

USE OF AIR INJECTION

Technical Summary of Research Findings

Timothy Perkins, Ph.D.

UVM Proctor Maple
Research Center

Nathalie Martin, Ph.D.

Centre Acer

Air Injection – Research Findings

BACKGROUND

- ▣ Air injection (AI) was introduced into the maple industry about 10 years ago
- ▣ Primary effect is to produce lighter-colored maple syrup
- ▣ Very little was initially known about the mechanisms by which AI worked or the impacts on chemistry, quality, and flavor of maple syrup produced with AI
- ▣ No guidelines for use

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OVERALL RESEARCH

- ▣ Both Centre Acer and the UVM Proctor Maple Research Center conducted several studies to examine how AI affected maple syrup
- ▣ Research included field surveys, laboratory studies, and evaporator studies
- ▣ A consensus technical report was generated to provide an overview of the key results, and to point out where results were similar, and where they were not

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LIMITATIONS

- ▣ No single study can encompass the wide range of conditions found among maple producers
- ▣ Each study has different objectives and is designed to answer a limited number of questions
- ▣ Although results may sometimes appear to be contradictory, perceived differences can usually be explained by the experimental design employed to answer a specific question

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DEFINITION...

Air injection (in the maple industry) is the forced introduction of air through a series of perforated pipes submerged in the boiling sap of the front and/or back pan of a maple syrup evaporator.

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LIGHT TRANSMITTANCE (Color)

- ▣ All studies indicate a strong effect of AI on color of maple syrup
- ▣ AI syrup is significantly lighter in color than syrup produced without AI
- ▣ Lightening is greatest in early to mid-season, and reduced or absent in late-season

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LIGHT TRANSMITTANCE (Changes in Storage)

- ▣ AI syrup packed in retail containers behaves similarly to syrup produced without AI over a storage period up to one year
- ▣ Color deterioration of both AI and non-AI syrups proceeds at the same rate for a given type of container

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pH

- ▣ Maple syrup made with AI has a lower pH than syrup made without AI
- ▣ The largest differences were observed from early to-mid-season
- ▣ In all cases, pH of syrup made with AI was within the established range of pure maple syrup

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CONDUCTIVITY

- ▣ No significant differences

CARBOHYDRATE COMPOSITION

- ▣ No significant differences
- ▣ Some tendency for AI syrup to have slightly elevated levels of invert sugars
- ▣ Range of invert sugar levels did not fall outside the range documented for pure maple syrup

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MINERAL & METAL COMPOSITION

- ▣ Relatively few differences observed in bulk mineral composition
- ▣ Occasional significant differences observed, but effects tended to be small and inconsistent
- ▣ Concentrations of minerals and metals was within the ranges of pure maple syrup

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ORGANIC ACID COMPOSITION

- ▣ In a laboratory-level study, AI reduced levels of oxalacetic acid
- ▣ No significant differences in five other organic acids examined

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PHENOLIC COMPOUND COMPOSITION

In a laboratory-level study, AI syrup had

- ▣ Significantly lower levels of syringaldehyde
- ▣ Tendency for higher levels of vanillin with AI
- ▣ Coniferol content did not differ
- ▣ Overall phenolic acid content decreased when AI is used
- ▣ Decreases more important at end of season

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BIOACTIVITY

Preliminary results indicate possible alteration in:

- ▣ Phenolic acid content
- ▣ Antioxidant activity
- ▣ Redox (oxydo-reduction) potential

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PRODUCTION FACTORS

Evaporator level studies indicate

- ▣ No difference in defoamer requirement
- ▣ No difference in scale deposition
- ▣ No difference in sugar-sand production
- ▣ Reduced temperature profiles throughout the evaporator when AI is employed

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FLAVOR & VOLATILE COMPOUNDS

Sensorial analysis (Maple flavor wheel, and Quebec's Official standardized quality grading system)

- ▣ Survey = tendency for more foreign off-flavors
- ▣ Laboratory scale = increased vanilla flavor with reductions in other flavor attributes
- ▣ Laboratory scale = AI produced twice the number of unidentified origin off-flavors ($\sqrt{R4}$)
- ▣ Similar results with parallel study in industrial evaporator

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FLAVOR & VOLATILE COMPOUNDS

(continued...)

Paired evaporator studies

(Sensory analysis by maple industry panel according to Vermont Maple Syrup Standards)

- ▣ No evidence of increased frequency of off-flavors
- ▣ Total concentration of volatile compounds significantly greater in AI syrup
- ▣ Several volatiles typical of maple syrup were significantly reduced or absent in syrup produced with AI (lighter syrup)

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PRODUCT SAFETY

Not directly addressed by studies, however the consensus opinion is that there is no cause for concern as long as adequate food safety measures and manufacturer's operating guidelines are employed:

- ▣ appropriate air filtration,
- ▣ appropriate air uptake positioning,
- ▣ appropriate materials for contact with food.

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POTENTIAL MECHANISMS OF AI ACTION

- ▣ The physical and chemical reactions involved in maple syrup production are very complex and not well understood
- ▣ Dominant mechanisms are a result of the interplay of caramelisation and Maillard processes and polymerization of phenolics
- ▣ AI may affect these processes in several ways

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POTENTIAL MECHANISMS (continued...)

(Order does NOT indicate importance)

1. Reduction in processing temperature
2. Chemical oxidation
3. Alteration of the alkaline degradation phase
4. Mechanical agitation of sap

More than one mechanism may be operating simultaneously. Importance likely varies with specific conditions

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SUMMARY

Results have demonstrated:

▣ *“Reduction of color and flavor development: lower processing temperatures, as well as the alteration of maple syrup chemical components through oxidation reactions.”*

▣ *“The processing conditions may favor one mechanism over the other, although these mechanisms could all be operating simultaneously. No one mechanism can be expected to explain the full spectrum of phenomena observed, given the range of equipment set-ups and operating conditions that exist in the field.”*

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SUMMARY (continued...)

▣ *“Although the majority of syrups produced with air injection may be considered to fall within the normal range of limits of composition of maple syrup*, they are decidedly skewed towards lighter colored syrup with considerably less developed taste.”*

* Limited to some of the compounds analyzed in the studies (sugars, organic acids, minerals and metals).