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Original Research Article

Biochemical composition of maple sap and relationships among constituents

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ABSTRACT

Maple sap is a product of great economic value with a variable composition. Samples of maple sap were collected at different periods of the 2007 and 2008 seasons in various locations in Quebec (Canada). The aim of the study was to establish a typical chemical composition of maple sap by analyzing a large number of maple sap samples. Multiple factor analysis was also performed to help establish relationships among compounds. Results confirm that total soluble solids and sucrose concentration were higher near mid-season. The concentration of specific organic acids in sap could depend on the sugarbush (malic acid) or could be influenced by microbial activity (acetic and lactic acid). Phenolic compounds of interest were present mainly at the beginning of the season and decreased as the season progressed. The concentrations of the main minerals (K, Ca and Mg) increased over the sap flow season and the presence of calcium and magnesium seemed highly correlated. These results will help in establishing an update of mean values and ranges for many components of maple sap.

1. Introduction

Maple sap is well known in North America as the raw material used to produce maple syrup and other derived products. It is collected from sugar maple trees (*Acer saccharum*) at the thaw period generally from early February to late April. This plant fluid circulating (from the root system toward the trunk) in the xylem of maple trees contains many components which are relatively unknown compared to what has been published for maple syrup. In fact, sap composition cannot be deduced from maple syrup composition since the many processing steps following sap collection are likely to influence the concentrations and types of components. Maple sap and syrup composition and properties were recently reviewed (Perkins et al., 2006; Perkins and van den Berg, 2009), giving an overview of concentrations reported previously in the context of maple syrup production. According to several studies, maple sap contains many organic and inorganic components such as sugars, organic acids, phenolic compounds, amino acids and minerals (Perkins and van den Berg, 2009; Pollard and Sproston, 1954). These reported data however, were not always obtained from the same maple sap samples, which make relationships between components difficult. Furthermore, many of them were obtained in the early days of maple syrup production when modern tubing systems under vacuum to collect sap were not present and samples were collected from a few trees or were from a relatively low number of samples. Today, the large majority of commercial maple sap batches produced each year are collected under vacuum using a plastic tubing system installed in the sugarbush. This system allows an increased productivity and a larger sugarbush area of production. This type of maple sap is now considered the typical product of the modern maple operation and the industry is looking at avenues to promote new applications and new product developments for this raw material in addition to maple syrup production. An example of this is the use of sterilized maple sap as a healthy beverage or in a new formulation of maple sap functional beverage by incorporating viable probiotic bacteria (Khalf et al., 2010). Although recent studies have shown interest in sterilized maple sap composition for its use as a functional beverage (Yuan et al., 2013), it is necessary to update levels of major components of maple sap and give a comprehensive overview of the relationships among these components in order to offer the industry a solid base for future developments when using it as a raw material. This paper reports data on main constituents of maple sap obtained from samples collected in many sugarbushes over two seasons and from many production regions of Quebec (Canada) where more than 75% of the world's

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production is located. Multivariate analysis of data is also reported to give a comprehensive illustration of the relationships that exist among constituents.

2. Materials and methods

2.1. Maple sap sampling

Samples of maple sap were collected at the sap tank located at the end of the tubing system. All systems were operated under vacuum at approximately 61–75 kPa (18–22 inches of Hg). Sampling was done at different periods from the beginning to the end of the 2007 and 2008 seasons (Table 1). These two seasons were similar in terms of total volume of syrup produced per region (Fédération des producteurs acéricoles du Québec, 2009). Except for a few sugarbushes, sampling was done at 5 periods corresponding to 0, 25, 50, 75 and 100% of the total volume of sap collected from the sugarbush. This procedure based on producer's experience, ensures that sampling periods are specific to each sugarbush and are evenly distributed in terms of volume produced. A total of 124 samples were obtained from 21 sugarbushes located in 8 regions of Quebec (Canada) in 500 mL sterile containers. Sampling was generally done in mid-afternoon for all sugarbushes. Samples were immediately stored in a freezer prior to analysis.

2.2. Reagents

Standards of sugars, organic acids, phenolic compounds and methanol were purchased from Sigma (Oakville, ON, Canada). Trifluoroacetic acid, formic acid, sulfuric acid, EDTA and ammonium hydroxide were obtained from American Chemicals Ltd (Saint-Laurent, QC, Canada). Water was purified in a Milli-Q system (Millipore, Bedford, MA, USA) and filtered through 0.22 μm membrane (Millipore) prior to use.

2.3. Physico-chemical and microbial counts analysis

Samples of maple sap were analyzed for pH using a PHM82 Radiometer pH-meter equipped with a pH Sensor Glass Sealed supplied by VWR (ON, Canada), and for total soluble solids (°Brix) using a AR200 Digital Hand-Held refractometer (Reichert Scientific Instruments, Buffalo, NY, USA). Microbial counts were obtained by diluting sap samples into peptone water (0.1%, w/v) and by plating appropriate dilutions on plate count agar (Difco laboratories, Detroit, MI, USA) which were incubated for 48 h at 30 °C for total aerobic counts. Fungal counts were obtained by plating on acidified potato dextrose agar (Difco laboratories) incubated for 5 days at room temperature. All microbial counts were expressed in colony forming units per mL of raw maple sap (CFU/mL) with log values used for calculations.

Table 1
Description of maple sap sampling conditions.

Sugarbush	Number of taps	Region	Number of periods sampled (dates)	
			2007	2008
A	8000	Montérégie-Est	5 (03/12–04/18)	–
B	2500	Bas-St-Laurent	5 (03/24–25/04)	–
C	3000	Outaouais	5 (03/13–04/12)	–
D	2500	Centre du Québec	5 (03/14–04/15)	–
E	9500	Centre du Québec	5 (03/13–04/12)	–
F	13,000	Estrie	5 (03/11–04/18)	4 (03/19–04/13)
G	4200	Beauce-Appalaches	5 (03/12–04/14)	3 (04/04–14/04)
H	6850	Beauce-Appalaches	5 (03/22–04/20)	5 (04/04–04/15)
I	2500	Laurentides	5 (03/22–04/14)	5 (03/04–04/17)
J	109,000	Portneuf	5 (03/14–04/22)	5 (04/04–04/22)
K	24,000	Outaouais	–	4 (03/30–04/15)
L	2000	Outaouais	–	5 (04/04–04/18)
M	2000	Montérégie-Est	–	4 (04/10–04/16)
N	12,700	Montérégie-Est	–	6 (04/03–04/15)
O	9000	Centre du Québec	–	4 (04/02–04/14)
P	29,800	Estrie	–	5 (03/07–04/17)
Q	11,700	Estrie	–	5 (03/26–04/20)
R	5000	Laurentides	–	5 (03/26–04/17)
S	26,000	Bas-St-Laurent	–	5 (04/06–04/24)
T	52,000	Bas-St-Laurent	–	5 (04/08–04/26)
U	23,168	Bas-St-Laurent	–	5 (04/04–04/24)