The reduction of naringin content of grapefruit by applications of gibberellic acid

M.A. Berhow* & C.E. Vandercook**
United States Department of Agriculture,† Agricultural Research Service, Fruit and Vegetable Chemistry Laboratory, 263 South Chester Avenue, Pasadena, CA 91106, USA

Received 5 February 1991; accepted 24 June 1991

Key words: Citrus, grapefruit, growth regulators, flavonoids, naringin accumulation

Abstract

Four different plant growth regulators, gibberellic acid (GA3), naphthaleneacetic acid (NAA), benzyladenine (BA) and abscisic acid (ABA), were individually mixed in a lanolin paste and applied to immature fruit on grapefruit trees beginning soon after fruit set. The treated fruit was allowed to mature on the tree. Application of 1000 ppm GA3 in this manner generally increased fruit size, decreased the concentration of the total acid in the juice and decreased the concentration of naringin in the juice sacs compared to that of the controls. GA3 increased the total soluble solids (brix) in the juice in some experiments. Treatment of fruit with 1000 ppm ABA and BA significantly decreased the size of the fruit and increased the naringin concentration, but had variable effects on the soluble solids content and the acid content. Treatment with 1000 ppm NAA did not produce any significant changes in size, acid content, brix or naringin concentration.

1. Introduction

Plant growth regulators (PGRs) have been used extensively both in basic citrus research and in numerous commercial citrus crop applications. PGRs have been found to promote citrus seedling growth, to control vegetative growth in mature trees and to improve cold hardiness of citrus trees. They have been used to control citrus fruit production by influencing flowering, fruit set, fruit thinning, pre-harvest control of fruit drop and in the control of fruit disease. PGR sprays have also been used to influence fruit quality factors such as rind quality, rind color, fruit size, to decrease juice acidity, and to increase juice soluble solids (for a review of PGR uses in Citrus see [1]). Little research has been conducted on the effect of PGR’s on the internal components of citrus fruit such as the flavonoids.

The flavonoids are an important class of plant secondary metabolites, whose functions are still not well understood [2]. Flavonoid biosynthesis and accumulation have been shown to occur during periods of active cell growth and differentiation in culture, but the relationship between this general regulation and wound-induced flavonoid metabolism has yet to be elucidated [3]. In citrus, flavonoids such as naringin and hesperidin are important quality factors in both fresh fruit and juice [4]. Naringin is a particularly bitter-tasting compound and grapefruit often can accumulate relatively large quantities of this compound which
sometimes renders the juice unfit for consumption. There have been a number of studies on the changes in naringin content of grapefruit over the harvest period. Naringin concentrations decrease as the fruit approaches maturity, but the levels remain fairly consistent throughout the harvest season [5, 6]. No consensus has been reached over whether the naringin concentration increases or decreases towards the later part of the harvest season, but at least one researcher has mentioned that the variability may be due to environmental factors [6]. Indeed, the environment has been shown to play a key role in the accumulation of flavonoids in many, if not all, plant species [7].

Most of the research on the regulation of flavonoid biosynthesis has been done with plant cell culture and not intact plants. In citrus plants, the flavonoids have been shown to be synthesized in young developing leaves and fruit [8, 9, 10, 11, 12]. The activities of some of the key enzymes involved in the early part of the general isopropanoid pathway that leads to the flavonoid precursors have been shown to parallel this accumulation [13]. The processes involved in both cell division and differentiation, as well as environmental signal recognition and transduction, involve a number of biologically active compounds, including the classical PGR’s. Many of these compounds may interact with the biochemical and genetic regulators of flavonoid biosynthesis. We are currently examining the effect of some of these PGR’s on the regulation of naringin accumulation in grapefruit. It is hoped that these studies will shed some light on the factors involved in the regulation of flavonoid accumulation in citrus and lead to the development of possible biochemical methods to control grapefruit bitterness.

2. Materials and methods

2.1 Chemicals

Gibberellin A₃ (GA₃), 2-cis-4-trans-abscisic acid (ABA) and lanolin were purchased from Sigma Chemical Co. (St Louis, MO). N⁸-Benzyladenine (BA) and 1-naphthylacetic acid (NAA) were purchased from Fluka Chemical Corp. (Ronkonkoma, NY). All other chemicals were purchased from local chemical supply firms.

2.2 Grapefruit trees

The trees used in the 1989–90 experiments were located in two groves. The Riverside trees were 20 year old Citrus paradisi [L.] MacFad. c.v. Marsh trees located at the University of California Citrus Research Center and Agricultural Experiment Station in Riverside. The Redlands trees were Citrus paradisi [L.] MacFad. c.v. Duncan located in a commercial citrus grove in Redlands owned by the Royal Citrus Packing House. The 1988–89 experiments were conducted on two grapefruit trees, c.v. Cecily and c.v. Hudson Foster, located at the Riverside Experimental Station.

2.3 Lanolin treatments

Lanolin pastes have been shown to be an extremely effective way of administering biologically active amounts of PGR’s to plant tissues over a long period of time [14, 15].

Growth regulators were dissolved in a small amount of water or dimethylsulfoxide and mixed with lanolin paste to achieve the appropriate concentrations (on a weight to weight basis). The pastes were applied to the base of the fruit with a small paint brush, covering the basal half of the fruit and the stem attaching it to the branch. Treatments were initiated when fruit were approximately 1 cm in diameter, during the middle week of April. The initial experiments were conducted on 50 (10 per treatment) fruit on each of two trees at the Riverside Station during the 1988–89 season. For the 1989–90 season experiments at the Riverside Station, at least 10 fruit were randomly chosen on 7 groups of 3 trees within two orchard rows. The selected fruit on the first group of three trees received no treatments, that of the second group were treated with lanolin only, that of the third group were treated with 1000 ppm GA₃ in lanolin, that of the fourth were treated with 1000 ppm GA₃ in lanolin on the branch at least 15 cm above the fruit, that of the fifth group were treated with 1000 ppm NAA in lanolin, that of the sixth group were treated with 1000 ppm BA in lanolin, and that of the seventh group were treated with 1000 ppm ABA in lanolin. Experiments conducted at the Redlands grove in 1989 were conducted on 5 trees in a single row. Four groups of at least 10 fruit were randomly selected on each tree. The first group