ETHNOBOTANICAL ENTREPRENEURSHIP FOR INDIGENOUS BIOCULTURAL RESILIENCE:

RHODIOLA ROSEA IN NUNATSIAVUT

A thesis submitted to the

School of Graduate Studies

In partial fulfillment of the

Requirements for the degree of

Doctorate of Philosophy

Department of Biology/Faculty of Science

Memorial University of Newfoundland

Submitted August 2019

St. John's Newfoundland

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General Abstract

Rhodiola rosea (L.) (syn. *Sedum rosea* (L.); Crassulaceae; rhodiola, roseroot) is an amphi-Atlantic, Arctic-alpine plant with considerable value in both traditional pharmacopeias and the commercial natural products industry. Global market demand for rhodiola as a natural health product with potent antioxidant and adaptogenic properties has resulted in unsustainable wild harvesting in Eurasia. However, rhodiola is not commercially sourced in eastern Canada, where it grows prolifically along the coast of Nunatsiavut, Labrador. Nunatsiavut Inuit have traditionally used rhodiola, locally known as *tulligunak*, as food and medicine; however, due to globalization and significant social-ecological changes, these Inuit communities are beginning to explore ethnobotanical innovation and entrepreneurship.

Cultivation of rhodiola in Nunatsiavut for natural health products presents an opportunity for a sustainable, community-based enterprise that integrates ancestral knowledge with biocultural innovation, bringing both socioeconomic benefits that align with community priorities and renewed connection to ancestral practices. Given the extensive range of this plant, the geographical variability in growth and phytochemistry of Labrador rhodiola populations must be addressed in order to inform ecotype selection and cultivation conditions. Further, because cultural context is a key factor influencing success of community-based enterprises, it is critical to consider the unique biocultural context when developing an enterprise intended to build capacity in participating communities. This thesis will explore the biology, biocultural context, and business

opportunity for Nunatsiavut rhodiola, to inform development of a community-based enterprise in Nunatsiavut, cultivating local ecotypes of rhodiola for a natural health product, bringing benefits to a remote Indigenous community, and helping mitigate pressure on wild populations of rhodiola due to commercial harvest activities.

The results showed that Nunatsiavut Inuit Elders and community report both medicinal and food uses of the local rhodiola, and they are enthusiastic at the prospective social, economic, and health benefits of a community-based enterprise centered around cultivation and marketing of local rhodiola. Coastal Labrador rhodiola was found to contain known medicinal marker compounds, and environmental factors were found to have a significant effect upon rhizome biomass and phytochemistry.

Chapter 1. General introduction

1.1 Introduction

At least 60-80% of the world's population relies on traditional medicine such as medicinal plants to meet primary healthcare needs (World Health Organization 2013); however, anthropogenic pressures such as climate change and unsustainable harvesting practices threaten many of these valuable medicinal plant populations (Allen et al. 2014). In addition, challenges faced by traditional cultures threaten native languages, customary practices, and ethnobotanical knowledge. Strategic objectives established in the World Health Organization's 2014-2023 Traditional Medicine Strategy assert the importance of understanding and recognizing the role and potential of traditional and complementary

medicine, building evidence and sustaining resources to strengthen the knowledge base for active management of traditional medicinal plant resources (World Health Organization 2013).

Ethnobotanical programs that facilitate synergy between traditional botanical knowledge and innovative applications are an important strategy to develop and sustain pathways for biocultural resilience and adapting to dynamic and changing social-ecological systems (Folke 2006). It is therefore critical to conserve the ethnobotanical knowledge surrounding traditional plant use, to encourage customary biocultural practices as well as innovation and entrepreneurship around medicinal plant use. Applied strategies of endogenous and sustainable development using traditional medicinal plant resources with locally-specific biocultural protocols that ensure equitable benefit sharing can also help to incentivize community-based conservation. This project aims to foster biocultural resilience in an Indigenous community by leveraging traditional knowledge innovations based upon medicinal plants, supporting community capacity to adapt and transform. However, success of a community-based enterprise is closely tied to the enterprise's ability to meet community priorities, which are often unique to the specific biocultural context, so it is critical to engage and form strong collaboration with local communities before and throughout the development process.

Many social-ecological changes in Northern Indigenous and Inuit communities have occurred within the last generation, and are accelerating dramatically, due to the combined effects of climate change and globalization (Turner et al. 2008; Downing and Cuerrier 2011). In Nunatsiavut (Labrador, Canada), climate change's impacts upon

weather patterns, sea ice, permafrost, and species distributions have disrupted the Nunatsiavut Inuit traditional land-based practices (Ford et al. 2017), undermining the foundations of their cultural identity (Cuerrier et al. 2012; Rapinski et al. 2017). Unpredictable weather patterns in Nunatsiavut, combined with unstable ice make it difficult and often unsafe for Inuit to engage in traditional hunting and gathering practices on both land and water (Ford et al. 2017; Rapinski et al. 2017). This disruption of traditional land and sea--based activities is having a negative impact on food security and cultural identity, and in turn upon mental health indicators within Nunatsiavut communities (Cunsolo et al. 2012, 2013, 2015; Durkalec et al. 2015). This brings unprecedented challenges for coping resiliently with the rapid pace of social-ecological disruption, demanding the combined leverage of bio-cultural tools and approaches (Berkes et al. 2003). Community-based enterprise can help cultivate cross-scale linkages between social and environmental systems, balancing sustainability with development, for greater resilience (Folke 2006). This project aims to create linkages between traditional knowledge and sustainable entrepreneurship, to bridge Labrador Inuit use of *Rhodiola rosea* from traditional knowledge to community-based enterprise, thereby fostering local capacity for biocultural resilience.

Ethnobotanical investigations in Nunatsiavut have shown a resurgence of interest in the traditional uses of plants, as well as in their potential for community economic development (Cuerrier et al. 2012). However, the effects of environmental conditions upon growth and potency of medicinal plants can be significant and should therefore be evaluated prior to the development of natural health products for potential community

enterprises. At the request of community-appointed Nunatsiavut Government leaders, with Elders' knowledge as the foundation of the project, the feasibility of a local medicinal plant cultivation enterprise was investigated through biological and ethnobotanical assessments, combined with a business opportunity analysis.

Rhodiola rosea (herein referred to simply as rhodiola) was chosen as the focus for this enterprise for several reasons. Rhodiola grows naturally in abundance along the Labrador coast. It is part of the traditional Inuit pharmacopeia, and it is in demand internationally as a natural health product in the commercial market. Rhodiola is considered an adaptogen, a therapeutic agent that modulates and normalizes cellular and physiological function, to improve performance, mood, endurance, energy, and resistance to stress (Ulbricht et al. 2011). Further, there are no known commercial sources of rhodiola originating from North American germplasm, so there is the potential for a unique product market niche. However, it was important to all involved that this enterprise is sustainable, as commercial harvest of rhodiola in the wild has led to overharvest and endangered wild populations in Russia (Galambosi 2006). The herbal industry has grown exponentially in recent decades (Smith et al. 2018), placing considerable demand upon the supply of medicinal plants in the wild, with estimates of the overall number of medicinal plant species threatened worldwide ranging from 4,160 to 10,000 (Schippmann et al. 2002; Hamilton 2004). Since the known active medicinal constituents of rhodiola are mainly concentrated in the plant's below-ground parts, the root and rhizome, commercial harvest of rhodiola for medicinal purposes could therefore endanger wild rhodiola populations. To prevent the overharvest of wild populations of

rhodiola in Labrador, and promote sustainable development, commercialization would require propagating and cultivating locally-sourced plants. Cultivation of medicinal plants can relieve the pressure on wild populations from overharvest, potentially ensuring a more reliable supply of raw materials, allowing selection of the most desirable traits in terms of growth and bioactivity (Schippmann et al. 2002). Rhodiola cultivation projects are also underway in Alaska, Bulgaria, Canada (Alberta), Denmark, Germany, Switzerland, and Norway, but have not been previously attempted in Labrador (Bejar et al. 2017).

1.2 Thesis outline

Chapter 2, "The impact of environmental variables on growth and phytochemistry of *Rhodiola rosea* in coastal Labrador", aims to determine if local rhodiola populations are suitable for commercialization based upon measures of growth and phytochemistry by comparing northern and southern Labrador populations.

Rhodiola rosea is a species that shows wide ecological amplitude, and phenotypic plasticity in both its morphology and its phytochemistry (Galambosi 2005; Martinussen et al. 2011; Adamczak et al. 2014). Due to its broad ecological amplitude, the habitat and environment in which Canadian populations of rhodiola are found can be very distinct from the Eurasian populations (Cuerrier et al. 2015). In eastern Canada, rhodiola grows along coastline, sand dunes and cliffs, growing with a number of other species and withstanding wave disturbance and salt spray. Commercially traded populations of rhodiola are found at high altitudes in alpine habitats of Russo-Siberia, without exposure to salt or the competition of other shoreline species. While these discrete populations of

Rhodiola rosea are taxonomically the same species, it might be expected, due to the plant's phenotypic plasticity that different ecophysiological conditions may have resulted in the emergence of distinct ecotypes or chemotypes, local phenotypes with unique chemical profiles or growth attributes (Cuerrier et al. 2015).

As there is no prior research on Nunatsiavut rhodiola, it was important to assess its growth and phytochemistry, to ensure its suitability for a natural health product. Phytochemical analysis was conducted on samples of local rhodiola populations to assess levels of known medicinal constituents, phenylpropanoids (rosarin, rosavin and rosin) and phenylethanol derivatives (salidroside) (Brown et al. 2002). Growth assessments of local wild rhodiola populations were conducted to determine the extent of morphological variability in both above- and below-ground parts of commercial interest, and whether there are local types that would be more appropriate for cultivation. To assess the extent to which rhodiola is affected by environmental conditions across the coast of Nunatsiavut, data were compared across latitudes (north – Nain vs south – Rigolet) and soil substrates (rocky, sandy, and organic).

Then **Chapter 3**, "The biocultural context for development of a community enterprise based upon medicinal plants: Nunatsiavut Inuit knowledge and perspectives on the use of *Rhodiola rosea"*, aims to determine if a natural health product based upon traditional knowledge is appropriate and acceptable to community members. Cultural context has been shown to be a key factor influencing success of community-based enterprises, so it is important to consider the specific biocultural context when developing a small enterprise intended to bring benefits to participating communities (Anderson and

Dana 2006; Meis Mason et al. 2012; Pengelly and Davidson-Hunt 2012). To explore the potential for development of a natural health product based upon Labrador rhodiola, ethnobotanical focus groups were conducted with Nunatsiavut Inuit Elders and youth, as well as semi-structured ethnobotanical interviews with community members. Ethnobotanical investigations aimed to explore the extent of traditional Inuit knowledge or *Qaujimajanngit* (Meis Mason et al. 2012) surrounding rhodiola, its uses as food and medicine, and its ecology, following on previous work by Cuerrier et al. (2012). Consultations with Nunatsiavut Elders, youth, and community leaders also investigated community perspectives and preferences on applying traditional knowledge for a commercial enterprise.

Lastly, in **Chapter 4, "**Bridging Nunatsiavut Inuit use of *Rhodiola rosea* from traditional knowledge to sustainable community enterprise", the viability of a sustainable local rhodiola cultivation and processing enterprise is explored by way of an opportunity analysis. Exploration of enterprise design and implementation was conducted in the opportunity analysis to provide an overview of the market for natural health products and operational considerations involved in the development of a successful medicinal plant enterprise. This business opportunity could bring both social and economic benefits to the community, by creating jobs and opportunities for advanced training. To tailor recommendations to the unique biocultural context of Nunatsiavut, the opportunity analysis was developed in consultation with the local community, Inuit Elders, and youth, in collaboration with the Nunatsiavut Government.

Chapter 5 is the General Conclusion and synthesis.

1.3 Co-authorship Statement

This research was conducted under the co-supervision of Dr. Luise Hermanutz and Dr. Alain Cuerrier. Pre-publication ethnobotany data from Makkovik was shared by Erica Oberndorfer and included with her permission in Chapter 3. I wrote the original drafts for all the manuscripts that make up the chapters of this thesis.

Financial support for the research conducted in Chapters 2, 3 and 4 was provided by Memorial University of Newfoundland, ArcticNet, and the Harris Centre.

Publications, both published and anticipated, resulting from this thesis are:

Chapter 2

Mardones V, Cuerrier A, Hermanutz L, Arnason JT, Saleem A, Uejio C, Liu, R. 2019. The impact of environmental variables on growth and phytochemistry of *Rhodiola rosea* in coastal Labrador.

Chapter 3

Mardones V, Cuerrier A, Hermanutz L, and Nunatsiavut Inuit Elders and community. 2019. The biocultural context for development of a community enterprise based upon medicinal plants: Nunatsiavut Inuit knowledge and perspectives on the use of *Rhodiola rosea*. Journal of Ethnobiology (in Revision)

Chapter 4

Mardones V, Cuerrier A, Hermanutz L. 2019. Bridging Nunatsiavut Inuit use of *Rhodiola rosea* from traditional knowledge to sustainable community enterprise.

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Chapter 2. Assessing the impact of environmental variables on growth and phytochemistry of *Rhodiola rosea* in coastal Labrador to inform small-scale enterprise.

Abstract

Ethnobotanical interviews with Nunatsiavut Inuit elders in Labrador, Canada have documented traditional knowledge and use of rhodiola, *Rhodiola rosea* (L.) (Crassulaceae), as well as enthusiasm for the development of a community-based enterprise to market value-added, locally cultivated rhodiola as a natural health product. The roots and rhizomes of rhodiola contain medicinal compounds that are valuable in commercial markets for their antioxidant and adaptogenic properties, however, the geographical variability in growth and phytochemistry of local rhodiola populations must be addressed in order to inform ecotype selection and cultivation conditions. This research investigated the effects of latitude, substrate, and sex on the growth and phytochemistry of rhodiola growing wild in coastal Nunatsiavut. Female and male plants, 87 in total, were sampled from northerly (Nain) and southern (Rigolet) Nunatsiavut populations, and from sand, organic, or rock substrates to compare growth, morphology, and phytochemistry.

Latitude and substrate were found to have a significant effect upon overall growth and below-ground biomass, while the only significant difference between males and females was plant height. Greatest biomass was found in plants gathered from southern populations around Rigolet, and those growing in sandy and organic substrates. Substrate had a significant effect on rosin levels, and latitude was found to have a significant effect upon salidroside, rosarin and rosavin, while plant sex did not have a significant effect

upon phytochemistry. Rhodiola specimens from more southerly latitudes grown in sandy substrates will be the best candidates for community cultivation, yielding greater biomass and potency.

Keywords: *Ethnobotany, Nunatsiavut Inuit, ecotypes, Nain, Rigolet*

2.1 Introduction

Recent ethnobotanical studies in Arctic and Subarctic communities have indicated a resurgence of interest in the traditional use of plants as medicine, as well as in their potential as economic products (Berkes and Davidson-Hunt 2007). Development of an Indigenous enterprise based upon traditional knowledge of a native plant could provide local Inuit communities with both tangible and intangible benefits, supporting customary values and improving community socio-economics to increase biocultural resilience (Cuerrier et al. 2012; Pengelly 2012). However, scientific research on the medicinal potential of plants native to Labrador is lacking. Environmental variables, both biotic and abiotic, such as latitude and temperature, soil types, and herbivory can all affect the plant's growth, morphology, and secondary metabolites (Lambers et al. 2008). Prior to investing in a sustainable local development project based upon cultivation of medicinal plants in Nunatsiavut communities (Chapters 3 and 4), it must be determined whether the local plant populations contain levels of bioactive compounds comparable to medicinal plants used in commercial trade. Geographical variability in growth and phytochemistry of populations must also be investigated to determine if local plant populations are suitable for commercialization, and to guide selection of appropriate local phenotypes for medicinal plant cultivation in Nunatsiavut.

Existing phytochemical research indicates the therapeutic potential of rhodiola (*Rhodiola rosea* L.) populating Atlantic Canada, due to the presence and quantities of standard medicinal constituents (Filion et al. 2008; Avula et al. 2009). Indeed, the local Nunatsiavut Inuit of coastal Labrador have a long tradition of using local rhodiola for a range of medicinal and nutritional applications (Cuerrier et al. 2012; Cuerrier et al. 2015a). Traditional Inuit use includes aerial parts of rhodiola (Cuerrier and Hermanutz 2012), however there has been limited research investigating the phytochemical basis for this use (Filion 2008). The local history of traditional use, in addition to previous regional phytochemistry results, suggests that coastal Labrador rhodiola could have potential as a natural health product for commercialization. As commercial overharvest of rhodiola in the wild in Siberia and Russia has endangered wild populations (Galambosi 2006), sustainable cultivation of local rhodiola in Labrador would relieve commercial harvest pressure (Allen et al. 2014).

Rhodiola is an alpine, arctic and coastal species showing remarkable ecological amplitude. It is nearly circumpolar in distribution (Figure 2.1), its range spanning central Russia to northern Europe, Greenland and the European Alps, west to the eastern coast of North America (Clausen 1975). Phylogenetic studies have shown that populations of rhodiola growing in Atlantic Canada likely arrived from Eurasia via an amphi-Atlantic route (Guest and Allen 2014; Zhang et al. 2014b; Cuerrier et al. 2015b), and yet, the habitat and environment in which the Canadian populations are found can be very distinct from Alpine Eurasian populations. In Canada, rhodiola grows along sandy and rocky coastlines and cliffs, sometimes competing with a number of other species and

withstanding wave disturbance and salt spray. Commercially traded populations of rhodiola on the other hand are found at high altitudes in alpine habitats of Russo-Siberia, without exposure to salt or the competition of other shoreline species.

Figure 2.1 Global distribution map of *Rhodiola rosea* (shown in dark grey)
Source: Cuerrier et al. 2015b

To adapt to this extreme range and diversity of environments, rhodiola shows significant morphological plasticity (Węglarz et al. 2008; Martinussen et al. 2011; Adamczak et al. 2014) and high genetic variability (Cuerrier et al. 2015b). Rhodiola is a succulent herbaceous perennial herb that is mostly dioecious, although occasionally hermaphroditic flowers and monoecious plants occur (Cuerrier et al. 2015b). A common name for rhodiola, roseroot, refers to the fragrance of the plant's large rhizome (Cuerrier et al. 2015b). Plant height varies from five to 70 cm, and belowground biomass from 36 to 250 g (Węglarz et al. 2008). Specimens growing in easily penetrated sandy or organic substrates reach greater maximum height and root mass while those restricted to rocky crevices have less biomass. Węglarz et al. (2008) confirmed that in Poland the

underground part of the plant was influenced by soil type; specimens growing in sandy soil had highly branched rhizomes with few roots while on alluvial or clay type soils specimens had compact rhizomes with many large roots, showing the range of rhodiola's root plasticity. This variability can help to limit resource allocation specific to the substrate and habitat in which it grows, allowing rhodiola to inhabit marginal areas where few other plants can survive, and conferring resistance to environmental stressors such as altitude, extreme cold, wind, and salt spray. Therefore, it is possible that ecophysiological changes may have resulted in the emergence of distinct ecotypes or chemotypes of rhodiola in coastal areas. Cree Elders have noted that northern populations of some Canadian medicinal plants are "stronger medicine" (Rapinski et al. 2014). Variability in potency of rhodiola due to its wide geographical distribution could pose challenges for quality control, both for traditional use, and in the event of commercialization of a natural health product. Taxonomic confusion can also lead to variability in commercial products, as rhodiola has many synonyms, and other species within the genus are sometimes mistakenly substituted (Cuerrier et al. 2015b).

More than 140 secondary metabolites have been identified in the roots and rhizomes of rhodiola (Panossian 2010), and a number of studies have shown remarkable variability in rhodiola's phytochemistry, in both wild and cultivated plants (Avula et al. 2009; Martinussen et al. 2011; Adamczak et al. 2014). This variability has been variously attributed to genetics, age, developmental stage, UV exposure, soil, and seasonality (Adamczak et al. 2014). Herbivory of rhodiola by bud mites (*Aceria rhodiolae*) (Beaulieu et al. 2016) or the recently documented root weevil (*Dryocoetes krivolutzkajae*) could

also affect its phytochemistry (Cognato et al. 2015). Slower-growing species, such as rhodiola, are known to have higher levels of background (constitutive) defenses that are always present to deter herbivores (Lambers 2008). Previous studies have assessed the phytochemistry of rhodiola populations in Nova Scotia and Nunavik (Canada) (Filion et al. 2008; Saunders et al. 2014; Cuerrier et al. 2015a); however, no prior research has investigated the biology and phytochemistry of rhodiola native to the Labrador coast.

This study assessed the growth and phytochemistry of northern (Nain) and southern (Rigolet) coastal Labrador populations of rhodiola, analyzing belowground biomass and salidroside, rosarin, rosavin, and rosin content. Variation was analyzed by latitude, substrate, and plant sex, to determine the best local phenotypes and cultivation sites, and inform development of a sustainable local enterprise with benefits for participating Nunatsiavut Inuit communities. It is hypothesized that environmental stressors, such as more northerly climates and poorer growth substrates will increase medicinal potency but correlate with less plant vigour. Rhodiola leaf phytochemistry was also assessed, as only a few prior studies have investigated the leaves (Filion et al. 2008), in addition to rhizomes.

2.2 Materials and methods

2.2.1 Sampling sites

Along the Labrador coast, rhodiola can be found growing in sandy, shoreline habitat up to the high tide line, occasionally associated with species such as beach pea (*Lathyrus japonicus* Willdenow) and American dunegrass (*Leymus mollis* [Trinius] Pilger). It also grows on rocky shoreline cliffs, as well as in organic soil set back from the

shore above high tide, where it competes with other species such as *Empetrum nigrum* L. and *Salix glauca* L.

In order to assess latitudinal differences, rhodiola specimens were gathered with stratified random sampling from shoreline populations near two Nunatsiavut communities: Nain, to represent a northerly latitude (56.5422° N, 61.6928° W), and Rigolet, to represent more southern populations of Labrador (54.1667° N, 58.4333° W). These areas were selected because representatives of the communities expressed interest in participating in the project, and they are also the most northerly and southerly coastal Nunatsiavut Inuit communities.

2.2.2 Growth measures

From Nain and Rigolet, 75 samples of rhodiola were collected in July-August 2012; 12 additional samples were collected in August 2013 to increase sample size where 2012 samples showed high levels of variability (see Results). In total, 87 plants were sampled in a range of substrates (26 rocky, 23 sandy, 24 organic), and analyzed for biomass and growth. Basic growth measurements (size, height, basal diameter) and reproductive data (sex (Female, Male or Hermaphroditic), number of flowers, seed productivity, number of ramets) were taken in the field. Plants were harvested to measure rhizome biomass production in relation to plant size and reproductive states.

In the field, substrate was visually assessed and recorded (sandy, rocky or organic), and the presence of conspecifics and GPS coordinates were noted. Care was taken to minimize site disturbance and ensure against local overharvest. Further observations about the specimen site were recorded including hermaphroditic rhodiola

specimens, as well as obvious signs of bud mite infestation, which were avoided in sampling. Samples were placed into plastic bags to prevent desiccation and taken back to the field research station for further assessment.

Above ground and below ground parts, leaves, and fruits were weighed (+/-0.01 gm) and height of the tallest ramet (cm), total number of ramets, number of green leaves on tallest ramet, reproductive stage, and number of flowering ramets were recorded. Samples were then dried to a constant weight in a Nesco electric food dehydrator or a Precision Mechanical Convection oven (32-39° C) and re-weighed (above ground and below ground parts, leaves, and fruits). Representative voucher specimens were deposited at the Marie-Victorin Herbarium (MT) of the Biodiversity Centre of the University of Montréal, Montreal, Canada.

2.2.3 Phytochemical analysis

Levels of medicinally important compounds were analyzed from 75 plants collected in 2012 to minimize interannual variation. Phytochemical analysis was carried out by A. Saleem and R. Liu at the University of Ottawa and conducted using UPLC-MS analysis to assess the presence and levels of medicinal marker compounds (salidroside, rosarin, rosavin, and rosin) in the root and rhizome (Gryszczyńska et al. 2013). Samples were ground in a Wiley Mill using a 1mm mesh screen and 0.5g material was extracted in 20ml of 60% MeOH, sonicated for 30 minutes, and then centrifuged for 15 min at 18.5 xg. Pooled supernatants were adjusted to 50 ml, then filtered with 0.2 mm PTFE filter and sonicated for 5 min before injection to UPLC-MS. Chemical standards for salidroside, rosin, rosarin and rosavin were purchased from ChromaDex (Irvine, CA).

UPLC-MS analysis of rhizomes and roots was based upon a validated method (Gryszczyńska et al. 2013). The analysis was carried out on a Shimadzu UPLC-PDA-MS system (Mandel Scientific Company Inc, Guelph, Ontario) which contains: LC30AD pumps, a CTO20A column oven, a SIL-30AC autosampler and a LCMS-2020 mass spectrometer. A Waters Aquity CSH C18 column (2.1x100mm, 1.7um particle size; Waters limited, Mississauga, Ontario) was used in this study.

Shimadzu lab solution software was used to quantify the concentration of marker compounds in the extract. Appropriate and corresponding standard curves were built by injecting dilutions of standard compounds stock solutions. These curves were then used to quantify the amount of each marker compound by lab solution software. The quantification range is 3.2-160ng, 6.1-152.5ng, 2.96-150ng and 3.08-154ng on column for salidroside, rosin, rosarin and rosavin respectively. The R^2 of the calibration curve is no less than 0.998.

Since the five marker compounds utilized for roots and rhizomes are absent or low in concentration in leaf samples, a different analysis was carried out on leaf samples. The additional analyses were carried out on the same systems as outlined above.

The Chromatographic Conditions were: Injection volume: 1 µL; Column oven temperature: 55°C; Flow rate: 0.8 mL / minute. Mobile Phases A: water+0.1% formic acid; B: acetonitrile+0.1% formic acid. Gradient elution: Initial at 7.5% and change to 20% B from 1.5 min to 8.5 min; then change to 95% B in 0.5 min and hold 95% B for 1

minute, then equilibrate the system for 1 minute. Detection: Photodiode array detector was monitored from 190-400 nm.

2.2.4 Statistical analysis

Data were analyzed using Analysis of Variance (ANOVA) to determine if there are differences in rhizome growth and phytochemistry variables in rhodiola from coastal Labrador in response to four factors: latitude, substrate, and sex. Redundancy Analyses (RDA) was used to summarize overall patterns of variation described by a matrix of explanatory variables. Prior to statistical analysis, visual inspection of residuals investigated the normality of the data, and parametric tests were used if assumptions were met, otherwise, non-parametric testing was done. Separate ANOVA models compare mean levels of growth or phytochemistry based on latitude, substrate, and sex. Standard post-hoc tests (Student's T and Tukey HSD) were carried out to determine in greater detail the statistical differences among categories.

2.3 Results

2.3.1 Growth measures

Based on ANOVA results, environmental variables were found to have significant effects upon growth measures of Labrador rhodiola (Table 2.1, Figure 2.2). Latitude and substrate had a significant effect on overall growth and rhizome biomass (the plant part of commercial interest), while differences between male and female plants were not significant. Results showed significantly greater but highly variable rhizome biomass in specimens gathered from southerly locations around Rigolet, and particularly in sandy and organic substrates, while specimens gathered from northerly populations around

Nain, and those growing in rocky substrates were less vigorous with regards to rhizome biomass.

Table 2.1. Summary of *p* values and R^2 values from one-way analysis of variance (ANOVA) results analyzing weight differences of *Rhodiola rosea* roots and rhizomes collected from sandy, rocky, or organic substrates around Nain and Rigolet (Northern and Southern Labrador). A square root transformation (Sqrt) was applied to increase normality and linearity. Significant results highlighted in bold font.

Rhizome dry weight	*p* value	R^2
Latitude	**0.0003**	0.200
Substrate	**0.0179**	0.200
Sex	0.3730	0.291

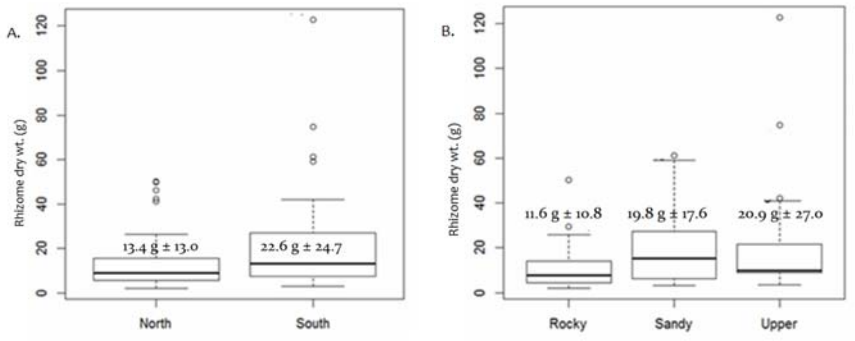

Figure 2.2. Box plots comparing root and rhizome dry weight by A) latitude (North – Nain; South – Rigolet); and B) substrate type. Whiskers indicate variability outside the upper and lower quartiles while outlier are represented with dots. Significant differences were found due to latitude ($p = 0.0003$); and B) substrate type ($p = 0.0179$).

The root weevil, *Dryocoetes krivolutzkajae*, was found burrowing in 31 rhizome samples to form galleries. This was the first documented presence of *Dryocoetes krivolutzkajae* in Labrador, (Cognato et al. 2015), however it did not significantly affect plant growth or biomass in this case.

2.3.2 Phytochemistry

Labrador rhodiola rhizomes and roots were found to contain all key phytochemical constituents known for medicinal potency (salidroside, rosarin, rosavin, and rosin; Table 2.2) according to industry standards in the US and Canada (Bejar 2017).

Table 2.2. Quantification of phytochemical constituents measured in Labrador *Rhodiola rosea*.

Compound	**Mean (mg/g) ±SEM**
Salidroside	4.51 ± 0.077
Rosarin	1.10 ± 0.016
Rosavin	3.67 ± 0.047
Rosin	0.29 ± 0.008
Total Rosavins	5.05

Environmental variables were found to have a significant effect upon the phytochemistry of Labrador rhodiola rhizomes (Figure 2.3); latitude had a significant effect upon salidroside, rosarin and rosavin, with higher concentrations in the south, while substrate had a significant effect upon rosin. Plant sex did not have a significant effect upon phytochemistry. Weevil infestation also did not have a significant effect on phytochemistry. Leaf analysis showed a predominance of flavonoid-type compounds (flavonols) and their glycosides (Gossypetin 3-O-glucose-7-O-xylose/arabinose, Gossypetin 7-O-rhamnose-8-O-glucose, Herbacetin-3-O-glucose-7-O-xylose/arabinose, Gossypetin-di-O-glucoside and Rutin).

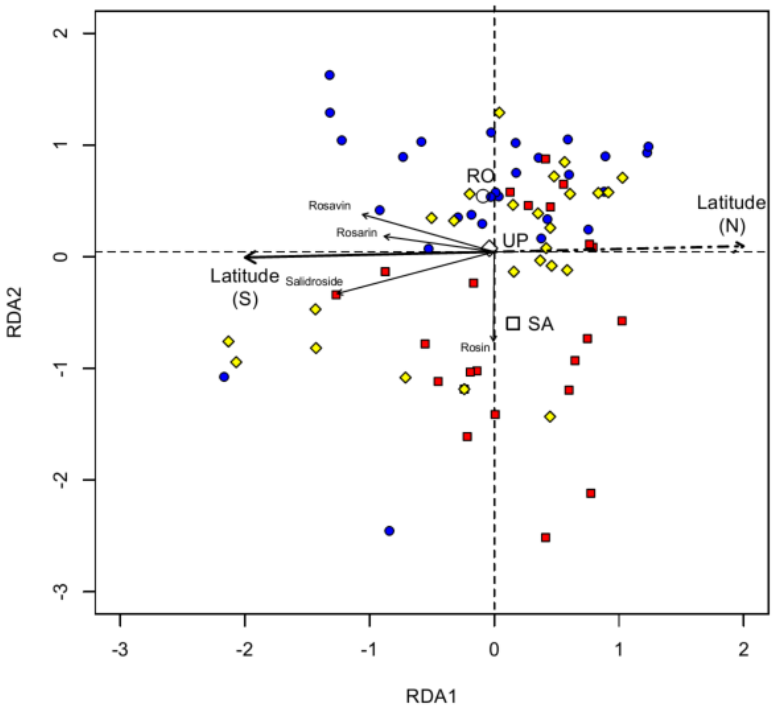

Figure 2.3. RDA showing overall variance in *Rhodiola rosea* rhizome phytochemistry explained by substrate and latitude. RO = rocky – in blue dots, SA = sandy– in red squares, UP = upper/organic – in yellow lozenges.

2.4 Discussion

Our comparative study of Labrador coastal populations of rhodiola showed that latitude and substrate had a significant effect on rhizome biomass and phytochemistry. While populations of *Rhodiola rosea* in eastern Canada are taxonomically the same species as the commercially traded Eurasian populations (Zhang et al. 2014b; Cuerrier et al. 2015b; Appendix A), it is possible that various ecophysiological or genetic changes may have resulted in the emergence of distinct ecotypes or chemotypes, particularly given the ecological amplitude of rhodiola. It is important to understand how environmental conditions affect phenotypic variability of natural products (Polatoglu 2013), as this can impact the quality of a potential Natural Health Product sourced from

Canadian rhodiola. Many studies are in agreement as to the morphological and phytochemical plasticity of both cultivated and wild rhodiola (Węglarz et al. 2008; Martinussen et al. 2011; Adamczak et al. 2014), and further, that there is a correlation between environmental factors and rhodiola phenotypes.

Our research also showed morphological variability in coastal populations of rhodiola in Labrador. We found that latitude had a significant effect upon rhizome biomass in wild plants, consistent with Martinussen et al. (2011), who also found that temperature positively affected growth and biomass in cultivated plants. Temperature, as well as differences in insolation patterns associated with latitude, could account for the latitudinal effect upon plant growth (Rapinski et al. 2014). In cold tundra soils, root stratification has been reported, such that roots are often confined to the warmer and slightly better drained soil layer (Bliss 1960). We also found that substrate had a significant effect upon rhizome biomass measures (dry weight), in agreement with Węglarz et al. (2008), who found that substrate affected both size and shape of underground plant parts in cultivated rhodiola; plants grown on sandy substrates formed highly branched rhizomes, while plants grown in clay soils had compact rhizomes and more numerous roots.

Rhodiola growing in Nunavik, Canada has been previously shown to contain all the key medicinal constituents for which the commercially traded Russo-Siberian populations are known (salidroside, approx. 0.2 mg/g; rosavins, approx. 0.2 mg/g), but not at levels that meet Health Canada standards (Filion et al. 2008). Wild populations of rhodiola growing in Nova Scotia were also found to contain levels of bioactive

compounds similar to or greater than those found in Eurasian populations (Saunders et al. 2014). However, another study on rhodiola growing wild in Nunavik found several compounds absent from Canadian specimens that were present in Eurasian specimens (Avula et al. 2009). Some studies have shown that marker compounds in Canadian medicinal plants may vary in response to environmental variables (Ferrier et al. 2012; Rapinski et al. 2014; Bailie et al. 2016), and previous research on rhodiola in other regions demonstrated significant phytochemical variability (Buchwald 2006; Avula et al. 2009; Elameen 2010; Martinussen et al. 2011; Adamczak et al. 2014).

We also found significant phytochemical variability associated with environmental conditions in coastal Labrador rhodiola. Our research showed that growth substrate had a significant effect upon phytochemistry, with most salidroside in specimens harvested from organic followed by sandy substrates (5.36mg/g or 0.54% in organic substrates; 4.43 mg/g or 0.44% in sandy substrates). This is consistent with the finding of Saunders et al. (2014) who also found that soil differences could explain variation in salidroside (between 0.28 and 1.76%) in wild-harvested rhodiola from Nova Scotia. Likewise, Węglarz et al. (2008) found that environmental factors associated with altitude (such as substrate) had a significant effect on phytochemistry in cultivated rhodiola in Poland, with greater salidroside and rosavin in rhodiola cultivated at higher altitudes. Elameen (2010), however, found that chemodiversity of wild rhodiola in Norway was not associated with environmental factors, but instead was linked to genetics. It has been shown that there are genetic differences between coastal populations and alpine populations of rhodiola in Russia, however the genetics of North American

rhodiola have not been thoroughly studied (Guest and Allen 2014; Cuerrier et al. 2015b). We found that sex did not have a significant effect upon phytochemistry, which is in agreement with Galambosi's (2014) findings in cultivated plants, however Platikanov and Evstatieva (2008; see also Filion et al. 2008) found that sex does significantly affect phytochemistry of cultivated plants, with male plants showing more variability, but higher salidroside content overall. The presence of flavonols and their glycosides in the leaf analysis is consistent with the findings of Petsalo et al. (2006). To further understand the bioactivity of rhodiola leaf constituents, the next step would be to conduct bioassays. Knowing that leaves possess rutin, we may hypothesise that it may act on the immune or inflammatory systems (Ganeshpurkar and Saluja 2017), and the presence of flavonoids may support further studies in antioxidant activities (González et al. 2011).

Regulatory standards for rhodiola root and rhizome set forth by the United States Pharmacopeia (USP) and Health Canada stipulate levels of salidroside content and total rosavins collectively (rosarin, rosavin, and rosin) (Bejar 2017). USP standards indicate not less than 0.08% of salidroside and 0.3% rosavins in raw, dry plant material, while Health Canada guidelines indicate 0.8–3% salidroside and 1–6% rosavins in standardized extract (Bejar 2017). The results of our phytochemical analysis of Labrador rhodiola indicates that the local rhodiola meets or exceeds USP specifications, but falls short of Health Canada guidelines, with an average of 4.5 mg/g of salidroside and 5.05 mg/g of rosavins (0.45% salidroside and 0.51% rosavins) (Table 2.2).

The weevil, *Dryocoetes krivolutzkajae*, recently documented in New Brunswick (Cognato et al. 2015), was found in the rhizomes of 31 of 76 rhodiola specimens;

however beetle infestation did not compromise growth or negatively affect the phytochemistry of the plants. There is limited research to support or contrast these findings; further work needs to be done to confirm the effect of weevil infestation on growth and phytochemistry (Cognato et al. 2015; Ford & Hermanutz 2019). In our investigation, we avoided sampling plants that were hermaphroditic or visibly infested with bud mites (*Aceria rhodiolae*), so we cannot report on the impact of these factors. However, Filion et al. (2008) reported finding higher levels of salidroside in plants not infested with bud mites, and higher levels of salidroside in hermaphrodites than female plants.

2.5 Conclusion

Our research confirmed that coastal Labrador rhodiola contains medicinal marker compounds, salidroside and rosavins, at levels that meet or exceed pharmacopeial standards for rhodiola established by the USP but not Health Canada (Bejar 2017), and that rhodiola from coastal Labrador populations has some potential for cultivation for a natural health product enterprise, with phytochemical variability due to environmental conditions as seen in other eastern Canadian rhodiola (Saunders et al. 2014). Confirmation of the presence of salidroside and rosavins in Nunatsiavut rhodiola also substantiates the traditional Nunatsiavut Inuit medicinal use of local rhodiola (Cuerrier et al. 2012; Cuerrier et al. 2015a; Cuerrier et al. 2019). Our findings indicate that Labrador rhodiola specimens from more southerly latitudes grown in sandy substrates will be the best candidates for community cultivation, yielding greater biomass and potency. To

further elucidate the effects of latitudinal variation, the next step would be to establish reciprocal transplant experiments.

2.6 Acknowledgements

We are very grateful to the Nunatsiavut Government and Inuit communities for welcoming us and facilitating this research. Thanks to Tom Sheldon, past NG Director of Environment for guidance and insight, and David and Charlotte Wolfrey, and Kenny Pottle, for taking us out to see the beautiful Nunatsiavut coastline by boat. Thanks to Katie Winters and Carla Pamak at the Nain Research Center for helping us to arrange our transportation and field permits. We are grateful to the researchers who worked in these communities, Laura Siegwart Collier, Ashleigh Downing, and Courtenay Clark, for establishing working relationships in Nain and in Nunatsiavut and an invaluable foundation for the present work. Thanks to Gary Dart and Corrina Copp for their help in collecting and processing specimens. And many thanks to John T. Arnason, Rui Liu, and Ammar Saleem at the University of Ottawa, for their careful work in analyzing the phytochemistry of our field specimens. This work was made possible through the funding granted by ArcticNet, the Harris Centre, and Memorial University.

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Chapter 3. The biocultural context for development of a community-based enterprise: Nunatsiavut Inuit knowledge and perspectives on the use of the medicinal plant *Rhodiola rosea*

Abstract

The medicinal plant rhodiola (*Rhodiola rosea*), while valuable as an adaptogen in the global trade of natural health products, has not been commercially sourced in eastern Canada. Rhodiola grows prolifically along the coast of Labrador (Canada), including rocky shorelines, sandy beaches, up to the high tidal zone. Nunatsiavut Inuit in these remote areas have traditionally used rhodiola as food and medicine; however, due to globalization and significant biocultural changes, these communities are shifting from traditional activities towards new ventures. The cultivation of local rhodiola presents an opportunity for a sustainable, community-based enterprise with economic and social benefits. Yet because cultural context has been shown to be a key factor influencing success of community-based enterprises, it is critical to consider the unique biocultural context when developing an enterprise intended to build capacity in participating communities. To explore the potential for development of a natural health product based upon Labrador rhodiola, semi-structured interviews and focus groups were conducted with Nunatsiavut Inuit Elders, youth, and community members. Participants used traditional Inuktitut nomenclature for rhodiola plant parts and reported both medicinal and food uses of the local rhodiola roots and leaves, as well as unique insights into its growth and conservation. They were enthusiastic at the prospective social, economic, and

health benefits of a community-based enterprise centered on cultivation and marketing of local rhodiola, but concerned about the potential for over-harvesting and wanted to ensure conservation of local populations. A community-based enterprise centered on local rhodiola cultivated in Nunatsiavut could benefit Nunatsiavut Inuit communities and enhance biocultural resilience.

Keywords: *Ethnobotany, Indigenous entrepreneurship, roseroot, Crassulaceae, Subarctic*

3.1 Introduction

In recent decades rhodiola (*Rhodiola rosea* L.; Crassulaceae) has become increasingly significant in the global trade of natural health products, for its adaptogenic, antidepressive, and immunomodulating properties (Brown et al. 2002; Ulbricht et al. 2011). This plant has had a history of traditional use as both food and medicine among the Inuit (Clark 2012; Cuerrier et al. 2012a). Recently an opportunity emerged for a sustainable enterprise based upon cultivation of rhodiola native to coastal Labrador's Inuit lands of Nunatsiavut (Newfoundland and Labrador, Canada). Cultivation of rhodiola for a community-based enterprise in Nunatsiavut could bring a variety of economic and social benefits to these communities.

Opportunity recognition, an important element of entrepreneurship, has been shown to be influenced by culture (Meis Mason et al. 2012), and can in turn influence enterprise development, particularly in Northern Indigenous communities (Dana and Anderson 2007; Pengelly and Davidson-Hunt 2012). Therefore, it is important to understand the biocultural context of a proposed community enterprise based upon local medicinal plants, as this will influence its success and sustainability. However, there is a

scarcity of ethnobotanical research that has been conducted in the Eastern Canadian Arctic; additional ethnobotanical research urgently needs to be done among the Inuit (Davis and Banack 2012; Meis Mason et al. 2012). Limited ethnobotanical research has been conducted with Nunatsiavut Inuit in Newfoundland and Labrador, and no previous ethnobotanical work had been done in Rigolet (Downing and Cuerrier 2011; Karst and Turner 2011; Clark 2012; Cuerrier et al. 2012a; Oberndorfer et al. 2017; Cuerrier et al. 2019).

Among Nunatsiavut Inuit, referred to as *Nunatsiavummiut*, connection to the land is foundational to traditional knowledge and cultural identity (Downing and Cuerrier 2011; Cuerrier et al. 2012b; Cuerrier et al. 2014; Oberndorfer et al. 2017). Nunatsiavut is the first self-governing Inuit region in Canada, and its name means "Our Beautiful Land" in Inuktitut, the local language (Cunsolo et al. 2012). Land-based activities such as hunting, fishing, and gathering are important in Inuit tradition for sustenance, cultural identity, and holistic well-being of body and mind. As the northernmost Inuit settlement in Nunatsiavut, Nain (population 1,188) is remote, with access via boats and airplane expensive and dictated by weather (Rapinski et al. 2018). Likewise, Rigolet (population 306), the southernmost Inuit community in the world, is inaccessible by road but can be accessed by boat and small aircraft, or snowmobile in the winter. Many Canadian Inuit communities are similarly geographically isolated, and consequently, the cost of living in these communities is very high, access is limited, and job opportunities are limited (Simon 2011; Davis and Banack 2012; Meis Mason et al. 2012). However, due to colonial history and globalization, these remote communities are significantly affected by

global cultural influences. As early as 1771, the first Moravian mission was established in Nain, affecting the culture and language of Labrador Inuit from an even earlier date than the Nunavik Inuit (Clark 2012). Fluency in Inuktitut in Nunatsiavut is 27% as of 2006 (Statistics Canada 2006), and the dialect of Inuktitut spoken in Rigolet, listed as a UNESCO endangered language, is maintained by only four people (Harper et al. 2012).

As a result of significant cultural changes in Labrador within the last generation (Cunsolo et al. 2012; Cunsolo et al. 2013), there is a generational gap and a lack of transmission of traditional knowledge and customary practices between Indigenous Elders and youth (Karst and Turner 2011; Cuerrier et al. 2012b). Community research is an important tool to help bridge generational (Cuerrier et al. 2012b) and cultural gaps (Meis Mason et al. 2012) and design research frameworks with applied benefits that build cross-scale linkages (Hindle and Lansdowne 2005; Berkes and Davidson-Hunt 2007). Further, integration of traditional Inuit knowledge, known in Inuktitut as *Qaujimajanngit* (Meis Mason et al. 2012), is a cornerstone of development in the Canadian North (Inuit Tapiriit Kanatami 2018). To inform culturally appropriate applications of traditional knowledge and practice and sustainable innovations, it is essential to integrate the knowledge and experience of the Elders, along with youth perspectives, into community development plans. If innovations based upon traditional knowledge are intended to bring economic and social benefits to the local community, then communities must be consulted, to define and prioritize what benefits are of value within their unique biocultural context (Meis Mason et al. 2012). In Northern Indigenous community-based research conducted with Inuit in Nunavut (Meis Mason et al. 2012) and Pikangikum

Anishinaabe in northwestern Ontario (Pengelly and Davidson-Hunt 2012), product elicitation methods were found to effectively bridge cultural differences to explore community perspectives, and inform development of products based upon traditional knowledge and/or biocultural resources. The need for inclusion of youth perspectives was also identified.

Biocultural innovations that incorporate and build upon traditional knowledge can increase community capacity, while also stimulating pride in the unique heritage. Co-creation of a community enterprise based on traditional knowledge and cultivation of local rhodiola in Nunatsiavut has the potential to confer economic benefits as well as a range of health benefits associated with customary practices and increased time on the land. Strengthening intergenerational connections with Inuit heritage and land in new and innovative ways will encourage biocultural resilience (Berkes and Davidson-Hunt 2007; Cuerrier et al. 2012b; Davidson-Hunt et al. 2012; Inuit Tapiriit Kanatami 2018) as well as resource conservation. Adhering to traditional ecological knowledge also minimizes the risk of overharvest inherent in commercial exploitation of natural resources, and will assist in informing locally appropriate conservation practices and precautions. Collaborating with Indigenous communities in the creation of entrepreneurship will stimulate the development of an enterprise that respects and integrates cultural traditions, and ensures sustainable use of local resources, while leading to the empowerment of communities as economic agents (Hindle and Lansdowne 2005; Davidson-Hunt et al. 2012).

This research examines the biocultural context of the valuable medicinal plant *Rhodiola rosea* in several Nunatsiavut Inuit communities, as a bridge from traditional knowledge to sustainable commercial enterprise. This project aims to create linkages among traditional knowledge, social enterprise, and sustainable economic activities, helping create community capacity to adapt and transform, for resilience within the social-ecological system. The objectives are to conduct interviews and focus groups in Nunatsiavut to: 1) document traditional Nunatsiavut Inuit knowledge surrounding rhodiola's use and ecology, and contextualize these findings with previous ethnobotanical interviews; and 2) solicit community perspectives on applying traditional knowledge for a commercial enterprise, to determine a) if a natural health product based upon traditional knowledge is appropriate and acceptable to community members, b) if there are any concerns, and c) how they envision distribution of benefits in the community.

3.2 Materials and Methods

Community meetings and round table sessions were held in two Nunatsiavut communities, Nain and Rigolet, to explore and document Inuit uses and traditional knowledge of rhodiola, and to gauge community perspectives and goals on enterprise development centered around the cultivation and marketing of rhodiola products. Fieldwork began in August 2012 in the communities of Rigolet and Nain (54.1667° N, 58.4333° W and 56.5422° N, 61.6928° W, respectively). Prior to start of the interviews, ethics approval was obtained through the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University of Newfoundland. Free, prior, informed consent (FPIC) was obtained from all participants. Focus groups were

conducted in Nain with Inuit Elders in August 2013, and with Inuit youth in March 2015. The community of Nain was selected because there are a greater number of Elders in this community than in other communities in Nunatsiavut. Additionally, our research team has a longstanding working relationship with many members of the community due to previous community-guided research projects and an intergenerational plant workshop (Clark 2012; Cuerrier et al. 2012b). Previously, 37 ethnobotanical interviews were conducted with Nunatsiavut Inuit Elders by Clark (2012) and Cuerrier et al. (2012a) in Nain 2009-2010, and our focus group research was informed by the findings of these earlier interviews. Interview data gathered by Clark (2012) and Cuerrier et al. (2012a) were filtered for respondents who spoke of "*tulligunnak"* or "roseroot" during the interview, and these respondents were then invited to participate in the subsequent Elder focus group in Nain.

In addition to these interviews, 13 Nunatsiavut Elders (nine female and four male) participated in the focus group that lasted approximately two hours. A semi-structured approach was used in facilitating the session. Discussions were structured around themes of plant use, habitat, harvesting, cultivation, and commercialization (with a focus on rhodiola in particular). Photos and live specimens of rhodiola were provided as object probes or aids to discussion. Traditional knowledge of its uses, habitat, and cultivation was documented, as were opinions and perspectives on commercialization, concerns, and possible options. As some of the Elders were more comfortable speaking Inuktitut, a local Elder helped to facilitate as interpreter, while also contributing to the discussion with their own opinions. The focus group was audio recorded as well as field noted. Out

of respect for their knowledge, and in compliance with Nunatsiavut Government protocols, Elders were compensated for their time and participation.

Once the Elders had indicated their approval for a community enterprise based on rhodiola, the views of youth were solicited, as they would be likely candidates for a community-based enterprise. The participation of youth (community members 25 and under) was important, to inform them of the opportunities associated with the project, and to elicit their perspectives, opinions, and willingness to engage in such an endeavor.
In March 2015, a youth focus group was held in Nain with six participants under the age of 25 (four female and two male). The purpose of the session was to introduce the youth of Nain to the potential for a community enterprise based upon rhodiola, and to give them an opportunity to help steer the project and give input. Youth were recruited for the focus group by the community's youth coordinator, who also helped facilitate. Prior to the meeting, youth were asked to consult with Elders in their family and community, to solicit stories about traditional uses of plants that they could share during the focus group. Nain youth speak English as their first language, so an interpreter was not necessary. After some icebreaker games and activities, participants were paired up and asked to discuss with each other the knowledge of medicinal plants they had gleaned from the Elders, then report back to the group. A brief multi-media presentation was given, describing the 2013 Elder focus group, and providing background on the medicinal properties of rhodiola, its commercial value, and the potential for local job opportunities. Follow-up discussion was then facilitated, encouraging youth to share their perspectives and/or concerns on using traditional Inuit knowledge for community enterprise, and to

solicit their perspectives on benefit sharing. Product elicitation has been shown to help bridge cultural gaps for exploration of product options (Meis Mason et al. 2012), so product samples were shared with youth to demonstrate possible natural health product derived from rhodiola. In concluding, the youth were asked if and how they might like to be involved in the project, moving forward.

As no previous ethnobotanical work had been done in Rigolet, we conducted five semi-structured ethnobotanical and product elicitation interviews in August 2013, and an additional five interviews in March 2015, for a total of 10 interviews with Rigolet community members, (five female and five male informants). Plant specimens and photos were utilized as visual aids and product elicitation was utilized to explore community perspectives on potential rhodiola-based products (Meis Mason, et al. 2012; Pengelly and Davidson-Hunt 2012). Samples of several commercial rhodiola product forms (tincture and capsules) were displayed during half of the interviews (those conducted in 2015), and participants were invited to taste, smell, or try the products, and to read the packaging. Community open house meetings were held in Rigolet in 2013 and 2015 to facilitate open discussion of the idea of the enterprise. The project goals were discussed with local government officials (mayor or *AngajukKâk*) in both Rigolet and Nain.

Qualitative analysis of the focus group (13 Elders and six youth from Nain) and ethnobotanical interview data (10 community members from Rigolet) was approached in an inductive, iterative fashion; alternating between emergent readings of the data and etic use of existing models and theories in the literature to integrate the research observations

into a broader scholarly context (Tracy 2013). An inductive approach has been used in other Northern Canadian Indigenous communities because it allows the research process to better adapt to fit the specific biocultural context (Pengelly and Davidson-Hunt 2012). Previous qualitative ethnobotanical studies in Labrador and other Northern Canadian Indigenous communities have yielded descriptive, non-quantitative summaries of ethnobotanical applications and reported uses, with attention to details that situate the results within the specific biocultural context (Karst and Turner 2011; Meis Mason et al. 2012; Pengelly and Davidson-Hunt 2012). For the present research, data from ethnobotanical interviews previously conducted in Nain by Clark (2012) and Cuerrier et al. (2012a) were pooled along with the ethnobotanical interviews in Rigolet, focus groups in Nain, and pre-publication data shared with permission from Makkovik (E. Oberndorfer, pre-publication data). The resulting transcriptions were first reduced and reorganized, then filtered for references to rhodiola, locally known as "*tulligunnak*" or "roseroot" (Flick 2014).

3.3 Results

3.3.1 Nunatsiavut Inuit uses of rhodiola

All uses of rhodiola reported by Nunatsiavut Inuit in Nain, Rigolet, and Makkovik were pooled, categorized by part used, purpose, and method of application, and summarized (Table 3.1). Previous interviews conducted with Inuit Elders in Nain documented traditional Nunatsiavut Inuit uses of rhodiola as food and medicine, and showed that Nunatsiavut Inuit Elders have unique nomenclature to describe rhodiola and its parts (Cuerrier et al. 2012a). The rhodiola plant is referred to in the local Inuktitut as

tulligunnak, and the below ground parts of rhodiola are sometimes called *utsuKammak* (Cuerrier et al. 2012a). Inuit from Nunavik similarly call rhodiola *tallirunnaq* or *tullirunnaq*, with the specific terms *uqaujatuinnait* when referring to the leaves and *utsuqammat* to refer to the roots (Cuerrier and Elders of Kangiqsualujjuaq 2011, in Cuerrier et al. 2014). In Makkovik, only the term *tulligunnak* was reported; *utsuKammak* was not documented as a secondary term for rhodiola, and no English names used for rhodiola either (Oberndorfer et al. 2017).

Elders and community of Nain, Rigolet, and Makkovik reported food uses of all parts of rhodiola except the flowers. In the 2013 focus group in Nain, Nunatsiavut Inuit Elders described traditional uses of rhodiola, including new uses that had not previously been documented in the community (Table 3.1).

Table 3.1. Traditional uses of rhodiola (*Rhodiola rosea)* by Nunatsiavut Inuit documented in Nain, Rigolet, and Makkovik (by Oberndorfer) documented through interviews and a focus group.

Nunatsiavut Inuit uses of *Rhodiola rosea*		
Part used	**Purpose**	**Method of use**
Green leaves	Food	Raw in salads; dipped in molasses and/or vinegar
Tips (leaves and tops)	Food	Out of hand as snack, especially new growth or when the leaves appear red in spring/fall
Buds (basal rosettes)	Food	Eaten in early spring, "like little brussel sprouts", when the buds are still purple in color
Stalks (all aerial parts)	Food	Cooked with pork
Root	Food	Raw or boiled "like a little turnip"
Root	External medicine	Crushed and applied as poultice or compress for skin conditions (esp. cuts and boils)*
Root	External medicine	Applied as compress/poultice for eye infections
Whole plant	External medicine	Boiled (decoction) to make a soak for eczema
Tops (green leaves and stems)	External medicine	Applied directly to chapped hands after working at the fish, to soothe and moisturize rough and dry skin
Root	Internal medicine	Boiled and chewed to stimulate appetite*
Root	Internal medicine	Taken for sore throat
Whole plant/unspecified	Internal medicine	Colds, especially head colds, stomach flu, toothache

* uses not previously documented in the community

Elders and community members noted that the aerial parts especially the new growth, were traditionally used as food, as a source of edible greens eaten in the spring. Some ate just the green leaves, alone or as a salad. The leaves are often dipped in molasses or another sweetener, sometimes also vinegar, according to taste. It was said that they used to harvest the tips (leaves and tops) when they were red to have as a trailside snack, for a burst of juice with sweet taste. In Makkovik, the early spring buds are compared to brussel sprouts, but participants said the plants were not good to eat once they'd flowered, that get too tough and that "they have a worm in them then" (Oberndorfer 2016). They would also cook the stalks with pork on special occasions. Several Elders in the focus group agreed that they had a separate word for the root itself, as found in previous interviews: *utsuKammak*, which was also said to be used raw or cooked as a food. Many noted that the roots taste sweet. One community member said that the root was eaten "like a little turnip". Another said that they used to boil the root sometimes, and also to chew it fresh.

All parts of rhodiola except the flowers were reportedly used as both internal and external medicine by Elders and community in Nain, Rigolet, and Makkovik. In Makkovik the green leaves and stems are used to soothe chapped hands after processing fish (Oberndorfer et al. 2017). Others in Nain report that the whole plant could be boiled up and used as a hand soak for eczema. The below-ground parts (rhizome/root) are used medicinally as a remedy for fatigue, infection, colds, and toothache (Cuerrier et al. 2012a). The roots are crushed and used raw to make a poultice which is applied to cuts and boils, or they are cooked and made into a poultice as a remedy for eye infections.

Elders said fresh or dried root could be applied as a poultice to boils (skin conditions), and that it could be used for healing cuts. The boiled root was chewed as an appetite stimulant, and a community member said it was used for stomach flus and bugs. Several community members said that it was good for colds, especially a head cold.

3.3.2 Traditional ecological knowledge of rhodiola habitat and cultivation

Elders and community members had observed rhodiola growing in Nunatsiavut on islands and shorelines, and they had unique insight into the local habitat of rhodiola and prospects for cultivation. Derrick Pottle of Rigolet observed that as soon as the ice melts, “they are the first plant you see in the spring on the beach and shorelines, popping up like a little rose. And they are one of the last to die back in fall.” In the wild, participants observed rhodiola growing in sandy, cool places, as well as in cracks and crevices of rocks and cliffs. Many observed that rhodiola often grew on the islands, sometimes among birds’ nests, and speculated that gull and duck droppings aided its growth. It was also noted that birds eat the seeds, and black bears and gulls eat the plants. Several people observed that rhodiola “needs some of its own soil to grow”. In transplanting, it was said that there is less risk of leaving a vital part of the plant in the ground if the plant is transplanted after dormancy. Some Nain residents had tried transplanting rhodiola without success and speculated that it could be due to dampness, or because the roots were too small. However, several interviewees in Rigolet said that rhodiola transplanted easily to their home gardens, and thrived as a low maintenance ornamental.

Of recent concern, “The *tulligunnak* is not as thick as it used to be, now the grass has taken over”, and within the last few years since this research has begun, “rising waters and rough seas are affecting the shoreline *tulligunnak* populations”. Former *AngajukKâk* /Mayor of Rigolet observed that this is happening all along Groswater Bay (outside of Rigolet), and the effect might be even more pronounced outside the bay where there is “bigger water” [i.e. rising waters and rough seas] (C. Wolfrey, pers. comm.), and predicts that in a few years, those shoreline populations will be gone. She suggests that these at-risk populations could be candidates for transplantation and/or for early product production while the cultivated crops are getting established. Environmental concerns were also voiced in Makkovik, where participants had limited their harvest of *tulligunnak* due to concerns of pollutants contaminating the plants in town, and the danger of traveling outside of town in Spring [as a result of recent climate fluctuations] (Oberndorfer 2016). In Makkovik it was also noted that traditional harvesting practices could benefit local rhodiola plants; by harvesting the edible buds in spring and prolonging the vegetative growth state, flowering is delayed, and plant growth is more vigorous (Oberndorfer 2016).

3.3.3 Perspectives on community enterprise and distribution of benefits

Elders were surprised to learn that a local, traditionally used plant was valuable in the global commercial trade of natural health products. They were enthusiastic at the prospect of jobs for young community members that would also perpetuate traditional Inuit ties to the land, and they indicated unanimous support for the proposed community-based enterprise centered on cultivation and marketing of rhodiola. Community members

recognized this as an opportunity for the youth to learn about the plants, to counter the loss of traditional botanical knowledge, and as an opportunity to generate fulfillment and pride from growing gardens. It was noted that with the high cost of living and the scarcity of jobs, economic benefits would be quite welcome, although many community members anticipated this opportunity would bring only moderate economic benefits, while much of the benefit would be more intangible. Several noted that it would be essential to recruit a knowledgeable program manager if the project would be successful. Everyone agreed that economic benefits from a commercial enterprise based upon local rhodiola should stay in the community. Many felt that the benefits could be directed towards student programs, particularly those that link Elders and youth to help sustain traditional plant knowledge.

Youth focus group participants were very enthusiastic about the prospect of a community enterprise based upon a local medicinal plant. They felt there was significant potential for community-wide benefits that would make it worth investing in, even if only a few people gained employment. One participant had observed interest in gardening expressed in the community, and that this project could therefore address community goals. It was also noted that the enterprise would benefit the health of the community on multiple levels; by getting out on the land and gardening, this could benefit the physical and mental health of youth and community members, and it would also bring greater attention to the medicinal and antidepressant properties of the plant, which were not widely known or employed among the greater community, despite the prevalence of depression the youth noted during the discussion. They also felt that benefits from an

enterprise based upon rhodiola should be distributed within the community, and particularly directed towards student programs. They felt that if the youth were planting and tending community gardens, then it would be fair to invest the benefits in the youth programs. In the words of one Nunatsiavut youth participant,

"If we find other people to get involved with it, if we got together, it could actually become real. It would be a good thing to do with the student program. Even if it was just ... [to] educate people on the importance of it, they'll know then. Because some people don't even know, I didn't know before, I knew you could eat it, but I didn't know all this, it's like really cool and if other people knew that too..."

3.3.4 Concerns and questions regarding community-based enterprise

Asked if there were any concerns, Elders thought that the garden could get vandalized by wildlife and/or people. They wondered if the garden would be looked after well enough to make it worthwhile. They were moderately concerned about the potential for misuse of the solvents to be used for extraction (alcohol), if tinctures were to be produced within the community. However, there was consensus that with adequate measures this would not be a problem, and that the enterprise could bring a host of benefits to the community.

Community members expressed concerns regarding natural resource conservation, and particularly the need to better understand how selective harvesting of wild rhodiola to start the gardens might affect local populations. There were concerns that wild rhodiola might be overharvested due to greed, and that it would be difficult to

monitor or regulate wild harvesting. However, as a former *AngajukKâk* /Mayor observed, pressure on wild populations is already occurring due to erratic weather and shoreline erosion, such that some populations are already decreasing. Another concern expressed by community members regards equal partnership between outsiders and local community. One community member stated that the research process is ideally a learning process from both sides, that Inuit can learn from *Kallunâk* (outsiders) as much as the reverse, and it is important to make community members part of the decision-making process.

When youth were asked if they had any concerns regarding a community enterprise based on rhodiola, one youth wondered who would own and manage the enterprise. Asked how she would ideally envision such an enterprise in her community, she pointed out that Nunatsiavut means "*Our* Beautiful Land" in Inuktitut, and that the plants growing on the land likewise are an asset that belongs to the whole community, and therefore she would like to see the whole community involved in the enterprise. Community open house meetings in Rigolet resulted in marginal attendance with only one attendee, although the *AngajukKâk* /Mayor shared many ideas, including ways to integrate the project with regional funding sources and Aboriginal business networks, leading to a successful discussion.

3.4 Discussion

Ethnobotanical knowledge is contextual and interconnected; it is embedded in culture and place, and the perception and success of entrepreneurial opportunities based

on traditional knowledge innovation is therefore dependent upon the biocultural context (Meis Mason et al. 2012; Pengelly and Davidson-Hunt 2012). Indigenous communities have suffered a range of invisible losses, with detrimental effects for customary practices and intergenerational knowledge transmission (Turner et al. 2008). Plants play a vital role in connecting customary values and practices for community well-being, in addition to their utilitarian applications as food and medicine (Oberndorfer et al. 2017). Equitable sharing of benefits accrued from utilization of biological resources must be ensured according to the Nagoya Protocol in the Convention on Biological Diversity (Secretariat of the Convention on Biological Diversity 2011). To ensure Indigenous communities have an active role in management of biocultural resources and community self-determination, it is important to engage in participatory, values-based discussions (Turner et al. 2008). Therefore, it was important to have open dialogs with Nunatsiavut community members about the traditional knowledge (*Qaujimajanngit)* of rhodiola and its potential applications for community enterprise. Nunatsiavut Inuit Elders and community members report medicinal and food uses of rhodiola, some of which are unique to Nunatsiavut, consistent with the findings of Clark (2012) and Cuerrier et al. (2012a). Elders and community members also shared unique traditional knowledge of rhodiola's ecology and habitat, which they have gained through extended observation of the local environment, as documented in another Labrador community, Charlottetown (Karst and Turner 2011).

Opportunity recognition was observed in both Inuit youth and Elder focus groups as well as in individual interviews, with fewer reservations cited than in other Canadian

Indigenous communities (Meis Mason et al. 2012; Pengelly and Davidson-Hunt 2012). Community members from the youth to the Elders were enthusiastic about the potential benefits of an enterprise based on a local medicinal plant, while still maintaining a pragmatic outlook on possible economic outcomes. However, there were some differences in the perspectives of Elders and youth when it came to the benefits that the enterprise could bring to the community. Elders anticipated that the enterprise would bring jobs for the youth in the community, and that an enterprise based upon a traditional medicinal plant would be valuable for perpetuating customary practices such as time on the land. Inuit youth, however, observed and articulated a wider range of benefits that could arise from the enterprise, for both physical and mental health, as well as economic and social benefits within the community. The youth perspective on the benefits of a community enterprise is consistent with the findings of Ratten and Dana (2015) that "social entrepreneurship is a key part of entrepreneurial activity for Indigenous people because of its linkage to the community and overall well-being of society." As a social enterprise, the youth felt this project could provide an opportunity for community members to engage in an expressed desire for more gardening activities while also perpetuating customary practices; it could educate community members more widely on the health benefits of this traditional plant; and it could help as a natural health product to remedy the rampant depression the youth observed in Nain, due in part to the effects of climate change as documented in Rigolet (Cunsolo et al. 2013). Youth also recognized the economic benefits of the enterprise and showed interest in the jobs and training this would entail, and felt that the economic benefits could help support local student

programs. Given the troublingly high levels of unemployment among Aboriginal youth in Canada and the high levels of school attrition rates (Abele and Delic 2014), community enterprises which provide training, engagement and employment for youth could be extremely beneficial.

Product elicitation methods were useful to explore community members' thinking on an opportunity for a community-based enterprise, as well as to gauge the cultural appropriateness of product options, consistent with the findings of Meis Mason et al. (2012) in another Canadian Inuit community. However, Nunatsiavut Inuit Elders and community members stated no preference amongst potential rhodiola product forms, whereas Elders of the Pikangikum First Nation, another Northern Canadian Indigenous community, preferred products of lower degrees of transformation (Pengelly and Davidson-Hunt 2012).

Reciprocity is an important value in Canadian Indigenous communities (Turner 2014), and we also found this to be an important value expressed by Nunatsiavut Inuit community members. It has been commonly observed in Nunatsiavut communities that researchers who come to work in these communities often do not incorporate the local knowledge or return to report on results (A. Cuerrier, unpublished data); however, it is important to integrate traditional knowledge for participatory research. Traditional knowledge will help inform the conservation of local rhodiola, which is becoming a more pressing issue with the recently observed decreases in shoreline populations (C. Wolfrey pers. comm.). Nunatsiavut Inuit described a need to better understand the factors that affect rhodiola's reproduction, and how harvesting the local rhodiola for propagation

would affect the wild populations. Concerns expressed by Nunatsiavut community members for conservation of rhodiola in the wild are very real; similar concerns have been documented in other Canadian communities (Meis Mason et al. 2012; Turner 2014). In the case of the anti-cancer drug Taxol, harvested from the Pacific yew tree, unsustainable commercial extraction of a traditionally used medicine led to overharvest, making this medicine unavailable to local Indigenous peoples (Turner 2014). Since rhodiola is already threatened due to overharvest in Russia and parts of Europe, especially in Bulgaria, where it is critically endangered (Allen et al. 2014; Cuerrier et al. 2014), it is important to understand the issues affecting its conservation in North America as well. Rhodiola is critically imperiled, presumed extirpated or extirpated in five states (NY, PA, VT, NC, TN) in the US (Cuerrier et al. 2014). More research needs to be done to understand the conservation status of Nunatsiavut rhodiola populations; how shoreline populations are being affected by climate change, tidal fluctuations, and shifts in species composition, and what effect selective harvesting for cultivation would have on already decreasing populations (Ticktin 2004). While community members in Rigolet found rhodiola transplanted easily into home gardens, Elders in Nain had been largely unsuccessful in attempts to bring wild rhodiola into gardens, pointing to the need to learn more about the factors that support successful cultivation of rhodiola in Nunatsiavut. Other factors such as land availability, youth availability, and funding will also influence the communities' decisions to establish rhodiola gardens in Nunatsiavut, with guidance from the Nunatsiavut government.

3.5 Conclusion

Abrupt and disruptive changes in the social-ecological system can present significant challenges for the resilience of a remote northern community. For Inuit living in the eastern Canadian Subarctic, climate change's effects on the local environmental conditions has a significant impact on traditional subsistence activities, increasing the risks associated with traveling on the land and across frozen water to secure resources (Downing & Cuerrier 2011; Rapinski et al. 2018). A resilient social–ecological system buffers change and uncertainty, providing adaptive capacity while also maintaining biocultural diversity (Holling 2004). By managing for biocultural resilience, social-ecological systems develop and sustain pathways for adapting to dynamic and changing environments (Folke 2006). Recognizing that the unique biocultural context will influence the success of a community-based enterprise (Pengelly and Davidson-Hunt 2012), the present research will inform the opportunity analysis of a community enterprise based on local medicinal plants in Nunatsiavut. By integrating intergenerational knowledge, experience, and perspectives, the resulting cross-scale linkages can inform innovation based upon traditional knowledge of a local medicinal plant, building community capacity and biocultural resilience.

3.6 Acknowledgements

We are grateful to the people of Nunatsiavut for welcoming us into the communities of Rigolet and Nain, and for sharing their knowledge, experience, and insight. We would especially like to thank the Elders of Nain who participated: Verona

Ittulak, Annie Lampe, Julius Merkuratsuk, Lucas Ittulak, Adam Lidd, Sabina Lidd, Mary Dicker, Jessie Ford, Christine Baikie, K. Naeme Merkuratsuk (Interpreter as well), Katie Winters, Julius Ikkusek, and Timo Townley; as well as the youth of Nain: Caroline Nochasak, Brianna Brown, Megan Dicker, Simeonie Merkuratsuk, Johnathan Lidd, and Sarah Karpik (facilitator); and the community members of Rigolet that participated in interviews: Arch Flowers, Charlotte Wolfrey, Derrick Pottle, Wendy Pottle, Garmel Rich, Liz Tooktoshina, Richard Rich, Sarah Baikie, and Jack Shiwak. We are also grateful to Erica Oberndorfer for sharing pre-publication data collected under permit working with plant mentors in Makkovik.

3.7 Declarations

Permissions: Research approval was obtained from the Nunatsiavut Government. Research methods were approved by the Memorial University of Newfoundland Interdisciplinary Committee on Ethics in Human Research. (ICEHR# 20130328-SC). Informed consent was obtained from each participant.

Sources of funding: Partial funding was provided by an NSERC - ArcticNet Centre of Excellence Award and a Harris Centre Applied Research grant granted to Hermanutz and Cuerrier. VM was funded by Memorial University and ArcticNet.

Voucher specimens: Representative voucher specimens were deposited at the Marie-Victorin Herbarium (MT) of the Biodiversity Centre of the University of Montréal.

Conflicts of interest: None declared.

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Chapter 4. Nunatsiavut Inuit use of *Rhodiola rosea:* from Traditional Knowledge to Sustainable Community Enterprise

Abstract

Rhodiola rosea (rhodiola) is traditionally valued by Nunatsiavut Inuit for its edible and therapeutic properties; it is also commercially valuable in the global trade of natural health products. Meeting the international demand for rhodiola has resulted in unsustainable wild harvesting practices, endangering this species in Eurasia. While there are extensive native populations of wild rhodiola growing in coastal Nunatsiavut, Labrador (Canada), there have been no previous initiatives to cultivate this prospective resource. Representatives of several Nunatsiavut communities expressed interest in a community enterprise based upon sustainable cultivation of local rhodiola. We conducted a business opportunity analysis to explore approaches to community enterprise in Nunatsiavut based upon traditional knowledge innovation. The business opportunity analysis examined the costs and benefits of various product options, and the logistical factors involved in cultivation, processing, marketing, and distribution. Our results examine a wide range of product options with differing degrees of transformation - from raw materials to value-added finished products such as capsules, teas, or extracts. Market data in the US and Canada clearly show a trend of consistent growth over the last decade in the demand for herbal dietary supplements, with a significant demand for rhodiola products in both the mainstream market as well as the natural market supply chains. This suggests that there is significant potential for social enterprises based upon local herbal products within Nunatsiavut communities. Entrepreneurship can be a powerful tool for

Indigenous communities to meet both economic and social objectives for self-determination, and implementation of the proposed social enterprise could enable Nunatsiavut Inuit communities to participate in the global market for natural health products on their own terms, bringing both socioeconomic benefits and renewed connection to traditional knowledge.

Keywords

Medicinal plants, Indigenous entrepreneurship, adaptive systems, supply chains, Nain, Rigolet

4.1 Introduction

Recent ethnobotanical studies in Arctic and Sub-Arctic communities have indicated a resurgence of interest in the traditional use of plants as medicine, as well as their potential as economic products through traditional knowledge innovation, although some aboriginal communities have decided not to pursue this avenue (Cuerrier et al. 2012a). Strong support from Nunatsiavut Inuit Elders and communities prompted research to investigate *Rhodiola rosea* L. (rhodiola) from Nunatsiavut, Labrador (Canada) for the development of a local enterprise with benefits for participating communities (Chapter 3).

Rhodiola rosea is a circumarctic coastal and alpine medicinal plant native to Labrador, with a history of traditional use among the Nunatsiavut Inuit (Clark 2013), as well as numerous other traditional Eurasian pharmacopeias around the world (Cuerrier et al. 2014). Rhodiola became significant in the global trade of natural health products after

scientific research on its ergogenic (or adaptogenic, performance-enhancing properties) conducted in the Soviet Union post World War II led to broader recognition and subsequent commercialization (Brown et al. 2002; Ulbricht et al. 2011). In 1985 the Swedish Herbal Institute developed a proprietary extract from *Rhodiola rosea* roots and rhizome, SHR-5 (an active constituent of Arctic Root® tablets and capsules (Panossian and Wikman 2015). The herbal industry has grown exponentially; since 2002, the supplements industry has seen consistent growth, topping $8 Billion USD in 2017 (Smith et al. 2018), driven by the consumer seeking supplements for energy, stress reduction, and immune health (Lindstrom et al. 2014)— many of which are evidence-based applications for rhodiola (Ulbricht et al. 2011). Adaptogenic herbs were reported to be among the top health and wellness trends in 2016 (Smith et al. 2017).

Until recently the international demand for rhodiola has been met primarily by wild-harvested plants of Eurasian provenance, placing conservation pressure on those wild populations, while largely neglecting to utilize rhodiola native to North American (Galambosi 2006). Based on IUCN status statistics, Eurasian wild rhodiola populations are threatened in Russia, the Czech Republic, and Bosnia; and critically endangered in Bulgaria (Allen et al. 2014; Cuerrier et al. 2014). North American rhodiola, however, is a vastly underutilized resource that is not commercially wild-harvested, with potential for cultivation as a high-value root crop. North American farmers are cultivating *Rhodiola rosea* in parts of Canada (particularly Alberta), but using Eurasian stock rather than rhodiola of Canadian provenance (K. Ampong-Nyarko 2014, pers. comm.). Alberta *Rhodiola rosea* Growers Organization (ARRGO) is a collective of farmers growing

rhodiola in Alberta for the commercial supply chain. As of 2012, 20 ha of rhodiola were under cultivation in Alberta, providing employment to over 150 people (Ampong-Nyarko 2014). A rhodiola growing operation has been initiated in Nunavik (homeland of the Quebec Inuit), in association with Nunavik Biosciences (Makivik Corporation); however, it has not progressed beyond cultivation to commercialization (Cuerrier et al. 2014). Commercial *Rhodiola rosea* cultivation operations are also underway in Alaska (https://www.akroseroot.com/), but it is unknown whether the germplasm under cultivation is of Eurasian or North American provenance. Therefore, while cultivation of rhodiola is ongoing in Canada, it is very limited and there remains an untapped opportunity to commercialize cultivated rhodiola of Canadian provenance. While there are extensive native populations of wild rhodiola growing in coastal Labrador, there have been no previous initiatives to capitalize on this biocultural resource. Recent research has shown that rhodiola native to Labrador contains known medicinal marker compounds for therapeutic potency (Chapter 2). In partnership with the Nunatsiavut government, we are proposing sustainable cultivation of Labrador rhodiola as a new source to meet an established market demand (Meis Mason et al. 2012), and as an opportunity to produce a northern fair trade product for a community-based enterprise.

Entrepreneurship can be a powerful tool for Indigenous communities to meet both economic and social objectives for self-determination (Anderson et al. 2006; Ratten and Dana 2015). The identification and implementation of opportunities based upon biocultural resources can be a means for building community capacity and participating in the global economy (Davidson-Hunt et al. 2012). Practices that leverage biocultural

diversity, the inherent links between nature and culture, can support resilience and adaptive responses while empowering communities to value traditional knowledge, language, and cultural identity (Maffi 2010). Commercial cultivation of medicinal plant crops is one such opportunity to bring both economic and social benefits to build capacity in Indigenous communities. In Malaysia for example, herbal entrepreneurship has become an engine of economic growth with "potential to become a significant industry", providing opportunities for product development and innovations in processing technologies (Paul 2013). Farmers in rural regions with limited agricultural opportunities, for example the Puna ecoregion in Peru, can often earn greater income from high value medicinal plant crops, such as maca (*Lepidium meyenii*) than other types of export crops, while also helping to increase pride in traditional ethnobotanical knowledge (Hermann and Bernet 2009). Additionally, the development of medicinal plant products can strengthen community capacity with the gain of valuable transferable skills, and catalyze a variety of supplemental businesses in the community related to processing, product development, and marketing (Hermann and Bernet 2009).

Recognizing a potential economic and capacity-building opportunity for local communities, Nunatsiavut Government officials facilitated collaboration on this project. Nunatsiavut is an autonomous, self-governing Inuit territory, comprised of land claimed by the Inuit in the Canadian province of Newfoundland and Labrador, including territory in Labrador, extending to the Quebec border. Community members in two Nunatsiavut communities, Nain and Rigolet (56.5422° N, 61.6928° W and 54.1667° N, 58.4333° W, respectively), expressed interest in participating in an enterprise involving cultivation of

local rhodiola. Nain (population 1,188) is the northern-most Inuit settlement in Nunatsiavut, and Rigolet (population 306) is the southern-most Inuit community in the world; both communities are accessible only by air or boat. We investigated the feasibility of commercial cultivation of Nunatsiavut rhodiola through a business opportunity analysis, to lay the groundwork for a potential community-based enterprise in Nunatsiavut, Labrador.

4.2 Methods

Opportunity analysis, a detailed review of the market prospects for a potential product, can provide a rational framework for "identifying, monitoring, and evaluating key economic, socio-cultural, demographic, environmental, political, governmental, legal, technological and competitive factors" (Montes 2012). We conducted a business opportunity analysis to explore approaches to community enterprise for Nunatsiavut based upon traditional knowledge innovation, and to examine the costs and benefits of various product options, along with the factors involved in sustainable cultivation, processing, marketing, and distribution. Included in our approach was detailed market research and engagement of business incubation resources (the Genesis Centre at Memorial University, St. John's, NL, Canada, http://www.genesiscentre.ca/ and Académie de l'Apothicaire, Montréal, QC, Canada, http://www.apothicaire.ca/) to assist in the development of the opportunity analysis. The objective of this opportunity analysis was to assess the viability of a sustainable local rhodiola cultivation and processing enterprise in Nunatsiavut, Labrador, intended to bring both social and economic benefits

to the community, through an exploration of the operational logistics and finished product options, as well as the current state of the natural health products market.

4.3 Findings

Below is a summary of the Opportunity Analysis; the complete Opportunity Analysis is available in Appendix A.

4.3.1 Market Data

Market data (Appendix A; page 8) show a trend of consistent growth in herbal dietary supplement sales in the US over the last 13 years (Smith et al. 2017). In 2013, the total retail sales of herbal dietary supplements in the US increased by the highest margin since the 1990's - an estimated 7.9% (Lindstrom et al. 2014) and annual growth continued at 6.8% in 2014 (Smith et al. 2015). In 2016, total retail sales of herbal supplements in the US surpassed seven billion USD for the first time, an increase of 7.7% from the prior year (Smith et al. 2017). Approximately 70% of Canadians have used natural health products (Sharma and Loebenberg 2014). Total retail sales of herbal and botanical dietary supplements in the United States mainstream multi-outlet channel in 2014 was calculated at $6.4 billion USD, marking the 11th consecutive year of market growth (Smith et al. 2015). We found little evidence however, that significant profits from herbal dietary supplements were returning to traditional knowledge holders where appropriate.

There is an established demand for products containing rhodiola (root and rhizome) in the commercial market; total sales of rhodiola supplements in the US exceeded $14 million USD in 2014 and $13 million in 2015, and in 2016, demand for

rhodiola remained consistent (Smith et al. 2015; Smith et al. 2016; Smith et al. 2017). In contrast to most rhodiola on the commercial market that is wild harvested in Eurasia, rhodiola from Labrador could occupy a unique market niche as a sustainable, fair trade product, based upon local Inuit traditional knowledge. Potential target markets for a Nunatsiavut rhodiola product includes: local retail to community members and visitors of local Nunatsiavut craft shops; wholesale of raw material to supplement manufacturers and grower's cooperatives; and wholesale of finished products to retailers of natural health supplements. Utilizing social media as a marketing tool can be effective in the broader promotion of traditional plant products, but it may come at a cost, leading to changes in customary practices around "the culture of home remedies and traditional domestic preparation of natural products" (Semotiuk et al. 2015). For example, in traditional Sonoran medicine markets, social media marketing was found to contribute to a shift in healing practices from the use of single herbs to preformulated preparations due to the marketing strategies utilized by shopkeepers which favoured formulations over simples (products based on a single herb), altering the cultural context in which natural resources are utilized (Semotiuk et al. 2015).

4.3.2 Product Options

Product options (Appendix A; page 1) from Nunatsiavut rhodiola would require differing degrees of transformation or post-harvest processing, and would therefore differ in the amount of value added to the raw materials (Pengelly 2011). Bulk rhodiola root requires the least amount of post-harvest processing, simply drying the rhizome, but adds only minimal value to the raw material. A tea blend combining dried rhodiola root with other

dried botanicals such as local herbs, berries, roots, flowers, or fungi for medicinal or flavor properties (i.e., Northern Delights tea from Nunavik) would require similar post-harvest processing, but could add greater value to the raw material (Barfoot 2006). Liquid extract is a product of moderate transformation, using solvents such as ethanol or glycerin to manufacture tinctures or glycerites, while encapsulation would require the most transformation, including use of excipients and encapsulation equipment (Cech 2000). Many of these product forms are available online, however they are primarily derived from rhodiola sourced in Eurasia, especially Russia.

Leaves of rhodiola plants are not commonly used in the commercial trade as they lack some medicinal marker compounds that the roots are commonly known for (i.e. rosavins; Filion et al. 2008), although they do contain salidroside, a bioactive compound found in the root as well as several other medicinal plant species (Peschel et al. 2013; Chapter 3). However, rhodiola leaves are used traditionally by Nunatsiavut Inuit as both food and medicine (Clark 2013; Chapter 3), and this new use could offer the opportunity for product innovation based upon traditional knowledge. As the leaves would otherwise be a by-product of the root harvest, the possibility of formulating a natural health product incorporating the leaves merits further investigation.

4.3.3 Scope of Operations

The Scope of Operations (Appendix A; page 6) for the proposed enterprise comprises production, processing, and manufacturing logistics, consistent with regulatory frameworks relevant to the chosen target market (Lubbe and Verpoorte 2011). Prior to commencing agricultural production, it is essential to develop appropriate cultivation

protocols specific to Nunatsiavut, as existing commercial operations are limited to more southerly locations and knowledge is lacking in northern cultivation techniques. Agricultural production should ideally adhere to *Good Agricultural Collection Practices* (GACP) (Lubbe and Verpoorte 2011). Post-harvest processing could occur within the community or in cooperation among local communities. Manufacturing of the finished product, with adherence to *Current Good Manufacturing Practice* (CGMP), could occur within Nunatsiavut communities or could extend to external partnerships with contract manufacturers. Depending on the interest, operations could either be centralized within a single Nunatsiavut community, or carried out jointly, such that components of the enterprise occur in separate communities as a collaborative venture. For example, Rigolet might specialize in agricultural production and Nain in post-harvest processing, however, the infrastructure and transportation costs of multiple sites, as well as community goals would need to be considered.

4.3.4 Community Benefits

An enterprise based upon traditional knowledge and local resources presents the potential for a variety of tangible and intangible benefits to participating communities, building capacity through job creation, technical training, youth participation, and economic gain, while supporting pride in Nunatsiavut Inuit culture. This enterprise could provide technical training and employment for participating community members, empowering participants with transferrable skills, while also creating a sustainable economy based upon a locally sourced plant, with profits staying in the community, and due diligence and full consideration for the intellectual property of Nunatsiavut Inuit Elders and

community. By integrating traditional knowledge with conscientious innovation, community members are empowered to create solutions to current social, economic, and environmental challenges, while encouraging pride in traditional Inuit culture, and maximizing biocultural resilience.

4.4 Discussion

The Nunatsiavut Roseroot Opportunity Analysis (Appendix A) examined the considerations involved in the development of a successful medicinal plant enterprise for benefits in Nunatsiavut communities. Community-based enterprise is an adaptive form of economic development that can be shaped to fit a specific biocultural context. This allows for maximal self-determination while also allowing a community to opt-in to the larger global economy, and delivers monetary dividends back to the communities (Anderson et al. 2006). While conventional businesses focus on growing financial capital for shareholders, community-based enterprises (CBEs) may deliver broader benefits to the community, to address social, environmental, and economic goals (Anderson et al. 2006; Peredo and Chrisman 2006; Berkes and Davidson-Hunt 2007; Pengelly and Davidson-Hunt 2012). Consequently, the benefits of such an enterprise are not only to financial stakeholders, but may also provide return on investment in the form of social dividends, such as return to communities and job creation. Community-based enterprise helps communities gain control of their "local natural resources, cultural adaptation and the path of their social and economic development" (Taiepa 2004; Pengelly and Davidson-Hunt 2012). By creating jobs and opportunities for advanced training, CBEs can help build community capacity, an integral goal to combat high unemployment in

northern communities. Therefore, the success of a community enterprise is not just about the bottom line, it is also about meeting the community's social mandate. The success of an enterprise, from a community perspective, depends upon the degree to which the enterprise fulfills community objectives for self-determination (Pengelly 2011). Instances of misappropriation by outsiders of traditional knowledge and intellectual property rights in a Quebec Cree community led community members to be cautious of external research collaboration. Global instances of biopiracy, such as the patent on constituents of the medicinal plant *Hoodia gordonii* in 1996 by the CSIR (Council for Scientific and Industrial Research), without any measures of benefit-sharing for the traditional knowledge holders, the San of South Africa, demonstrate that cautious and respectful relationships between researchers and traditional knowledge holders are critical (Bavikatte et al. 2010). In order to conduct ethical ethnobotanical investigations, other researchers investigating antidiabetic plant products through collaborative research gave the Cree editorial authority over traditional intellectual property written up in scientific manuscripts as part of the research agreement signed by all parties (Cuerrier et al. 2012a). When it comes to Canadian Aboriginal groups, as with many indigenous cultures, the control of traditional lands, local resources, and livelihood opportunities is particularly important for community self-determination (Berkes and Davidson-Hunt 2007; Pengelly and Davidson-Hunt 2012). This is especially the case in Nunatsiavut Inuit communities, as Inuit cultural identity is deeply rooted in the connection with the land and sustainable use of its natural resources (Downing and Cuerrier 2011; Cuerrier et al. 2012b).

Disconnection from the land in this context can take a drastic toll on community health and the well-being of youth. Inuit way of life has changed dramatically in the last generation, as the traditionally nomadic culture shifted to settled and re-located communities (Davis and Banack 2012). Traditional practices that have been central to Labrador culture are falling out of favor with youth in some communities, leading to lack of transmission of traditional knowledge and practice (Karst and Turner 2011), although our research indicated Inuit youth were taking a renewed interest and pride in traditional land-based practices (Chapter 3). Lifestyle changes associated with modernization can be compounded by environmental changes such as unstable ice that also lead to decreased time out on the land (Cunsolo et al. 2013; Rapinski et al. 2017). Recent research in the Labrador community of Rigolet has shown climatic changes are negatively affecting the physical and mental health of community members (Cunsolo et al. 2012; Cunsolo et al. 2013). Social problems within these northern communities, such as substance abuse and mental health issues including high rates of suicide, low high school graduation rates, and high unemployment rates are the result of declining traditional practice, loss of language and traditional land-based activities (Cunsolo et al. 2012; Cunsolo et al. 2013). Nunatsiavut Inuit youth have the highest unemployment rates among Northern Aboriginal youth (Abele and Delic 2014). This makes apparent the need to foster healthy growth in Nunatsiavut communities, by encouraging transmission of traditional knowledge across generations and incorporating innovation based upon traditional knowledge for community development, to generate employment opportunities that are accessible to the youth (Downing and Cuerrier 2011; Cuerrier et al. 2012b). Time on the

land is important to Nunatsiavut Inuit, for cultural identity as well as for physical and mental well-being (Cuerrier et al. 2012b; Cunsolo et al. 2012), therefore opportunities such as a community enterprise based on local plants will bring the benefits associated with increased time on the land, while also helping to build capacity, and provide economic benefits.

Cultivation of medicinal plant crops can bring both economic and social benefits to remote indigenous communities. In the Puna, for example, a harsh ecoregion of the Peruvian Highlands, farmers of the medicinal root crop maca earn far more from maca than from any other crops, and proceeds from activities have helped to improve quality of life in a rural impoverished area (Hermann and Bernet 2009). These farmers no longer need to leave their communities to work in mineral extraction, now that there is an alternative livelihood (Hermann and Bernet 2009). Additionally, development of maca production in the Puna has catalyzed a variety of supplemental community businesses related to processing and marketing, and has improved community capacity with the gain of valuable, transferable skills associated with product development and marketing (Hermann and Bernet 2009). However, the exponential growth of international demand for maca has recently brought other social problems to Peru as well, including a spike in violent crime and dwindling supplies of this traditional resource for community use, problems that could be avoided in developing sustainable, community-based cultivation of Nunatsiavut rhodiola (Smith 2014). Barring this sort of economic bubble, Nunatsiavut rhodiola likewise represents an opportunity for a community-based enterprise with a range of associated social, economic, and health benefits to participating communities,

building capacity through job creation, technical training, and youth participation, while supporting pride in Nunatsiavut Inuit culture. In Labrador, plant harvesting has traditionally "played a large role in the social life of the community that still exists today" and is "an integral part of the culture and lifestyle" (Karst and Turner 2011). In Nain (Nunatsiavut), community members have recently begun selling locally harvested tea blends with Labrador tea and other herbs at community markets (L. Hermanutz, pers. comm. 2017). Greater awareness and use of rhodiola as a natural health product in Nunatsiavut could also bring health benefits associated with mood and energy (Brown et al. 2002; Ulbricht et al. 2011).

Cultivated rhodiola offers a number of advantages from a product quality standpoint (Appendix A; page 2), including improved traceability, sustainability, and minimizing variability in product potency. Traceability is an important concern for quality control in natural product markets to prevent adulteration and misidentification (Groot and Van der Roest 2006), and ingredient transparency has been shown to be an important consideration to consumers as well (Marrapodi 2016). Recent research tested commercially available *Rhodiola rosea* products on the EU market derived from wild-crafted sources, and found that approximately one fifth of products were missing a key reference marker compound (rosavin), indicating products of limited potency, possibly adulterated with other species (Booker et al. 2015). A previous study analyzed marker compounds in 18 commercial samples of rhodiola and found that 33% did not contain characteristic rosavins (Ma et al. 2011). Development of a North American source of cultivated rhodiola for market could shorten the supply chain, helping keep profits local,

and improving consumer confidence in source quality, while also avoiding overharvest of wild resources (Booker et al. 2012). However, there is the potential for negative conservation impacts if cultivation of medicinal plants requires chemical control and/or reduces incentives to conserve wild habitats (Schippmann et al. 2006). Nunatsiavut Inuit Elders have indicated that such overharvesting must be avoided for the CBE to move ahead, and Cree Elders have voiced similar concerns (Cuerrier et al. 2012a) regarding their medicinal plants.

Such an enterprise would be consistent with conservation goals set in the Convention on Biological Diversity, and deliver benefits as outlined in the Nagoya Protocol, a supplementary agreement to the Convention on Biological Diversity that was adopted in 2014 to ensure equitable sharing of the benefits accrued from utilization of genetic resources. In Cree communities of Quebec, a precedent has been established for this type of access and benefit sharing in assessing entrepreneurial opportunities elated to traditional knowledge of medicinal plants, although there is no Canadian policy to specifically address access and benefit sharing. (Cuerrier et al 2012a).

Market analysis (Appendix A; page 8) shows consistent growth in the sales of natural health products, indicating robust economic potential in developing a natural health product from Canadian rhodiola. While the viability of a business start-up is difficult to predict, the business opportunity analysis helps to ensure that all aspects of the enterprise have been thoroughly considered, so that stakeholders, in this case, Nunatsiavut Inuit, can make informed decisions regarding development and implementation of a business plan.

The opportunity analysis uncovered a range of possible products (Appendix A; page 1) with varying degrees of transformation, from the low levels of transformation of a bulk raw material, to moderate transformation of tea or tincture, and encapsulation, requiring the highest degree of transformation. The degree of product transformation directly affects the amount of value added to raw material (Pengelly 2011). While medium to high degrees of transformation (powder, capsules, and extracts) generate higher revenues over time (Hermann and Bernet 2009; Ten Kate and Laird 1999), cultural context also determines what types of product transformation or innovation based upon traditional knowledge are appropriate. In Canadian Indigenous communities, cultural protocol is a primary consideration in product development (Pengelly 2011). Anishinaabeg Elders of the Pikangikum First Nation in Northwestern Ontario demonstrated a preference for products with lower degrees of transformation, which more closely reflected traditional knowledge, in contrast to products of higher degrees of transformation that utilized technology that limited the ability of Elders to contribute traditional knowledge, without a complete understanding of how the highly altered product worked (Pengelly and Davidson-Hunt 2012). However, the Anishinaabeg Elders felt that as long as the purpose of the product was to benefit the people, and the cultural protocol is adhered to, then the degree of product transformation was of lesser concern (Pengelly and Davidson-Hunt 2012). Our research with Nunatsiavut Inuit Elders revealed that although their traditional uses of rhodiola utilized the raw plant with minimal transformation, there were no strong preferences between product options or degrees of transformation for commercialization (Chapter 3). Production of value-added herbal

products in the form of intermediate ingredients or finished products enables botanical raw material producers to move up the value chain, a goal that has been documented amongst botanical raw material producers around the world (Brinckmann 2004). Since greater revenues accrue over time from medium to high degrees of transformation, it may be advantageous to develop innovations in product transformation to add value to the raw materials within the community (Pengelly 2011; Lombard 2012), or to gradually add to the product portfolio as technical capacity allows. This is especially true for a plant such as rhodiola for which rhizomes with roots can be labour intensive (i.e., cleaning) to prepare raw bulk samples for commercial sales.

A local, sustainable, fair trade product, developed with full regard for intellectual property associated with traditional knowledge may be worth more to socially conscious consumer groups, adding value to the raw material before it is even further processed or transformed (Appendix A; page 10). Sustainably cultivated rhodiola may be medicinally comparable to raw material that was wild harvested in Eurasia (Chapter 2), but could be worth more, as consumers are often willing to pay a premium for fair trade, ethically produced plant products (Lyon 2006). Further, brands with content, or marketing that tells a story about the product's origins and ingredient sourcing help to meet the increasing consumer demand for supply chain visibility (Marrapodi 2016). However, the cost of attaining fair trade certification can be prohibitive for the small grower (Lyon 2006).

Formulation of an herbal tea(s) containing Labrador rhodiola could offer advantages over other product options (Appendix A; page 2). To begin, there are few

rhodiola-containing herbal teas available on the commercial market. A blended herbal tea could utilize other sustainably produced local plants, and adds value to raw materials. Herbal tea requires less post-harvest processing than products of higher degrees of transformation such as tinctures or capsules, and does not require the use of solvents or excipients. Further, there is a precedent for successful commercialization of herbal tea based upon traditional indigenous Canadian herbs (i.e. Algonquin Tea and Northern Delights tea), although these companies are not necessarily owned by indigenous community members. And lastly, tea is a familiar and accessible mode of administration for most consumers, making it more easily marketable.

The resources required for commercial-scale cultivation and adherence to regulatory requirements for quality control can be barriers to market access, excluding stakeholders who do not have the land rights or financial resources to invest in large-scale operations (Schippmann et al. 2006). To overcome barriers and gain access to markets, capital, and technical expertise, successful community-based enterprises require diverse networks and partnerships, and can benefit from regional collectives or cooperatives (Brinckmann 2004; Berkes and Davidson-Hunt 2007; Lombard 2012). Strategic alliances can also help mitigate price fluctuations (Hermann and Bernet 2009). Cooperatives, with linkages that enhance the collective leverage of individual growers, could help to prevent or attenuate the type of economic instability seen in the maca market (Brinckmann 2004; Lombard 2012). Community-based enterprises with cross-scale linkages have been demonstrated to be more likely to fulfil community objectives, as defined by the UNDP

Equator Initiative, a United Nations program which incentivizes entrepreneurship in concert with biocultural conservation (Seixas and Berkes 2010).

Throughout the project, community stakeholders and regional policy-makers were consulted to ensure alignment with community priorities, participatory development, and better understand the potential partnerships that could contribute to a successful community-based enterprise. Linkages forged through exploration of the opportunity to commercially cultivate Labrador rhodiola led to network development and the emergence of partnerships between Memorial University, the Nunatsiavut Government, the Food Security Network of Newfoundland and Labrador, the Montreal Botanical Garden/Institut de recherche en biologie végétale, and ArcticNet, supporting collaborative business development. These linkages will contribute to the success of the project as defined by the cultural context to include socioeconomic benefits, job creation, and renewed connection to the land and traditional knowledge, while allowing Nunatsiavut Inuit communities to participate on their own terms in the global market for natural health products.

4.5 Acknowledgements

The authors are grateful for the expertise, collaboration, and contributions of Inuit Elders, youth, and community of Nain and Rigolet, especially Charlotte Wolfrey, and Tom Sheldon.

4.6 Declarations

Permissions: Appropriate research permits were obtained from Nunatsiavut Government. Research methods were approved by Memorial University of Newfoundland's Interdisciplinary Committee on Ethics in Human Research (ICEHR# 20130328-SC). Free, prior, and informed consent (FPIC) was given by all participants.

Sources of Funding: Funding was provided by an NSERC - ArcticNet Centre of Excellent Award and a Memorial University Harris Centre Applied Research grant granted to Hermanutz and Cuerrier. Mardones received support from Dept. of Biology, Memorial University and the Natural Products Foundation.

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Chapter 5. General conclusion

A community enterprise based on local medicinal plants has the potential to contribute to biocultural resilience in remote Nunatsiavut communities, while also bringing social and physical health benefits connected with increased time on the land. However, for a successful enterprise based on ethnobotanical innovation, it was important to consider the unique biocultural context, and understand the geographical variability in growth and phytochemistry of local rhodiola populations to guide phenotype selection and cultivation conditions.

Chapter 2 explored the biology of Nunatsiavut rhodiola, investigating the effects of latitude, substrate, and sex on the growth and phytochemistry of coastal Labrador populations of rhodiola. This research confirmed that coastal Labrador rhodiola contains known medicinal marker compounds found in commercially traded (Eurasian) rhodiola, consistent with pharmacopeial standards for rhodiola established by the USP but not Health Canada specifications (Bejar 2017), and that rhodiola from coastal Labrador populations would therefore have limited suitability for cultivation of a natural health product enterprise. These phytochemistry results also support traditional Nunatsiavut Inuit medicinal use of local rhodiola (Cuerrier et al. 2012; Cuerrier et al. 2014; Cuerrier et al. 2019).

Latitude and substrate were found to have a significant effect upon biomass (including dry weight of rhizome, the part of commercial interest), while the only significant difference between males and females in growth measures was plant height.

Biomass was higher in plants from southern populations around Rigolet, and those growing in sandy and organic substrates. Our findings indicate that Labrador rhodiola specimens from more southerly latitudes grown in sandy substrates will be the best candidates for community cultivation, yielding greater biomass and potency; however, a common garden growing a variety of rhizomes from north and south would allow the partition of genetic and environmental variation and would further clarify the preferred ecotypes for cultivation.

In **Chapter 3** we examined the ethnobotany of Nunatsiavut rhodiola to better understand the biocultural context for development of a small community enterprise intended to bring benefits to participating communities. Recognizing that biocultural context is a key factor influencing success of indigenous enterprises, it is critical to engage with the local community and consider their unique insights and perspectives. To explore the potential for developing a natural health product based upon Nunatsiavut rhodiola, ethnobotanical interviews and focus groups were conducted with Nunatsiavut Inuit Elders and youth. Nunatsiavut Inuit community reported both medicinal and food uses of the local rhodiola, as well as unique insights into its local growth and conservation, and they were enthusiastic at the prospective social, economic, and health benefits of a community-based enterprise centered around cultivation and marketing of local rhodiola. Elders as well as youth were concerned about conservation of local rhodiola. Participants were more engaged when asked to recount stories about traditional land-based activities rather than being asked directly for ethnobotanical knowledge about specific plants. In addition to detailed knowledge of plant ecology and traditional uses, these stories often included

recollections of family ancestors and activities on the land, like hunting, collecting berries, and fishing. Traditional ethnobotanical knowledge is interconnected with these ancestral practices, experiences, and relationships with each other and the land (Oberndorfer 2017).

Lastly, **Chapter 4** explores the business opportunity for rhodiola in Nunatsiavut. Entrepreneurship can be a powerful tool for Indigenous communities to meet both economic and social objectives for self-determination, and implementation of the proposed social enterprise could enable Nunatsiavut Inuit communities to participate in the growing market for natural health products on their own terms, bringing both socioeconomic benefits and renewed connection to traditional knowledge. Market data in the US and Canada clearly show a trend of consistent growth over the last decade in the demand for herbal dietary supplements, with a significant demand for rhodiola products in both the mainstream market as well as the natural market supply chains. This suggests that there is significant potential for social enterprises based upon local herbal products within Nunatsiavut communities. The business opportunity analysis examined the costs and benefits of various product options, and the logistical factors involved in cultivation, processing, marketing, and distribution. Our results show a wide range of product options with differing degrees of transformation - from raw materials to value-added finished products such as capsules, teas, or tinctures.

This analysis of the biology and ethnobotany of Nunatsiavut rhodiola will inform and support development of a community-based enterprise cultivating local ecotypes of rhodiola for commercialization, supporting biocultural resilience in a remote Indigenous

community, and helping mitigate pressure on wild populations of rhodiola due to commercial harvest activities. By integrating intergenerational traditional knowledge, experience, and perspectives with analysis of rhodiola's biology and potential business opportunity, the resulting cross-scale linkages can inform innovation based upon traditional knowledge of a local medicinal plant, building community capacity and biocultural resilience.

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Appendix A. Business opportunity analysis

The following document was developed at the request of Nunatsiavut government representatives and was distributed Spring 2014 to the Director of Economic Development, Nunatsiavut Department of Education and Economic Development; the Director of Environment, Nunatsiavut Department of Lands and Natural Resources; mayors (*AngajukKâk*) of Rigolet and Nain, and promoted through a community engagement tour May 2015 conducted by student representatives of Enactus Memorial (https://enactusmemorial.ca/), with support from Nunatsiavut Economic Development.

NUNATSIAVUT ROSEROOT

Opportunity Analysis for a Sustainable Community Enterprise

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Executive Summary

The goal of this proposed enterprise is to establish a community-based business involving the sustainable cultivation and processing of rhodiola, a local medicinal plant, for market. This business will be collaboratively designed and implemented by the Nunatsiavut Government (NG) with input from the local community, in consultation with a team of advisors from Memorial University and Montreal Botanical Gardens. This enterprise will provide technical training and employment for approximately 2-4 community members or more, while also creating a sustainable economy based upon a locally sourced plant, with full consideration for due diligence and the intellectual property of Inuit Elders.

The following document represents an opportunity analysis, highlighting various business options to provide an overview of the considerations involved in the development of a successful medicinal plant commercialization project. Pending decisions by the NG regarding the project budget, scale of operations, and organizational structure, it is anticipated that a more detailed product roadmap will be devised if/when the NG decides to move ahead with this project. This project will be referred to herein as "Nunatsiavut Roseroot", until the NG decides what they would like to call the project or product.

Description of Business

Despite general economic downturns, the natural products industry has seen consistently robust growth in the last decade. Herbal supplement sales have seen steady growth for nine consecutive years, and in 2012, sales increased by 5.5% from the previous year[1]. Consumer awareness of the ill effects of stress is leading to increased interest in stress-modulating, or adaptogenic herbs such as rhodiola root. More than forty years of research on adaptogens and rhodiola in particular has brought its benefits to the awareness of the consumer, who seeks better health through natural supplements.[2] This, combined with the growing market for sustainably sourced fair-trade botanicals, and the lack of such sources for rhodiola in the market, give the enterprise proposed herein a distinct competitive edge. Therefore it is proposed that a fair trade, sustainably grown and potency assured medicinal plant product such as Nunatsiavut Roseroot shows significant market potential.

Product Description/Option(s)

Tulligunnak, as it is known in Inuktitut, is known scientifically as *Rhodiola rosea*. It is also sometimes called "roseroot", in reference to the fragrance of the root. In the natural health industry, roseroot is usually referred to simply as "rhodiola". Rhodiola is an herb which is traditionally valued by Inuit Elders for its healing properties, and it is also valuable in global commercial trade.

Nunatsiavut Roseroot will be unique to the market for several reasons. Most rhodiola in the commercial supply chain is sourced from Eurasia, and as such this enterprise would provide a North American source, potentially shortening the supply chain and thereby increasing profits, as well as confidence in source quality. The only other commercial North American source is the Alberta Rhodiola Rosea Growers Organization (ARRGO), which produces rhodiola root derived solely from Eurasian genestock rather than the native North American gene pool (Ampong-Nyarko 2014, pers comm). To evaluate and compare the activity of Nunatsiavut rhodiola plants to commercially available stock, biological and phytochemical analyses have been conducted to identify environmental variables that affect rhodiola's potency and growth in Nunatsiavut populations. This will allow for the selection of the most appropriate plantstock and optimize growing conditions (Mardones, PhD research) for potential cultivation across Nunatsiavut.

Nunatsiavut Roseroot will also be unique as the only known "fair trade" rhodiola produced by way of an Aboriginal community enterprise. Round-table discussions which have been conducted with Inuit Elders, as well as a collaborative approach to business development, helps to ensure a business that will bring benefits to Nunatsiavut, both in employment and revenue. Fair trade products occupy a specialized market niche that educated consumers are often willing to pay a premium price for.

Rhodiola root has an established niche in the natural products channel, with a bottle of 30 capsules retailing for approximately $15-45, depending upon the potency, brand, and retail outlet. The types of products that may be created from rhodiola include herbal teas, liquid extracts, and capsules, and these products could be manufactured in Nunatsiavut as well as in conjunction with contract manufacturers.

As rhodiola leaves are used traditionally by Inuit, the NG might wish to develop this use as a unique product in the market. The leaves of the rhodiola plant are not common in commercial trade, since they do not have all the same medicinal compounds that the roots are known for (i.e. rosavins), although they do contain salidroside, a bioactive compound found in the root as well as several other medicinal plant species. Since the leaves would otherwise be a byproduct of the

root harvest, it would not require significant additional processing time or special equipment to harvest and dry the leaves for use in teas, etc. However, commercialization of the leaves may require separate NHP (Natural Health Product; *note that underlined phrases throughout this document are hyperlinked for more information*) approval with Health Canada (demonstration of use, and possibly a separate NPN / Natural Product Number), because the existing Health Canada monograph discusses only the root and rhizome (see Appendix 1). Topical applications made from the leaves, such as creams or salves, would be significantly more complicated than teas to produce, both in terms of equipment and product stability.

The type(s) of product selected for this enterprise will depend upon the desired market/target consumers, as well as the amount of post-harvest processing deemed both culturally appropriate and economical from a cost-benefit standpoint. Four options are presented for comparison:

1) *Raw material sold in bulk or supplied to contract manufacturer*

This is the simplest option from a production standpoint. This would require that the rhodiola cultivated in Nunatsiavut be minimally processed onsite post-harvest. Mature roots would require washing, course chopping, and drying. These raw materials are then transferred to a contract manufacturer for further processing (i.e. liquid or supercritical extraction or powdering and encapsulation) or sold in bulk to a growers cooperative (for example Frontier Co-op) for distribution through established channels. Wholesale distribution has the advantage of minimizing marketing expenditures as well as production costs, but may result in lower profits than sale of value-added products. Raw materials are typically accompanied by a technical dossier which consists of a certificate of analysis and raw material specifications. Health Canada has published the Quality of Natural Health Products Guide to offer guidance on production of natural health products (see Appendix 2).

2) *Tea blend*

This option is also fairly simple from a production standpoint, requiring similar post-harvest processing (washing, chopping, drying) followed by sifting and possibly blending with other local ingredients (i.e. Labrador tea, dried berries, etc.), before being packaged as a loose tea or bagged tea. A tea blend has several advantages. It requires little in the way of equipment, and at the same time adds value to the raw material. From a marketing standpoint, this type of product is familiar to the consumer (i.e., Algonquin Tea or Northern Delights tea). A box or tin of local medicinal tea might be an appealing product for visitors to purchase at the

craft stores, for their own use as well as for gifts. The disadvantage might be a somewhat limited shelf life, depending on packaging.

3) *Liquid extract*

Also known as tinctures (alcohol-based extracts) or glycerites (alcohol-free extracts), liquid extracts are an efficient means of capturing and delivering the active constituents of medicinal plants. This process would require the cut and dried rhodiola root to be macerated or extracted in either an alcohol (ethanol) or glycerine solvent for a period of approximately one month. Alcohol-based extracts are high potency and have the additional advantage of having a fairly long shelf life. Glycerites are advantageous for avoiding the use of alcohol but are slightly lower potency and have a significantly shorter shelf-life due to the risk of mould contamination.

Many liquid extracts are delivered to the consumer via a dropper bottle. While being a fast-acting means of taking herbal medicines, this has the disadvantage of being a slightly less familiar mode of administration to the mainstream consumer, and would be targeted to a more sophisticated user of nutraceuticals. Liquid extracts may also be encapsulated but this does add a significant processing step. Spray administrations are trending as a novel means of administering liquid extracts (i.e., Urban Moonshine Energy Tonic). "Power shots" are also trending in the natural products industry; single serving energy boost drinks that often combine herbal extracts with other vitamins, etc. (i.e., Gaia Herbal Energy Plus Stress Response).

4) *Capsules*

Capsules have the advantage from a marketing standpoint of being a more familiar, mainstream mode of supplementation than tinctures or teas. However from a manufacturing standpoint, they require more equipment and handling than liquid extracts or teas. The manufacture of capsules could be done using contract manufacturers, by supplying them with bulk cut and dried plant material. This material is then powdered and sifted under humidity controlled conditions before being encapsulated using automated equipment. Excipients or additives (i.e., rice bran, maltodextrin) may be added as needed to the powdered rhodiola root for ease of production and product consistency and stability. Alternately, contract manufacturers may use extraction processes (hydroethanolic or supercritical) prior to encapsulation for a higher potency product. Encapsulation can also be done by hand with a small device that aligns empty capsules for manual filling and capping of 24-50 capsules per operator (takes about 2 minutes).

Summary of product options

The following table outlines the inputs required for the product options discussed above:

Product type or output	Materials needed	Equipment needed	Processing required and estimated labor time	Facilities	Costs	Distribution and pricing
Raw material	• Rhodiola, cut, dried, and sifted	• Washing equipment • Driers, either commercial or homemade • Sifters • Scales	Roots must be dug, coarsely chopped, washed, further chopped, and dried. Raw material is then packaged in bulk for transfer to contract manufacturer or distributer.	• Counter space for chopping roots • Adequate space and conditions for drying	Root crop washer: $2,550-2,950 Grindstone Farm barrel washer Commercial dryer: $15,000 (used)-30,000 (new) and/or Locally constructed dryer: $500-5,000	16 oz (454 g) of powdered, conventional rhodiola retails for approximately $25; fair trade material could retail higher.
Tea/ Blend	• Rhodiola, cut, dried, and sifted • Option to blend other dried herbs and berries (lab tea, etc.) • Cellulose bags • Tins or boxes	• Washing equipment • Driers, either commercial or homemade • Sifters • Scales • Scoops/funnels	Roots must be dug, coarsely chopped, washed, further chopped, dried, and sifted. This then may be blended with other locally sourced flavor ingredients before being packaged loose for retail sale or measured into cellulose individual serving bags and packed for retail sale.	• Counter space for chopping roots and blending • Adequate space and conditions for drying	Root washer and dryer (see above)	Retail approx. $7-8.95/20 tea bags (Following pricing of Algonquin and Inuit teas)
Liquid Extract	• Rhodiola, chopped and dried (can be fresh if ethanol is	• Washing equipment • Driers, either commercial or homemade	Roots must be dug, coarsely chopped, washed, further chopped, and most likely dried. This material is then macerated or	• Counter space for chopping roots and blending	• Root washer and dryer (see above) • Tincture press, 1/2 gallon	Retail approx. $12/fl oz (30 mL) or greater

	used as solvent) • Solvent (glycerine and/or ethanol) • Glass dropper bottles or glass spray bottles	• Food-grade carboys for maceration • Tincture press • Funnels	steeped in solvent for 2-4 weeks before being strained, pressed, bottled, sealed, and labelled.	• Adequate space for drying • Secure space for extraction	stainless steel: 780 USD Horizon Herbs Tincture Press	
Capsules	• Rhodiola, cut, dried, ground • Empty two-piece capsules, either HPMC (VegiCaps) or gelatin • Excipients (additives, as needed) • Bottles	• Washing equipment • Driers, either commercial or homemade • Commercial grinder • Manual or mechanized encapsulation equipment • Funnels / bottling equipment	Roots must be dug, coarsely chopped, washed, further chopped, and dried. Dry material is then ground to standard particle size and encapsulated in two-piece capsules either manually or mechanically. Capsules are then counted, bottled, labelled, and sealed.	• Counterspace for chopping roots • Adequate space for drying • Space to house grinder	• Root washer and dryer (see above) • Grinding mill • Encapsulation equipment: Approx. $20/device (manual) Or mechanized $10,000-175,000 (used) http://www.equipnet.com/	Retail approx. $15-45 for 30 capsules, depending on potency and market segment

Target Consumers

Numerous studies in the US and in Canada have shown that the predominant consumers of natural health products including herbal supplements are white, middle-aged and elderly women, with a higher level of education, living in a food-secure household.[3-8] Survey data of nearly 12,000 participants collected over 20 years showed that the most commonly reported reasons for using supplements were to improve (45%) or maintain (33%) overall health.[9]

There are distinct regulatory frameworks that apply to natural health products in Canada, the US, and the EU, so marketing products in each of these regions would require different packaging specific to the marketplace. Regulatory consultants

could be contracted for guidance in this area, depending on the NG's preferred scale of marketing. Potential target consumers include:

- Tourists visiting local Nunatsiavut craft shops (for retail sale of finished product)
- Retailers of natural health supplements (for wholesale of finished product)
- Supplement manufacturers and grower's co-operatives (for wholesale of bulk material)

Operations

Nunatsiavut Roseroot operations will consist of horticultural, processing, and manufacturing components. Operations may be centralized or decentralized such that components of the enterprise occur in different communities as a joint venture (i.e. one community might specialize in agricultural production and another in post-harvest processing). The infrastructure costs of multiple sites including ease of access and transportation to and from each possible site will need to be considered.

Horticultural

Rhodiola is a multi-year crop, requiring approximately 3-5 years from transplant to harvest, depending on the methods of propagation used in planting.[10] Horticultural trials have already begun in both Nain and Rigolet to determine appropriate cultivars, suitable soil types, locations, and propagation techniques for rhodiola in Labrador (Mardones, PhD research, unpublished data). Expansion of existing plots and/or establishment of new gardens located within or outside participating communities will be necessary to ensure sufficient sustainably sourced plant material for manufacturing. Soil testing of selected sites should be conducted to ensure there is no trace of unwanted chemical residue before final site selection.

Good Agricultural Collection Practices (GACP; Appendix 3) should inform the horticultural operations. Plant stock which has been selected for desired growth and potency attributes should be generated in a nursery prior to transplantation to the field. Stock may be generated from seed or from sustainably selected rootstock divisions.[11] This stock will require a minimum of one to two years to establish prior to transplanting.[12]

Transplanting would best occur in early springtime, once the ground begins to thaw. During the first season while becoming established, the plants will require regular

monitoring (every week or so) and may require intermittent watering depending on environmental conditions (during hot or dry weather). Some re-planting may be necessary in the fall or the next spring if a few individuals have died. During subsequent growing seasons, the crop would require occasional monitoring (every other week or so) to ensure there has not been vandalism due to animals, etc. Watering may be necessary again during hot or dry weather.

Harvest may occur as early as fall of the third growing year.[10] Harvesting can be done manually with forks and spades, or with the assistance of mechanized equipment to loosen the soil around the roots to facilitate lifting. The plants will be dug up and manually processed to separate the below ground portion from the tops. The roots will be washed either manually or using a commercial root washer, then coarsely chopped and spread out to dry using commercial grade driers. If desired, the leaves may also be dried separately for further use. Subsequent processing will depend upon the target product selected.

Several local technicians will be trained by specialists from either MUN or Montreal Botanical Garden, and employed to propagate, transplant, monitor, and maintain the crops (2-4 employees per community, depending on the scale of operations decided upon). The initial workload (springtime propagation and transplanting) will be greatest, while monitoring and maintaining the crop will require fewer labour hours. Once the crop reaches maturity, labour hours will again increase as the plants will need to be carefully dug up and lifted for further processing.

Processing

Post-harvest processing will ideally occur the day of harvest to ensure product quality, minimizing the degradation of active constituents or any microbial contamination. Depending again upon the scale of operations (and whether leaves will be processed) decided upon by the NG, processing will require 2-4 technicians for seasonal employment. The plants will be cleaned, cut, and set out to dry in driers which meet commercial specifications. Drying will take approximately 36-48 hours depending on the specifications of the driers, and will require occasional monitoring to ensure even distribution of material and safe operations of equipment. Once drying is complete, product storage prior to distribution should be in a humidity-controlled environment to maintain product purity and potency.

Manufacturing

Depending on the product option(s) selected, further processing may occur onsite (tea blends, liquid extraction, encapsulation) or in collaboration with contract manufacturers. Current good manufacturing practice (CGMP; see Appendix 4)

protocols must be adhered to for product specifications, ID testing, etc. Bottling, packaging, and labelling may be done manually or mechanically. Design of packaging might engage the art skills of community members, possibly in consultation with a graphic designer. Any copy or taglines written on packaging will need to be evaluated for regulatory compliance by a specialist familiar with applicable regulations in the target market (i.e., Nutrasource diagnostics, Inc. described below).

Market Analysis and Plan

The Natural Products Industry

Market data

Herb supplement sales increased 5.5% in 2012, a trend of continuous growth that has been consistent for nine consecutive years.[1] The total trade in herbal supplements for 2012 was 5,593 million USD according to aggregated market statistics calculated by Nutrition Business Journal.[1] Sales of specific adaptogenic herbs, such as maca root (*Lepidium meyenii*) increased nearly 23% in the US mass market channel. In the US natural and health food channel maca sales increased a staggering 40% in 2012.[1] While statistics for the sales of rhodiola are not available at this time, the impressive growth in sales shown by a comparable adaptogenic root gives some indication of the growth potential for this type of herbal supplement. Further, maca is native to and primarily cultivated in South America, while rhodiola can be locally sourced in North America, thereby shortening the supply chain and increasing the potential for profitable sales. According to the American Botanical Council, much of the growth in the supplements industry is driven by the consumer who seeks supplements for energy, stress reduction, and reproductive conditions — all of which are evidence-based applications for rhodiola.[13]

Outlook and trends

Because the natural supplements industry has seen consistently robust growth in recent decades, even despite general economic downturns, this would seem to indicate that the prospective market for a sustainably grown and potency assured medicinal plant product such as Nunatsiavut Roseroot will also show steady growth. The thriving market for natural ingredients becomes evident at events such as the recent 2014 Natural Products Expo West, a forum which brings together global ingredient suppliers and buyers, where attendance grew 5% in the last year for a

total of 67,000 attendees.[14] Market insights shared by industry intelligence agency Penton predict an annual growth rate of 8.6 percent in the natural channel, for a projected revenue of $226 billion by 2018.[14] Advanced market analysis is offered as well by businesses such as SPINS or the Nutrition Business Journal, which deliver consumer insights (for a fee; NBJ reports range 3,295-3,595 USD), syndicated reports, as well as custom marketing consultancy, and also maintains a comprehensive product library.

The popularity of literature such as the Rhodiola Revolution[15] and Adaptogens: Herbs for Strength, Stamina, and Stress Relief[16] indicates relevant consumer interest in mass markets for adaptogens in general and specifically for rhodiola. Rhodiola may be used to alleviate fatigue or depression, to improve concentration, physical performance, and emotional balance, with little to no incidence of adverse effects.[2] Numerous pre-clinical and clinical trials published in peer-reviewed journals[13] support the use of rhodiola for many of these popular uses, validating these applications and indicating that rhodiola's popular use is not merely a passing fad but has valid evidence-based application that will continue to develop as further scientific research on its benefits reaches consumer awareness.

Competitive edge and profitability

Buzzwords in the Natural Channel (the commonly used name for the natural health products industry) include phrases like "fair trade", and "sustainably harvested".[17] Nunatsiavut Roseroot would "hit" on several of these targets. While there are a number of other companies selling rhodiola products in capsule or liquid extract form, they are primarily sourcing their raw materials from Eurasia, and they are often wild-harvested. Rhodiola products derived solely from cultivated North American rhodiola are not widely available. Nor is there any other rhodiola product in the market which is cultivated and processed by way of an Aboriginal community enterprise, so Nunatsiavut Roseroot would be unique to the market in several ways.

Market Strategies

Industry trade shows such as the aforementioned Natural Products Expo West are a key forum for vendors of raw materials and value-added natural products to connect with buyers and other service providers (contract manufacturers, analytical labs, consultants, etc.). Other key international trade shows include Supplyside West and Vitafoods. In Canada, the Canadian Health Food Association (CHFA) hosts CHFA East, West, and Quebec. Exhibition registration is typically charged by the

square foot. For more details on these tradeshows including dates and websites, see Appendix 5.

Online and digital resources for cultivating market potential are increasingly valuable. Not only for industry insight, as with SPINS or Penton, but also to increase online presence and reach a larger market. For example, Nutra ingredients is a go-to online trade publication which reaches a wide segment of the natural channel, and also maintains an online database of ingredient suppliers, searchable by formulators and manufacturers within the industry. A simple LinkedIn company profile page can be an inexpensive and effective means of promoting the product and building a business network.

Small business accelerators can offer useful resources in business development, for a fee. The newly established Next Accelerator builds upon the established industry insights accrued by its parent company New Hope Media to offer resources for natural products entrepreneurs to grow their businesses. Similarly, Nutrasource diagnostics, Inc. offers comprehensive consultancy including contract research, product testing, and regulatory consulting, for the purpose of increasing the success of natural health companies bringing products from concept to market launch.

Competitive Analysis

Competitors selling rhodiola-based products vary based upon the form of product sold and the location it is sold at. Health food stores are more likely to sell liquid extracts in addition to capsules. Mass market outlets such as grocery stores that do carry rhodiola products tend only to sell capsules, which is the most commonly sold form of rhodiola product. Rhodiola-based teas are the least common form of rhodiola seen in any retail outlet.

Example companies

The following companies sell one or more rhodiola-based products, and could be viewed either as competitors providing finished products, or potential clients for raw materials, depending on the chosen market strategy for Nunatsiavut Roseroot.

Natural Factors, based in Coquitlam, British Columbia, with Eastern offices in Mississauga, Ontario and US Sales & Distribution Center in Everett, Washington. Sells a 30 capsule bottle of 150 mg *Rhodiola rosea* extract, standardized to 3.5% rosavin. Package claims "*Support for stress and the nervous system*." Sold at mass market and natural channel outlets in the US and Canada for a retail value of approximately $15.95.

Alberta Rhodiola Rosea Growers Organization (ARRGO), based in Alberta, Canada is a cooperative of Alberta farmers specializing in the cultivation of *Rhodiola rosea*. ARRGO provides lifecycle support to member farmers from cultivation, production, quality assurance, and sale of raw materials and herbal products based on rhodiola. It was estimated in 2010 that at least 75 acres (30 ha) of rhodiola in various stages of growth were in production in Alberta.[12]

New Chapter, based in Brattleboro, Vermont, USA. Sells 30 capsule bottles of *Rhodiola rosea* hydroethanolic extract, both a 100 mg (= 880 mg root; min. 5 mg total rosavins and min. 1.8 mg salidrosides) and a 300 mg (= 2,550 mg root; min. 15 mg total rosavins and min. 5.4 mg salidrosides). Package claims "*Promotes overall mental health and stamina*." New Chapter also sells several combination formulas which contain rhodiola (Stress Take Care, Perfect Energy, and Supercritical Diet & Energy). Sold at mass market and natural channel outlets in the US and Canada for a retail value of approximately $18.95(100mg) or $37.95 (300mg).

Herb Pharm, based in Williams, Oregon, USA. Sells hydroethanolic and glycerite liquid extracts of organic *Rhodiola rosea* in 1 ounce (retail approx.$12.50) and 4 ounce (retail approx. $47.50) dropper bottles as well as a 60 capsule bottle (retail approx.$17.00) containing 340 mg of extract per capsule (= 2,720 mg whole root). Package claims read "*Promotes Energy, Endurance & Stamina*." Herb Pharm also sells a liquid combination formula containing rhodiola called Stress Manager / Adaptogen Compound. Sells primarily in the Natural Channel (i.e., health food stores) but recently expanded into mass market outlets.

Urban Moonshine, based in Burlington Vermont, USA. Sells a hydroethanolic liquid extract of organic *Rhodiola rosea* in a 2 ounce dropper bottle (retail approx. $23.99). Also sells a rhodiola-based combination formula called Organic Energy Tonic in both a 2 ounce dropper (retail approx. $15.50) as well as the more novel (and faster acting) 15 mL spray bottle (retail approx. $7.99). Packaging states, "*Outdo Fatigue*Promote Vitality*Athlete Approved*." Sells primarily in the Natural Channel (i.e. health food stores).

Company strategies/assets

The following companies utilize unique market strategies which could be applicable in the development of Nunatsiavut Roseroot.

Urban Moonshine: "Our mission is to rekindle the relationship between herbal medicine and the modern world."

"*Handcrafted*": Urban Moonshine emphasizes the smaller scale of their production in packaging and promotional material, an advantage which Nunatsiavut Roseroot might also share, in contrast to the industrial scale of other competitors selling rhodiola products. Urban Moonshine also has capitalized on a fairly uncommon mode of administration, the 15 mL spray bottle which has the advantage of being smaller than dropper bottles and so lends itself to point-of-purchase or impulse buys. This format is also arguably faster acting than capsule formulas or even other liquid extracts, due to the direct delivery via oral mucosa. Additionally this size packaging lends itself to convenience for the consumer; easy to carry along in purse or pocket for dosing as needed.

Clef des Champs is an organic herb and spice company based in Quebec. Marketing products which are both medicinal and culinary, Clef des Champs models a business based upon sustainable organic cultivation, striving to be carbon neutral, while also giving back to the community in the form of ecological initiatives. Clef de Champs manufactures liquid extracts from 200 different plant species, all of which are cultivated in their own gardens in the Laurentian Mountains of Quebec. They also offer capsules, loose teas, and culinary herbs and spices. Plants which are sourced from producers outside of North America are in many cases fair trade certified. They do not sell any products containing rhodiola.

Alaffia is a successful mission-driven enterprise that sells quality assured products in the natural channel. Based in Olympia, Washington, USA, in cooperation with communities in Togo, Africa, Alaffia was founded to alleviate poverty and advance gender equality in West Africa through the sustainable fair trade of handcrafted shea butter. Their products are intended to inform the public about interconnections between communities and how poverty can be ameliorated through fair trade and sustainable choices. Their cooperative business model and community projects encourage self-empowerment and gender equality for women in West African communities. Projects include Bicycles for Education, Maternal Health, School Supplies & Repairs, and Reforestation & Environment.

While not involved in the trade of rhodiola, Alaffia is an example of a successful sustainable fair trade enterprise which brings benefits to the communities involved. Alaffia products are certified FairTrade by the Institute for Market Ecology (IMO). Founder of IMO, Dr. Rainer Bächi, states "We build bridges between regional suppliers and discerning consumers across many languages, cultures and expectations." Informed consumers often will choose a fair trade product when it is a viable option, knowing that they are supporting empowerment and community development through their purchase. "The major aim is not just the product and its quality alone but above all the people involved in the projects. It is important to

support their work by respect and cultural understanding. Together, we are creating perspectives for a sustainable future."

Fair trade certification is available by applying to IMO or to the Fair for Life Social & Fair Trade Certification Programme, a certification scheme that IMO utilizes for evaluating social and fair trade activities. The cost of certification will depend on the size and complexity of an operation, its location, and the scope of certifications applied for, so an exact figure cannot yet be predicted for the present enterprise. However, a sample breakdown of cost estimation for an operation in Canada is included in Appendix 6; total cost was approximately 3,400 USD (approx. 3,750 CAD).

Strategy and Implementation

Design and Development

The major milestones in designing the organizational and operational structure of Nunatsiavut Roseroot from concept to market are as follows.

1. Define mission, scope of operation, and budget
2. Establish organizational management structure
3. Select target products based on NG goals
4. Initiate horticultural operations (likely rotational cropping)with adherence to Good Agricultural Collection Practices (GACP; Appendix 3)
5. Develop the market; design packaging, select contract manufacturer, develop distribution channels
6. Harvest
7. Process
8. Manufacture with adherence to Current Good Manufacturing Practices (CGMPs; Appendix 4)
9. Package (ensuring regulatory compliance)
10. Distribute

Financial Factors and Projections

Initial capital investment will be minimal, early expenses consisting mainly of the training and wages for technicians involved in horticultural operations, which may be subsidized by available federal jobs programs. Other costs associated with crop production will include the costs of seeds or seedlings, soil preparation, transplanting, weeding, fertilizer, harvesting, and root washing.[12] The land upon which the crops will be situated will likely be provided by the NG, and so will not require leasing or purchase. Equipment and soil amendments required for planting will be minimal. As further processing won't be necessary for several years, these are the only initial expenditures. It is estimated that yields per acre should be at least 2,300 lb (2,577 kg/ha) to be profitable.[12] In central Alberta, yields of approximately 5,220 lb per acre (5,850 kg/ha) have been realized in five-year-old plants.[12] For a detailed projection of agricultural production costs per acre, see Appendix 7.

Once the crop nears maturity, the procurement of drying equipment and space will be necessary, and mechanical harvesting equipment may also be desired, requiring lease or purchase. Most likely the facilities for housing the driers and processing will be provided by the NG, and so will not contribute significant overhead costs. Wages and material costs (solvents for extraction, etc.) will also factor in post-harvest processing expenditures. If utilized, contract manufacturing may be the most significant expenditure at this point.

Marketing and distribution will likely be minimal if the target consumer segment is local or regional, with products to be sold in Nunatsiavut craft shops. Marketing and distribution, as well as regulatory consultations, could incur significant costs if a wider market is sought.

Funding programs offering targeted wage subsidies are available that might assist with employment costs, for example the NG's Aboriginal Skills and Employment Training Strategy (ASETS), the Labrador Aboriginal Training Partnership, or the NL Job Creation Partnerships program. The National Research Council's Natural Health Products Program and the Research and Development Corporation of Newfoundland and Labrador have funding such as R&D Vouchers or R&D Proof of Concept that could help defray research and development costs including those associated with regulatory compliance (i.e. animal testing or lab work). An NSERC Engage grant could be applicable in developing a new research and development partnership between Nunatsiavut Roseroot and an academic researcher.

This preliminary opportunity analysis highlights a variety of options, and it is anticipated that a more detailed analysis of start-up costs and projected revenue will be undertaken if the NG decides to move ahead with this project, depending upon the scale of operations, type of products, organizational structure, and the target market that the Nunatsiavut Roseroot steering committee decides upon.

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(Note that full-text references can be provided upon request)

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Additional resources:

(Note that the full-text for these resources was included as appendices in the Opportunity Analysis distributed to Nunatsiavut community leaders, but it represents many additional pages, so only the most current hyperlinks are included here.)

1. Health Canada *Rhodiola rosea* monograph (note that monograph has been updated since this was distributed)
2. Quality of Natural Health Products Guide
3. Good Collection and Agricultural Practices (GCAP)
4. Current Good Manufacturing Practices (CGMP)
5. Industry Trade Shows

Trade Show	Location	Website
Natural Products Expo West (larger)	Anaheim, California, USA	http://www.expowest.com/ew14/public/enter.aspx
Natural Products Expo East (smaller)	Baltimore, Maryland, USA	http://www.expoeast.com/expoeast2014/public/enter.aspx
Supplyside West	Las Vegas, Nevada, USA	http://west.supplysideshow.com/
Vitafoods	Geneva, Switzerland	http://www.vitafoods.eu.com/

CHFA West	Vancouver, BC	https://www.chfa.ca/tradeshows/expo-west-2014/
CHFA East	Toronto, ON	https://www.chfa.ca/tradeshows/chfa-east/
CHFA Quebec	Montreal, QC	https://www.chfa.ca/tradeshows/chfa-quebec/

6. Fair Trade certification costs

7. Estimated production costs for *Rhodiola rosea* per acre

Estimated production costs for Rhodiola rosea per acre (20,000 plants) *

VARIABLE COSTS	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Seed	$230.00	0	0	0	0
Media (Promix)	$300.00	0	0	0	0
Fertilizer	$200	$200	$200	$200	$200
Trays	$782.00	0	0	0	0
Fuel, Utilities	$200	$200	$200	$200	$200
Labor planting	$1,200	0	0	0	0
Labor weeding	$3,200	$3,200	$3,200	$3,200	$1,200
Harvesting Costs (remove plastic, dig roots)	0	0	0	0	$1,880
Washing Costs	0	0	0	0	$3,100
Slicing Costs	0	0	0	0	$1,780
Drying	0	0	0	0	$880
Bag/store/marketing	0	0	0	0	$200
FIXED COSTS					
Machinery (Seedling Planter, Mulch Layer, Harvester , sprayer , Tractor, Cultivator/Rototiller or other ground preparation equipment	$866	$866	$866	$866	$866
Production Costs	$6,978	$4,466	$4,466	$4,466	$10,306

Cumulative Production Costs	**$6,978**	**$11,444**	**$15,910**	**$20,376**	**$30,682**

Sensitivity Analysis for return on investment considering various sale prices and yield *

	Price per kg dry root of Rhodiola rosea				
Yield of Rhodiola rosea/acre (kg dry root weight)	$30/kg roots	$35/kg roots	$42 per kg roots	$50 per kg root	$60 per kg root
1,333	$9,308	$15,973	$25,304	$35,968	$30,682
1,600	$17,318	$25,318	$36,518	$49,318	$65,318
2,000	$29,318	$39,318	$53,318	$69,000	$89,318
2,500	$44,318	$56,818	$74,318	$94,318	$119,318

***Provided courtesy of Dr. Kwesi Ampong-Nyarko, Government of Alberta Agriculture and Rural Development.**