Lenticel Origin on Golden Delicious Apple Fruits[1]

MOHAMED A. SHAHEEN,[2] NEIL W. MILES, AND GERALD L. KREITNER[3]

Additional index words. *Malus domestica* stomata formation, anatomy, morphology.

Abstract. Lenticel development on fruits of Yellowspur, Smoothee, and standard Golden Delicious apple (*Malus domestica* Borkh.) was studied by light microscope examination. Samples were randomly collected at periodic intervals from 6 days before to 55 days after anthesis. Samples for anatomical study were taken from the cheek of the fruit.

The results show that the lenticel formed from the stomatal trace. First evidence of the stomatal trace was obtained at 6 days after anthesis. The transition from stomata to lenticels was completed by 55 days after anthesis.

The fruit of the apple, *Malus domestica* Borkh., is a pome, the edible portion being receptacle, a modified stem. As a modified stem, lenticles are a characteristic structure of the epidermis. The lenticel, as defined by Esau (3), is "a limited part of the periderm in which the phellogen is more active than elsewhere and produces a tissue that, in contrast to the phellem, has numerous intercellular spaces."

Kidd and Beaumont (5), unable to find stomata on the mature fruit of Bramley's Seedling, concluded that stomata took part in gas exchange and might act as lenticels. Clements (2) stated that pome lenticels might arise from stomata, from breaks in the epidemis caused by a complete removal of the epidermal hairs, and from other epidermal breaks caused by inability of the epidermis to keep pace with the growth of inner tissue. Tetley (8) was unable to find the transition stages between stomata and lenticels in several apple cultivars. Pratt (6) reported that lenticel-like structures developed at the base of pubescent hairs and in stomatal cavities.

Since evidence for the development of lenticels from the stomata has not been described previously, a study of lenticel development in Golden Delicious apple fruits seemed appropriate.

MATERIALS AND METHODS

Yellospur, Smoothee, and standard Golden Delicious apple fruits studied were obtained in 1980 from the Kansas State University research orchard near Manhattan, Kansas.

Random samples of fruit were selected at periodic intervals from 6 days before to 55 days after anthesis. Samples for anatomical study were taken from the cheek of the fruit.

The tissues were killed and fixed in standard formalin-acetic acid-alcohol (FAA) solution, carried through an alcohol-xylol dehydration series, and infiltrated and embedded with paraffin by standard procedures (4, 7). Ten-micron sections of embedded tissues were stained with Delafield's heamatoxylin and safranin (1, 4). Photomicrographs were recorded with a Zeiss photomicroscope II.

RESULTS AND DISCUSSION

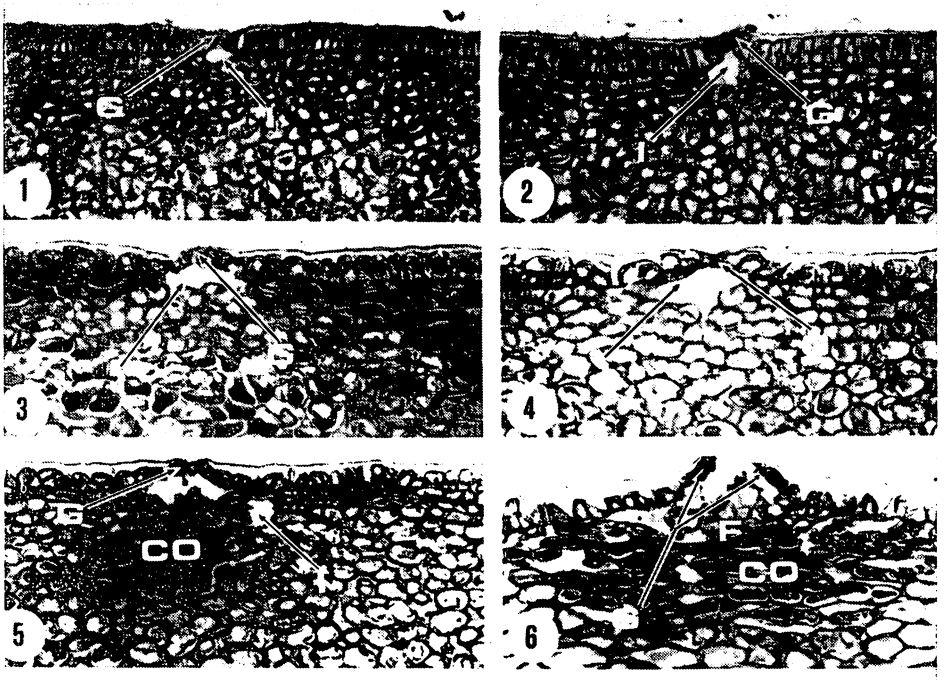
The stomatal complex was evident approximately 6 days after anthesis (Fig. 1). This complex had two small guard cells (G) attached together and situated above a small intercellular space (I) (Fig. 1, 2). By 18 and 24 days after anthesis, the intercellular space beneath and guard cells had enlarged (Figs. 3, 4) and the connection between the cells weakened. They separated in their median parts and the stomatal opening was formed at 31 days after anthesis (Fig. 5).

In this stage the stoma may function

[1]Agricultural Experiment Station, Kansas State University, Manhattan. Contribution 81-406-j.

[2]Former Graduate Student, Department of Horticulture, Kansas State University, now Assistant Professor, Department of Plant Production, College of Agriculture, Riyadh University, Riyadh, Saudi Arabia.

[3]Associate Professor, Department of Horticulture and Research Associate, Department of Agronomy, Kansas State University.



Figs. 1-6. Cross section of Yellospur Golden Delicious fruits showing stoma and lenticel structure. Fig. 1. 6 days after anthesis. 189X. Fig. 2. 12 days after anthesis. 189X. Fig. 3. 18 days after anthesis. 189X. Fig. 4. 24 days after anthesis. 189X. Fig. 5. 31 days after anthesis. 189X. Fig. 6. 5 days after anthesis 151X.

as a channel for air exchange, which agrees with Kidd and Beaumont (3), who concluded that there are no lenticels in young apple fruits but connection with the atmosphere is provided through the stomata.

The intercellular space (Fig. 5) continued to increase and cork (CO), which stained heavily, formed beneath the opening. Continued development of cork cells led to the enlargement of the intercellular space below the stoma. This shows an early stage of lenticel formation.

Transition stage from stoma to lenticel was completed approximately 55 days after anthesis (Fig. 6). The complete structure of the lenticel had the two guard cells of the stoma, filling tissue (F) with frequent and large intercellular spaces, and cork—a structural arrangement that agrees with Esau's (3) definition.

Examination of fruits from Smoothee and standard Golden Delicious provided comparable evidence for the origin of the lenticel.

Kidd and Beaumont (5) considered that the epidermal hairs and stomata of Bramley's seedling developed into lenticels when cork formed below. Pratt (6) reported that lenticel-like structures on Starking were initiated by periclinal divisions at the base of pubescent hairs and in stomatal cavities. Tetley (8) stated that since stomata were difficult to find on mature apple fruits, lenticel formation must

occur from nearly every stoma without leaving any stomatal traces whatsoever. Our work shows clearly that lenticels are derived from the stomata.

Literature Cited

1. Ayensu, E. S. 1967. Aerosol OT solution—an effective softener of herbarium specimens for anatomical study. *Stain Tech.* 42:155-156.
2. Clements, H. F. 1935. Morphology and physiology of the pome lenticels of Pyrus malus. *Bot. Gaz.* 97:101-117.
3. Esau, K. 1960. Anatomy of seed plants. (2nd ed) John Wiley and Sons, Inc., New York. 550 pp.
4. Johansen, D. A. 1940. Plant microtechnique. McGraw-Hill, Inc., New York. 523 pp.
5. Kidd, M. N. and A. Beaumont. 1925. An experimental study of the fungal invasion through the lenticels. *Ann, Appl. Biol.* 12:14-33.
6. Pratt, C. 1972. Periderm development and radiation stability of russet-fruited sports of apple. *Hort. Res.* 12:5-12.
7. Sass, J. E. 1971. Botanical microtechnique. (3rd ed) Iowa St. Univ. Press, Ames, Iowa, 288 pp.
8. Tetley, V. 1930. A study of the anatomical development of the apple and some observations on the pectic constituents of the cell walls. *J. Pom. Hort. Sci.* 8: 153-172.

Book Review

Plant Science: Growth, Development, and Utilization of Cultivated Plants. 1981. Hudson T. Hartmann, William J. Flocker and Anton M. Kofranek. Prentice-Hall, Inc., publisher. Englewood Cliffs, NJ 07632. Price $26.95.

"Plant Science" is a valuable contribution toward the understanding of specialized aspects of growth, development and utilization of cultivated plants. This text is easily understood and covers the vast critical mass of cultivated plants. The authors are to be commended for their effort in compiling such a great wealth of information as a handbook reference on so many diversified topics.

These topics are divided into units as follows: Unit I. Plant structure, classification, growth, reproduction and utilization; Unit II. An overview of the fruit crops and ornamental plants; and Unit III. Major agronomic, vegetable and fruit crops.

Each unit could in itself be an individual book, but the important part of this text is that so many plant science facets are incorporated under one cover.

Unit I is an introduction to plant science and plant growth, Unit II deals with the specifics of horticultural crops. It contains two chapters on tree fruits, grapes, brambles and strawberries followed by eight chapters on ornamentals, shade trees, woody shrubs, production and use of greenhouse flowering plants, bedding plants and the bulbous kinds of plants. The final two chapters in this unit deal with fundamentals of lawn grooming and the basic principles of home and community landscaping.

Unit III's nine chapters are devoted to encyclopedic coverage of the world's important food, forage, and fiber crops. Included are cereal and sugar crops; oil, forage and fiber crops; vegetables grown for their fruits or seeds; vegetables grown for their leafy parts and for underground parts. Fruit crops are discussed in three categories — temperate zone, subtropical and tropical plants. Unit III also has a reference section with literature citations for each crop.

In addition, the book contains an extensive glossary and an English-metric conversion chart.

—R. K. SIMONS