Final Technical Report for
DOE grant DE-FG02-04ER15565 / DE-FG02-08ER15969
Maltose Biochemistry and Transport in Plant Leaves
PI Thomas D. Sharkey
University of Wisconsin-Madison/Michigan State University

Starch is a desirable plant product for both food and biofuel. Leaf starch is ideal for use in biofuels because it does not compete with grain starch, which is used for food. Starch is accumulated in plant leaves during the day and broken down at night. If we can manipulate leaf starch breakdown it may be possible to design a plant that provides both grain starch for food and leaf starch for biofuel. The pathway of leaf starch breakdown was not known when this work started. Preliminary evidence had shown that maltose was the primary product of leaf starch breakdown (Weise, Weber & Sharkey, 2004) and that it was metabolized by a disproportionating enzyme called amylomaltase but given the initials DPE2 (Lu & Sharkey, 2004). In this work we showed that only one form of maltose was metabolically active (Weise *et al.*, 2005a) and that maltose was located in two different places when the amylomaltase was knocked out but only inside the chloroplast when the maltose transporter was knocked out (Lu *et al.*, 2006a). This allowed us to estimate the energetics of maltose export and to show that maltose export is more efficient than glucose export (Weise *et al.*, 2005b). We examined how daylength affected starch breakdown rate and found that starch breakdown rate could respond to changes in daylength within one day (Lu, Gehan & Sharkey, 2005). We also were able to show a second starch breakdown pathway by chloroplastic starch phosphorylase (Weise *et al.*, 2006). Work to this point was summarized in a review (Lu & Sharkey, 2006).

We were able to show that the amylomaltase in plants could substitute for the amylomaltase in bacteria (Lu *et al.*, 2006b). In this paper we also showed the importance of a second enzyme called alpha-glucan phosphorylase in starch breakdown. Finally, we were able to determine the enzymatic mechanism of the amylomaltase (Steichen, Petty & Sharkey, 2008).

Lu Y., Gehan J.P. & Sharkey T.D. (2005) Daylength and circadian effects on starch degradation and maltose metabolism *Plant Physiology*, **138**, 2280-2291

Lu Y. & Sharkey T.D. (2004) The role of amylomaltase in maltose metabolism in the cytosol of photosynthetic cells *Planta*, **218**, 466-473

Lu Y. & Sharkey T.D. (2006) The importance of maltose in transitory starch breakdown *Plant, Cell and Environment*, **29**, 353-366

Lu Y., Steichen J.M., Weise S.E. & Sharkey T.D. (2006a) Cellular and organ level localization of maltose in maltose-excess Arabidopsis mutants *Planta*, **224**, 935-943

Lu Y., Steichen J.M., Yao J. & Sharkey T.D. (2006b) The role of cytosolic ‡-glucan phosphorylase in maltose metabolism and the comparison of amylomaltase in Arabidopsis and e. Coli *Plant Physiology*, **142** 878-889

Steichen J.M., Petty R.V. & Sharkey T.D. (2008) Domain characterization of a 4-α-glucanotransferase essential for maltose metabolism in photosynthetic leaves *J. Biol. Chem.*, **283**, 20797-20804

Weise S.E., Kim K.S., Stewart R.P. & Sharkey T.D. (2005a) α -maltose is the metabolically active anomer of maltose during transitory starch degradation *Plant Physiology*, **137**, 756-761

Weise S.E., Schrader S.M., Kleinbeck K.R. & Sharkey T.D. (2006) Carbon balance and circadian regulation of hydrolytic and phosphorolytic breakdown of transitory starch *Plant Physiology*, **141**, 879-886

Weise S.E., Sharkey T.D., (2005b) Energetics of carbon export from the chloroplast at night. In: *Photosynthesis: Fundamental aspects to global perspectives, the proceedings of the 13th international congress on photosynthesis*, pp. 816-818. International Society of Photosynthesis/Alliance Communications Group, Lawrence.

Weise S.E., Weber A. & Sharkey T.D. (2004) Maltose is the major form of carbon exported from the chloroplast at night *Planta*, **218**, 474-482