FoodInfo Confidential Report No. 133

Understanding deterioration in harvested asparagus

A report prepared for the
Asparagus Council

EO O'Donoghue, G King, P Hurst,
D Irving & J Heyes

June 1995

New Zealand Institute for Crop & Food Research Limited
Private Bag 4704, Christchurch, New Zealand

CROP & FOOD RESEARCH
Mana Kai Rangahau

FoodInfo Confidential Report No. 133
Understanding deterioration in harvested asparagus
EO O'Donoghue et al.

CONTENTS

1 EXECUTIVE SUMMARY

This report describes progress on the research project supported by both the New Zealand Asparagus Council and the Foundation for Research Science and Technology.

- A controlled atmosphere treatment that can prolong the shelf life of harvested asparagus also alters sucrose metabolism in harvested spears. The sucrose content of the spear is probably closely related to postharvest deterioration.

- Some of the earliest cellular responses to harvest are found in the very youngest regions of the asparagus tip. The main axis of the spear does not, however, respond with such intensity. The concentration of an enzyme that provides vital chemical energy for normal growth and development slowly declines over the whole spear after harvest.

- A sequence of DNA involved in turning on a gene after harvest (called a promoter) has been isolated. The availability of this promoter brings the project a step closer to the aim of genetically modifying asparagus plants.

The research has reached an exciting stage, with the development of detailed knowledge of the early responses of asparagus spears to harvest, and having found that loss of sucrose is a crucial postharvest event. With transformation technology becoming available, the group is now able to consider options for altering the genetic makeup of asparagus to enhance postharvest quality. This would provide invaluable information to plant breeders for line-selection studies, and may also result in the direct production of new, elite asparagus cultivars.

2 INTRODUCTION

The aim of the asparagus research is to understand the physiological, biochemical, and molecular processes that cause harvested asparagus spears to deteriorate, because the resale value and market image of fresh asparagus depends on postharvest quality.

Previous work at Crop & Food Research has included research on carbon and nitrogen metabolism and gene expression after harvest. This year, further developments are reported, including a post-harvest storage treatment that alters sucrose metabolism, and the isolation of a harvest-induced gene promoter. A new line of research has also been developed, focusing on cell wall and cell membrane enzymes to identify processes influencing tip softening and breakdown.

3 RESULTS AND DISCUSSION

3.1 Sucrose and acid invertase activity

The ability of controlled/modified atmospheres at 20°C to increase residual shelf-life of spears of up to three days was described in last year's report to the Council. To understand this beneficial effect, the effect of a controlled atmosphere (CA - 10% CO_2, 2% O_2) on spear tip sucrose and acid invertase levels was measured. Acid invertase is an enzyme that breaks down sucrose into glucose and fructose; it may be responsible for the rapid loss in sucrose in the tips of harvested asparagus.

Sucrose levels remained high in CA-stored spears (Fig. 1) and acid invertase activity did not increase as it normally does in air-stored spears (Fig. 2).

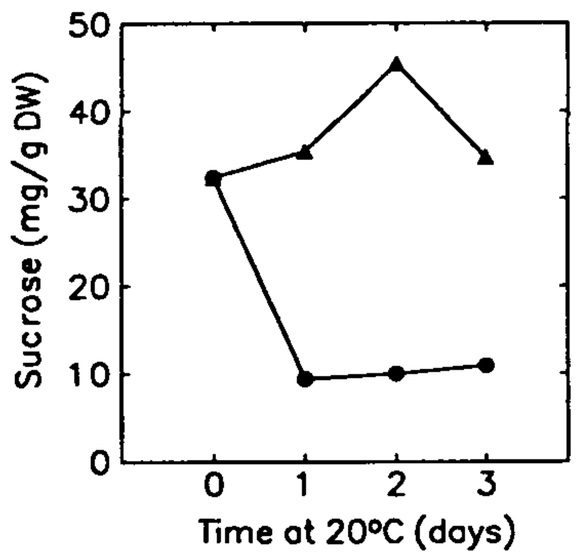

Figure 1: Sucrose levels in tips of spears stored in air (•) and CA (▲).

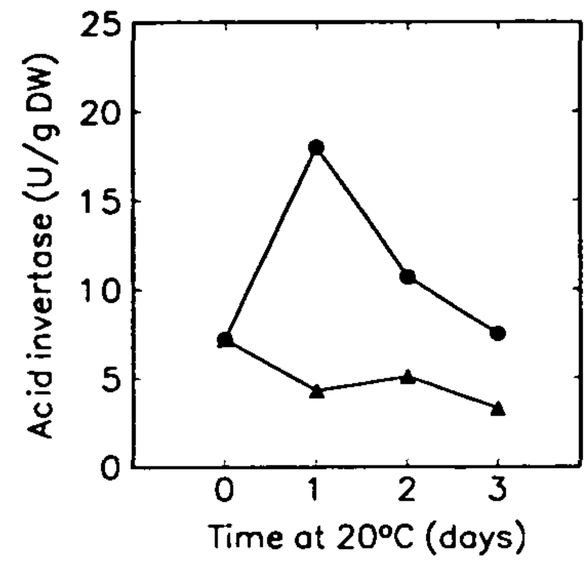

Figure 2: Acid invertase activity in tips of spears stored in air (•) and CA (▲).

The results are striking as the loss of sucrose from the spear tip after harvest has not been prevented before. The results suggest strongly that sucrose plays a crucial role in the postharvest life of asparagus.

A three-year PhD collaborative programme with the Biochemistry Department of Otago University has recently been initiated to investigate further the effects of controlled atmosphere on the enzymes involved in sucrose metabolism. A range of compounds involved in the intracellular breakdown of sucrose and the flow of carbon into energy production in harvested asparagus is being characterised.

3.2 Cell walls and membranes

Softening of the spear tip in asparagus, and general flaccidity of the spear after harvest, have significant impacts on the market perception of asparagus quality. Previous research in this project has indicated that the enzymes encoded by some of the genes expressed following harvest could contribute to changes in cell wall structure and spear texture. Additionally, the activity of ATPase (an enzyme that provides chemical energy for biochemical processes) may be altered after harvest. One possible consequence of change in the activity of this enzyme is that the acidity of the cell wall may change, which could then affect wall structure and overall spear texture.

In situ hybridization is a technique that identifies cells whose gene expression alters in response to harvest. The cells that accumulate RNA coding for β-galactosidase (a cell wall-degrading enzyme) have been localised. Most cells that could produce transcripts coding for this enzyme were in the axillary branches and young bracts of the asparagus spear tip. Cells in the main axis of the spear did not show such intense activity. This work was presented at the Asparagus Council Research Seminar. The enzyme activity of β-galactosidase in the branches and bracts of the spear tip is now being measured.

The ATPase enzyme is involved in processes such as cell expansion and inter-cellular transport of dissolved salts that require high levels of energy, has been used a biochemical marker to examine changes in the distribution and abundance of ATPase in asparagus spears. At harvest, ATPase was abundant in all tissues in the spear, reflecting the rapid expansion occurring at that time. After harvest, the enzyme concentration declined markedly. By five days after harvest, ATPase was detected only in the conducting tissues. This suggests that the spear can still load metabolites into the xylem and phloem although active growth has ceased. This work will continue as the significance of these findings are explored.

3.3 Asparagine synthetase (AS) promoter

A promoter is a piece of DNA that turns individual genes on and off. Each gene has its own promoter and the promoter may be influenced by many biochemical factors. Several genes from asparagus that are turned on or off after harvest have been identified during this project. The promoters of these genes are particularly valuable in helping to identify specific factors that influence gene expression.

The promoter that turns on the AS gene in harvested asparagus has now been isolated. It is being sequenced. Current work seeks to find whether the promoter is sensitive to sugar depletion, because sugar is lost quickly after spear harvest. The AS promoter may be a useful tool for turning on other genes that may be introduced into asparagus to delay deterioration.

An important event during the past year has been the development of a gene transformation system for asparagus by Canadian researchers. This means that molecular studies aimed at altering asparagus physiology are now technically feasible.