DIURNAL VARIATION OF CARBOHYDRATES IN DEVELOPING COTTON FIBERS

Allen K. Murray
Glycozyme, Inc.
Irvine, CA
Daniel S. Munk
University of California Cooperative Extension
Fresno, CA

Abstract

The diurnal variation in soluble oligosaccharide content of developing cotton fibers is of interest since it is related to the presence of acid labile oligomers associated with cell wall biosynthesis. The sucrose, raffinose, stachyose and verbascose content of developing Maxxa and Pima S-7 has been determined and expressed on a μg/mg fiber basis. The range of values of sucrose and raffinose is much wider for Maxxa than for Pima S-7 during the 24-hr period suggesting that the metabolism of Pima S-7 is more tightly regulated than Maxxa. Although the ranges were different for both species, the total values of sucrose and raffinose observed for the 24-hr period were almost identical. This suggests that the amount of soluble sugars, which can be incorporated into a unit mass of fiber in a 24-hr period, may be relatively constant. This relationship is the subject of ongoing investigation.

Introduction

Carbohydrate analysis of developing cotton fibers has been employed in this laboratory (Murray, 1996, 1998, Murray and Brown 1996, 1997, Murray *et. al.* 1997, 1999). This work has elucidated a relationship between soluble oligosaccharides and structural oligomers (~mers) which are contained in a "glue matrix" in association with cellulose as shown in Figure 1. Earlier work indicated that the oligosaccharides and the ~mers which can be extracted from developing fibers both vary with the time of day. This present work was initiated to investigate the diurnal variability.

Methods

Cotton plants, Pima S-7 and Maxxa, were grown at the University of California, West Side Research and Extension Center. Temperature data was obtained from the California Irrigation Management Information System. Bolls of approximately 24 days post anthesis were harvested The bolls were placed directly in a dry ice chest with 2in slabs of dry ice. Frozen bolls were transported to the laboratory and freeze dried. Cotton fibers were subjected to aqueous extraction and analysis of the soluble carbohydrates by high pH anion chromatography with pulsed amperometric detection (HPAEC-PAD) (Murray, 1998). Values are averages of at least three determinations. The values are subject to significant variation (up to 30%) but error bars are not shown to simplify the figures. Additional extraction of the oligomers (~mers) was achieved under conditions of dilute acid and elevated temperature prior to HPAEC-PAD (Murray, 2000).

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Results

The content of sucrose, raffinose, stachyose and verbascose was determined at seven time points for both Maxxa and Pima S-7. All values are averages of a minimum of three determinations and they are express on a μg/mg fiber basis. The oligosaccharide content of developing fibers of Pima S-7 is shown in Figure 2. Sucrose varied between about 11.5 and 17 μg/mg with the minimum value at midnight and the highest values at noon and 0600. Raffinose varied between about 3 and 11 μg/mg with a low point at midnight and the highest values at 0600 and 1600. Stachyose and verbascose values were less than 1.5μg/mg.

The oligosaccharide content of developing fibers of Maxxa is shown in Figure 3. Sucrose varied between about 2 and 30 μg/mg with the minimum values at noon and midnight and the highest value at 0400. Raffinose varied between about 4 and 11 μg/mg with a low point at noon and the highest value at 0600. Stachyose and verbascose values were less than 1.5μg/mg.

Discussion

The difference in the variability of the sucrose and raffinose content of developing fibers from Pima S-7 and Maxxa is striking. It appears that the metabolism of the Pima plant is much more highly regulated than is the metabolism of the Maxxa plant. This higher degree of regulation appears to maintain sucrose and raffinose levels in a more narrow range with the difference for sucrose being more dramatic than for raffinose. These differences may also reflect difference in stress tolerance due to a decreased influence by the daily temperature variation. The sum of the sucrose and raffinose values for all time points is nearly identical even though the range of the values is much greater for Maxxa. Since these values are on a μg/mg fiber basis the difference in size of the bolls is not meaningful. What may be meaningful, if this relationship is observed in other samples, would be the relatively constant ratio of soluble oligosaccharide to mg fiber. This would suggest that a certain mass of fiber could incorporate a certain mass of soluble oligosaccharide in a 24hr period. The difference in the range may be indicative of a more highly regulated incorporation into Pima fibers, which may contribute to the higher fiber quality. This observation is the subject of current research.

In data not shown here, the acid labile oligomers released from the developing fibers were also analyzed. The oligomers are associated with the onset of secondary wall formation (Murray, 2000). The oligomers were most prevalent in Pima S-7 at 0600 and 2130 and there was little variability between samples. The oligomers from Maxxa were also most prevalent at the same times but the variability was much greater than for Pima S-7. One can speculate that the oligomer observations may reflect a more constant rate of fiber synthesis with less variability due to daily temperature and other variables.

Summary

The content of sucrose, raffinose, stachyose and verbascose were monitored for a 24hr period. The sucrose and raffinose values varied over a wider range than did stachyose and verbascose. The range of sucrose content for Maxxa fibers was much greater than for Pima S-7 fibers. However the total content for the 24hr period was almost identical.

References

Murray, A. K., 1998, Method For Monitoring Growth And Detection Of Environmental Stress In Plants, U.S. Patent No. 5,710,047

Murray, A. K., 2000, Method For Detecting Growth And Stress In Plants, U.S. Patent to be issued.

Murray, Allen K., 1996, The use of Glycoconjugate Analysis to Monitor Growth and Environmental Stress in Developing Cotton Fibers, 1996 Proceedings Beltwide Cotton Conferences, p. 1255-1259.

Murray, Allen K. and Judy Brown, 1996, Glycoconjugate Analysis of Developing Cotton Fibers From Several Varieties Grown on the Same Site, 1996 Proceedings Beltwide Cotton Conferences, p. 1205-1209.

Murray, Allen K., Daniel S. Munk and Jonathan Wroble, 1997, Glycoconjugate Profiles of Developing Fibers from Irrigated and Non-Irrigated Plants, 1997 Proceedings Beltwide Cotton Conferences, p. 1439-1441.

Murray, Allen K. and Judy Brown, 1997, Glycoconjugate Profiles of Developing fibers from Different Fruiting Branches on the Same Plant, 1997 Proceedings Beltwide Cotton Conferences, p. 1496-1499.

Murray, Allen K., Daniel S. Munk and Jonathan Wroble, and Gretchen F. Sassenrath-Cole, 1999, *myo*-Inositol, Sucrosyl Oligosaccharide Metabolism and Drought Stress in Developing Cotton Fibers, *in vivo*, *in vitro* and *in planta*. 1999 Proceedings Beltwide Cotton Conferences, p. 518-520.

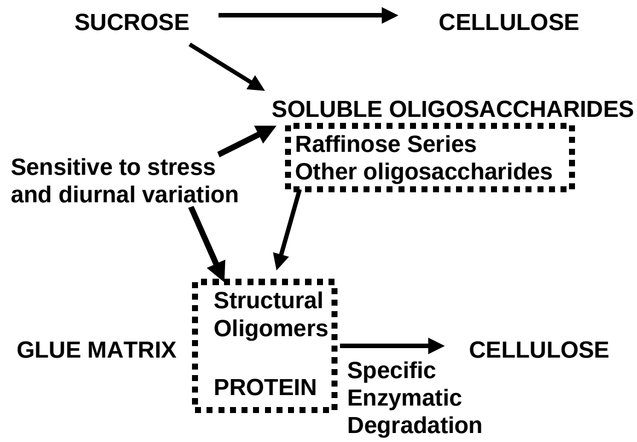

Figure 1. The relationship between soluble oligosaccharides, structural oligomers and the "glue matrix" of developing cotton fibers.

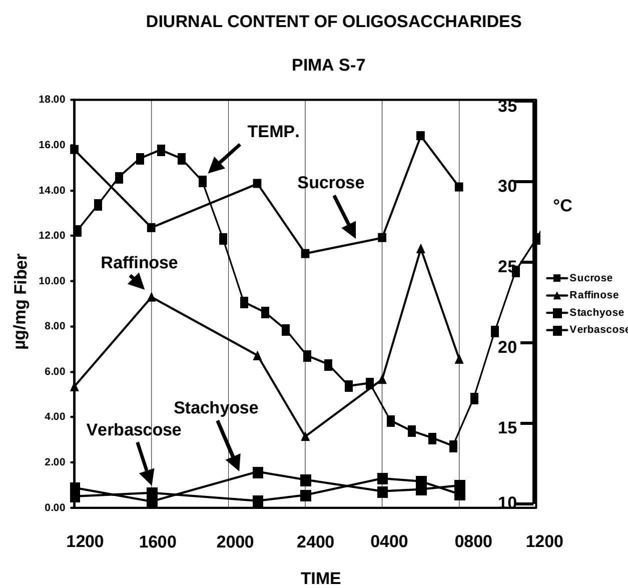

Figure 2. Diurnal content of oligosaccharides in developing Pima S-7 fibers.

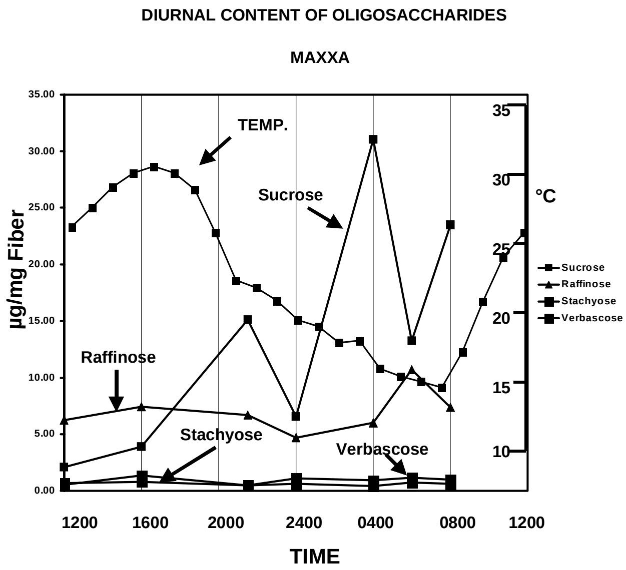

Figure 3. Diurnal content of oligosaccharides in developing Maxxa fibers.