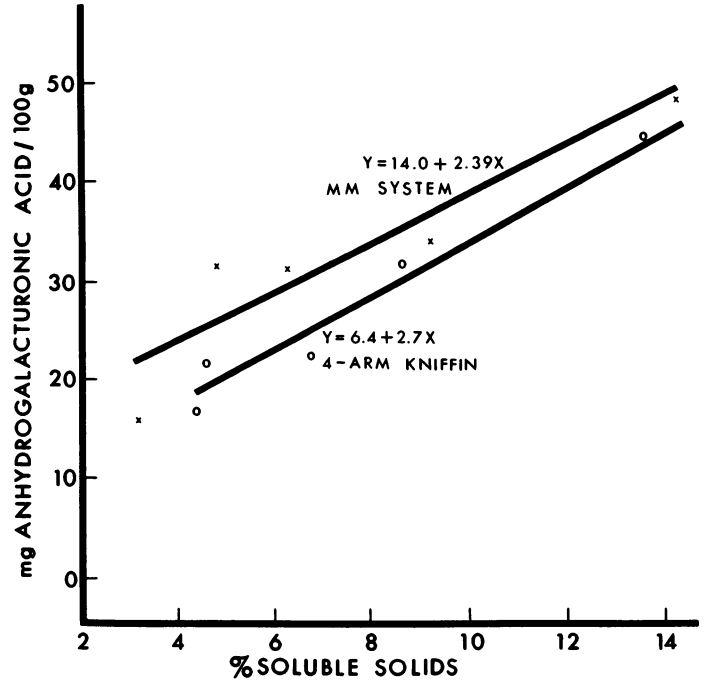

Fig. 4. Influence of the Modified Munson (M.M.) and 4-Arm Kniffin training systems on oxalate soluble pectin content of 'Concord' grapes. The linear regression of anhydrogalacturonic acid on % soluble solids was statistically significant at the 5% level of probability.

Literature Cited

1. Bittner, T., and H. M. Muir. 1962. A modified uronic acid carbazole reaction. *Anal. Biochem.* 4:330-334.
2. Carter, G. H. 1968. Pectin substances in 'Concord' grapes with relation to maturation in 1963. *Proc. Amer. Soc. Hort. Sci.* 92:319-322.
3. Couvillon, G. A., and T. O. M. Nakayama. 1970. The effect of the Modified Munson Training System on uneven ripening, soluble solids, and yield of 'Concord' grapes. *J. Amer. Soc. Hort. Sci.* 95:158-162.
4. Hopkins, E. F., and J. H. Gourley. 1930. Nitrogen fertilization and pectic materials in grapes. *Proc. Amer. Soc. Hort. Sci.* 27:164-168.
5. McCready, R. M., and E. A. McComb. 1952. Extraction and determination of total pectic materials in fruits. *Anal. Chem.* 24:1986-1988.
6. Mehlitz, A. 1933. *Konserven-Ztg.*, 20:113 (Quoted by Kertesz, Z. I. 1951.) *The Pectic Substances* Interscience Publ. Inc., New York, 628 p.
7. Rouse, A. H., and C. D. Atkins. 1955. Pectinesterase and pectin in commercial citrus juices as determined by methods used at the Citrus Experiment Station. *Fla. Univ. Agr. Expt. Sta. Bul.* No. 570.