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Fruit growth and chemical properties of *Ribes magellanicum* "parrilla"

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ABSTRACT

The aim of this work was to study the time course and pattern of fruit growth and the evolution of some of the chemical attributes such as soluble solids, acidity, and anthocyanin content in *Ribes magellanicum* plants growing in a natural environment near Ushuaia city, Tierra del Fuego (Argentina). Fruit growth and composition presented significant changes along the days from the full bloom phase. Fresh and dry fruit weight exhibited a typical double sigmoid curve. The first period of rapid fresh fruit growth was from full bloom phase until 28 days after, followed by a lag period until 42 days from the full bloom phase, and then by a second period of rapid increase until 56 days from the full bloom phase. Then, fresh fruit weight increased slowly (days 70–98 from the full bloom phase), reaching its maximum. Afterwards, fresh fruit weight decreased significantly until the end of the summer, and the fruiting period approximately ended 112 days from full bloom phase. On a dry weight basis the maximum fruit biomass was reached 98 days from the full bloom phase. Evolution of fruit growth was related with the compositional changes evaluated. By day 98 from the full bloom phase, soluble solids (17.5°Brix) and anthocyanin content (240.1 mg/100 g fruit fresh weight) were at their maximum, while at this time the total titratable acidity was at a minimum (0.4%). The results obtained not only contribute to the knowledge of the quantitative content of anthocyanin, a metabolite with nutraceutical value, but also give some tools for the definition of the optimal harvest time of *R. magellanicum* fruits, which it is important for fruit destination.

1. Introduction

The importance of wild flora as sources of food and medicinal substance is well known (Iriondo, 2001). However, more studies on diversity and agronomic and medicinal potential of the wild flora (Arena and Vater, 2005) are necessary as only a few species have been evaluated for these purposes (Iriondo, 2001). An attention is particularly focused on many of the small fruits that are now considered for their nutraceutical properties as functional foods, that is foods containing essential organic and inorganic nutrients and metabolic regulation factors and also specific metabolites that give additional health benefits (Henriques et al., 2004; Kuskoski et al., 2005). Soft fruits of *Ribes*, *Rubus*, and *Vaccinium* cultivated species are an excellent source of natural products such as pigments (Flores Cantillano, 2004; Henriques et al., 2004) with antioxidant properties (Deighton et al., 2002).

Ribes magellanicum Poiret, commonly named "parrilla", is found in the forest clearings and wood margins of *Nothofagus pumilio* in Tierra del Fuego (Moore, 1983). It is a deciduous, erect shrub up to 4 m high, with racemes with 20 or more yellow to reddish flowers and globose berries, purple at maturity (Moore, 1983), with an ornamental value. As a first step towards its domestication, shoot growth and fruiting were studied in plants growing naturally near Ushuaia city, Tierra del Fuego, Argentina (Arena et al., 2007). At present, this non-timber forest product has a local and regional market (Tacón Clavaín, 2004), because its purple berries can be consumed fresh, in marmalades and syrups (Correa, 1984). However, commercial orchards of this native *Ribes* species are being projected, as it represents an attractive potential crop such as the cultivated *Ribes* species in Argentinean Patagonia. Berries are currently of increasing importance for the local industry as for the fresh market, because of its diversity in soils and climates and, mainly, to the possibility of producing out of season, with regard to the north hemisphere. *Ribes* and *Rubus* species are important for diversification of production in mountainous and marginal areas such as Southern Apennines (Rotundo et al., 1998; Hummer and Barney, 2002), which present similar characteristics to Tierra del Fuego. The fruits, both for food and non-food (pharmaceutical, cosmetic industries) use, is a source of revenue for people living in marginal areas.

The aim of this work was to study the time course and pattern of fruit growth and the evolution of some of the chemical attributes such as soluble solids, acidity, and anthocyanin content along the

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days from the full bloom phase in *R. magellanicum* plants growing in a natural environment of Tierra del Fuego (Argentina). The results obtained could be of value in defining the optimal time for fruit harvesting according to the future use, as well as contribute to the establishment of the nutraceutical value at a particular stage of maturity (Gonzalez-San José et al., 1990).

2. Materials and methods

2.1. Geographic data and climatic parameters

R. magellanicum plants were studied from an area located near Ushuaia city, 54°48′S, 68°19′W (Tierra del Fuego, Argentina). Values of maximal, minimal and mean daily air temperatures (°C), mean ambient relative humidity (%), and rainfall (mm) were collected using a meteorological station located at the Centro Austral de Investigaciones Científicas (CONICET, Argentina) from October to March for the 2004/05 growing season. Mean daily air temperature was 9.0 °C, with the highest mean daily air temperature in February (11.2 °C). Minimal and maximal daily air temperatures were 4.6 and 13.5 °C respectively. Mean ambient relative humidity of the registered months was 74.9%. Cumulative rainfall was 295.6 mm, while December had the highest rainfall (83.8 mm).

2.2. Plant material, samplings, and measurements

Fruits (200 g) were manually collected from *R. magellanicum* plants ($n = 20$, with a mean height of 1.85 ± 0.30 m), growing naturally in *Nothofagus* forest clearings, from November (14 days from full bloom phenological phase) to February (112 days from full bloom phenological phase) (Figs. 1 and 2). For chemical properties, fruits were analyzed from 14 days from full bloom to 98 days from full bloom, due to the fruits were overripened at 112 days from full bloom, being difficult to obtain the juice and therefore to perform the analysis of the chemical variables.

Fig. 1. *Ribes magellanicum* racemes at full bloom.

Fig. 2. *Ribes magellanicum* ripened fruits.

2.2.1. Morphological characterization

The following parameters were recorded and evaluated: fresh fruit weight, dry fruit weight, dry fruit weight as percentage of fresh weight, equatorial and polar fruit diameters (using a digital calliper Mitutoyo Model 500-196, 150 mm × 6″ − 0.01 mm × 0.0005″), fresh seed weight, dry seed weight, dry seed weight as percentage of fresh weight, seed number, and dry seed weight/dry fruit weight ratio.

2.2.2. Soluble solids and total titratable acidity

Soluble solids were determined in fruit juice using an ATAGO N1-α refractometer with 0–32°Brix measurement range with 0.2°Brix increments, and no temperature compensation. Total titratable acidity was measured by titration with 0.1 N NaOH solution. Total titratable acidity was expressed as citric acid. Soluble solids/total titratable acidity ratio and initial pH were also recorded.

2.2.3. Anthocyanin content

Anthocyanin quantification was performed by the pH differential method of Giusti and Wrolstad (2001). Samples (5 g) of initially frozen fruits were extracted for 24 h in 50 mL 0.1% HCl–MeOH solution at 4 °C. Then, aliquots were diluted from 1:5 to 1:80 with either a 0.025 M KCl (pH 1) or 0.4 M sodium acetate (pH 4.5) buffer. Absorbance measurements were made at 510 and 700 nm with a Shimadzu 1203 UV-Visible spectrophotometer. Anthocyanin fruit tissue content was determined on the basis of a molar extinction coefficient of 26,900 and a molecular weight of 449.2 for cyanidin 3-glucoside. Values were expressed in terms of milligrams of anthocyanin/100 g of fresh-frozen fruit.

Anthocyanin fruit content (mg/100 g fruits) = ($A \times$ molecular weight × dilution factor × initial volume/$\varepsilon \times$ sample weight) × 100

with A (absorbance)

$$= (A_{510\,\mathrm{nm}} - A_{700\mathrm{nm}})_{\mathrm{pH\ 1.0}} - (A_{510\,\mathrm{nm}} - A_{700\,\mathrm{nm}})_{\mathrm{pH\ 4.5}}$$

2.3. Statistical analysis

Data were subjected to an analysis of variance, and means were then separated using the Tukey multiple range test at $p \leq 0.05$ through the Statgraphics Plus (version 5.1) program.

3. Results

3.1. Fruit growth

As expected, the fresh ($F = 30.98$, $p = 0.000$) and dry ($F = 38.56$, $p = 0.000$) weight of fruits significantly varied along the days from