



**Date:** 12/10/2018

**PSU Ref. No:** 206019

**Title:** Crop Load Effects on High-Tannin Apples and Evaluation of American-Origin Hard Cider Varieties

**Submitted to:** Patti Keller, Secretary, SHAP Research Committee  
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**Proposed Project**                      **7/1/2019 - 6/30/2020**                      **Total Project Request: \$5,962**

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**EIN: 24-6000376**  
**DUNS No: 00-340-3953**

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## Research Grant Proposal to State Horticultural Association of Pennsylvania

### Crop Load Effects on High-Tannin Apples and Evaluation of American-Origin Hard Cider Varieties

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**Duration:** 1 year

**Justification:** This proposal addresses the SHAP Research Priorities: Crop Load Management and New Variety Evaluation. Hard cider is a rapidly developing market opportunity for Pennsylvania apples. Pennsylvania cider producers need to produce a high-quality product to differentiate their product in the marketplace.

#### Part 1: Crop Load Management:

Crop load has profound effects on fruit quality, but these effects from a standpoint of premium apple juice production for cider are poorly understood, particularly with respect to high-tannin cultivars. An inverse relationship between heavy crops and fruit quality has been well-demonstrated in wine grapes. Is there a similar relationship between quality and crop load for apples?

Crop load, the balance between fruiting and vegetative components of growth, has strong effects on fruit size, fruit quality, and fruit maturity. Until recently the relationship between crop load and polyphenol (tannin) content was relatively unexamined in apple, while other measures such as sugar, texture, and acidity were well-documented. Peck et al. found that polyphenol content of fermented cider made from York Imperial increased with increasing crop load, following an opposite trend from other measurements of fruit quality. In 2018 we conducted a pilot study to determine whether we could corroborate these findings but found instead that polyphenol content decreased with increasing crop load in our study of Frequin Rouge (see figures below), following the same trend as that for sugars and acids. This finding is directly opposed to that of Peck et al. and requires a second study of greater intensity before it can be fully corroborated.

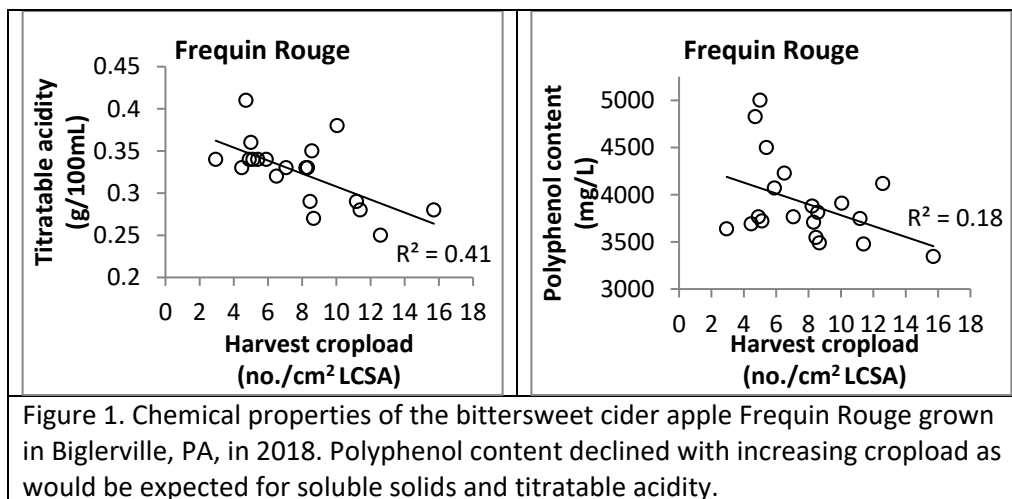


Figure 1. Chemical properties of the bittersweet cider apple Frequin Rouge grown in Biglerville, PA, in 2018. Polyphenol content declined with increasing cropload as would be expected for soluble solids and titratable acidity.

#### Part 2: Variety Evaluation

Some producers believe high-tannin bittersweet apples of European origin represent a necessary component of quality hard cider. Many of the European bittersweets are not well adapted to our Pennsylvania climate, are highly susceptible to fire blight, or simply do not produce as well as in their places of origin. Other U.S. cider producers utilize traditional cider apples of American origin.

American-origin high-tannin cultivars have been promoted within the cider community as well-adapted to U.S. conditions and as producing high-quality tannin-rich juice for producing heirloom hard cider. Many of these varieties are untested in Pennsylvania and the claims of juice chemistry are not documented with verifiable measurements.

The following are some of the American apples that are available commercially and have been marketed as effective cider varieties, most having high tannin chemistry. Some of these varieties are not yet grown in Pennsylvania.

Bitter Pew  
Gnarled Chapman  
Harrison  
Campfield  
Hewe's Crab  
Old Fertile  
Nailbiter  
Bittersweet Beauty of the Quabbin  
Stark® Franklin Cider™ Apple  
Blue House Bitter  
Ashcroft Bittersharp  
Redfield  
Northern Spy  
Winchester

To our knowledge these apples have not been systematically analyzed together for polyphenol content, sugars, and acids, and compared directly with European bittersweets.

**Objectives:** 1) to evaluate the effect of crop load on fruit characteristics relevant to hard cider production, particularly polyphenol content, and to establish target crop thresholds for Dabinett and Frequin Rouge relative to juice quality. 2) to determine the sugar, acid and polyphenol profiles of traditional cider apples of American origin and compare their chemical characteristics directly to two well-known European bittersweets.

The potential benefits of this study include:

- Contribute to our understanding of the influence of crop load on polyphenol content, sugar, and acidity, which are important quality characteristics for all apples, regardless of market.
- Provide the basis for recommendations for crop load that will maximize fruit quality in commercial orchards of European bittersweets.
- Provide Pennsylvania producers with knowledge of reliable and desirable hard cider apples well-suited to our climate.
- Provide much-needed objective analysis of new cultivars touted to bring high-tannin apples to commercial orchards.

## **Procedures**

Part 1: We will establish a range of crop loads from about 4 to 15 fruits per unit of trunk cross-sectional area on 20 trees of Frequin Rouge and 20 trees of Dabinett grown at FREC in the 2019 season. At harvest we will count and weigh the fruit from each data tree. We will analyze the chemical characteristics of the fruit after juicing, including soluble solids, titratable acidity, and polyphenol content and determine relationships between chemical characteristics and cropload variables.

Part 2: Fruit samples of a selection of American-origin cider apples will be obtained. We will weigh, photograph and describe their physical appearance, then analyze the fruit juice for soluble solids, titratable acidity, and polyphenol content. The chemical properties of these samples will be compared with the European bittersweets, Frequin Rouge and Dabinett.

**Budget:**

Wages:	\$4000
Fringe:	\$312
Postage:	\$150
<u>Supplies:</u>	<u>\$1500</u>
Total:	\$5962

**Budget Justification:** Wage and associated fringe are needed to count and establish crop load treatments, harvest, evaluate fruit characteristics and chemical constituents, data tabulation and analysis. Postage is needed to obtain fruit samples from more distant producers via UPS 2-day shipment. Supply needs include flags, tags, and bags for fruit collection, as well as fruit shipping containers, chemical reagents, a pH probe, and spectrophotometer cuvettes.

Fringe Benefits

Fringe benefits are computed using the fixed rates of 38.97% applicable to Category I Salaries, 14.74% applicable to Category II Graduate Assistants, 7.81% applicable to Category III Salaries and Wages, 0.18% applicable to Category IV Student Wages, and 25.34% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2019 (July 1, 2018, through June 30, 2019). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2019, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

**Other Support:** Orchard maintenance provided by Penn State University. Additional funding provided by the Penn State Hard Cider Extension Program.