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CANADA: SEA BUCKTHORN

Sea buckthorn berry production, largely unharvested, is estimated at more than 1.6 million kilograms (Mkg) from shelterbelt plantings and 200 hectares (ha) of orchard plantation across Canada and may provide an opportunity to further diversify Canadian agriculture. The berries, considered amongst the most nutritious and vitamin-rich fruits found, have very good potential as a leading candidate to create a value added industry with many agri-food products. Sea buckthorn's ideal suitability to climatic conditions across most of Canada and its low to zero nutrient and pesticide requirement also make it a good candidate to contribute to improved environmental farming practice under Agriculture and Agri-Food Canada's (AAFC) Agriculture Policy Framework (APF). This *Bi-weekly Bulletin* provides a summary of sea buckthorn research undertaken by the food research program within AAFC.

Background

Sea buckthorn (*Hippophae rhamnoides L.*), a plant native to Europe and Asia, is currently being domesticated in Canada. Sea buckthorn has been known and used by Eurasians for centuries. It was first mentioned in the ancient Greek writings where horses fed with the leaves and young branches of the sea buckthorn plant experienced increased weight gain and developed a shiny coat. This provided the basis for the Latin name, 'Hippo' - horse and 'phaos' - to shine. The medicinal value of sea buckthorn was also recorded in Tibetan medical records in the eighth century.

In Russia, the sea buckthorn industry has been thriving since the 1940s, when scientists began to investigate the active properties found in the fruit and leaves. In China, research and plantation establishments were initiated in the 1980s and since 1982 over 300,000 ha of sea buckthorn have been planted. This has created 150 processing factories, producing over 200 products.

Plant and Environment

Of the five species of sea buckthorn, only one, *Hippophae rhamnoides*, has an extremely wide distribution stretching from China westward to Britain and north to Finland. This variety is further divided into eight subspecies. It grows on hills, valleys, riverbeds, and along seacoasts and islands. Sea buckthorn usually forms a shrub or tree varying from less than 50 centimetres to more than 20 metres (m) in height.

Sea buckthorn can grow in arid conditions and tolerates cold winters. It is considered drought resistant, however it is not recommended to be grown on regions that receive less than 400 millimetres of rain as fruit production will be significantly reduced. It prefers sandy and neutral soils but is most productive in soils with pH values from 5-9. It can tolerate sea water flooding and will survive in soils that have developed salinity problems. Its extensive root system and the plant's ability to multiply by suckering, make sea buckthorn an ideal plant for soil conservation and riverbank erosion control.

Sea buckthorn is a dioecious species with male and female flowers on separate trees, therefore it is essential that both male and female plants are in proximity to ensure fruit production. The flowers do not produce nectar which eliminates pollination by insects. One male plant can pollinate six or more females through the movement of air, aided by wind. Sex of the plant can only be determined after the seedlings reach four years old. Vegetative propagation of male and female plants from suckers, softwood, hardwood or roots is the only way to pre-determine sex.

Rows of sea buckthorn are planted perpendicular to prevailing winds to

ensure good pollination. Spacing between rows is about 4 m and spacing of plants within a row ranges between 1.0-1.5 m depending on the variety and growth pattern. It is recommended that male trees be mixed into every second or third row of female trees in a systematic pattern to yield a ratio of between 1:6 and 1:12 males to females.

Beyond fertilization during initial planting, sea buckthorn rarely requires fertilization as it is able to fix atmospheric nitrogen and conserve other essential nutrients. Pruning of the female plants is recommended for ease of picking and to provide sunlight to the berries on lower limbs. Weeds can be controlled by the use of plastic mulch, glyphosate or tilling but are not considered a serious threat to established plants. Sea buckthorn can experience disease problems such as verticillium wilt on the plant, but infestations are not a concern. Integrated pest management practices are not needed, but pests specific for infestations such as the sea buckthorn fly are sometimes used. Severe infestations are unlikely and therefore spraying for flies is rarely needed.

Sea buckthorn berries range from yellow, orange, to red in colour and come in many types of shapes and sizes. Berries can weigh between 4-60 grams (g) per 100 berries. Normally sea buckthorn has thorns surrounding the berries which also vary in density, shape, size and sharpness. In Russia, Germany and Mongolia, thornless or near thornless cultivars have been bred.

Current Environment

Sea buckthorn was originally imported into Canada from Russia as early as 1938, primarily as an ornamental plant. It was later widely used in farmstead shelterbelts, in land reclamation, wildlife protection and improvement and to control soil erosion. The plant's hardiness, low to zero nutrient and pesticide requirement, adaptability to the extreme prairie climate and its ability to promote growth of pine trees and poplars make it one of the best suited plants for conservation purposes. From an environmental perspective, sea buckthorn production fits well into Agriculture Canada's Agriculture Policy Framework goal of improved environmental responsibility. Since 1982, it is estimated that more than one million seedlings have been distributed for use in prairie conservation programs.

The largest concentration of sea buckthorn plants is the result of a habitat improvement initiative at the Rafferty wildlife mitigation project, located near Estevan, Saskatchewan. Since 1989, over 50,000 sea buckthorn shrubs have been planted. The population is estimated to have grown significantly since then through colonization by suckering.

Farmstead shelterbelts are used in the Prairies as a shelter against winds and can lower energy costs, reduce noise and filter pollutants. In 1995, 59,000 sea buckthorn plants, equalling 70 kilometres of trees, were planted on farms for shelterbelt purposes and an additional 78,000 plants were planted in fields to prevent soil erosion and improve soil quality.

More recently, in Saskatchewan and British Columbia, seeding of sea buckthorn orchards has taken place in anticipation of consumer demand and commercial processing.

Sea buckthorn associations , such as the British Columbia Sea Buckthorn Growers Association are sources of additional information.

Nutritional Values

The relatively recent interest in sea buckthorn production is due to the fact that the berries are among the most nutritious and vitamin-rich fruits found. The berry can contain up to ten different vitamins as well as trace elements, fruit acid, sugar and oil. Sea buckthorn is rich in proteins, and contains up to 18 amino acids. There are over 24 chemical elements present in the juice, including calcium, iron, and manganese.

Vitamin C concentrations in the berry pulp vary from 100 milligrams (mg)/100 g of berries, to 2500 mg/100 g of berries for the Chinese subspecies sinensis. Comparatively, orange juice contains about 35-40 mg/100 g of fruit. The carotene content ranges from 30 to 40 mg/100 g of berries and the carotenoid levels range from 9 to 35 mg/100 g of berries. Sea buckthorn is also high in flavonoids, in the range of 120-2100 mg/100 g of berries, and contains significant levels of water soluble vitamins.

Oil from the pulp is highly unsaturated having 62-63% of its fatty acid composition represented by palmitaleic, oleic, and lineolic acids. Pulp oil contains vitamin E concentrations which can be up to 160 mg/100 g of berries.

Sea buckthorn seed oil is very high in unsaturated fat. Up to 73% of the seed oil is comprised of linoleic or linolenic acids and up to an additional 19% is oleic acid. The vitamin E content of the seed oil ranges between 61-113 mg/100 g of seed and contains significant levels of carotenoids.

Yellow pigment, a byproduct from the sea buckthorn berries can be extracted from the residue once the juice has been removed. The pigment, water absorbent, can be extracted and concentrated by spray-drying to yield a yellow powder. The powder contains mainly flavones and lower levels of carotene and vitamin E. This product can be used as a natural food colouring material and/or as a supplement to boost nutritional values.

Medicinal and Cosmetic Values

Concentrations of a rare fatty acid (palmitoleic) and carotenoid levels found in sea buckthorn oils are claimed to promote healing of skin burns and the relief of other skin ailments such as eczema and dermatitis. The most significant potential healthful benefit is the high content of the tocopherol (vitamin E) component within the seed oil. Tocopherol is recognized as the natural antioxidant in the human body. It is believed that high levels of tocopherol minimize skin oxidation, which helps to maintain skin integrity and reduce skin toughening and wrinkling.

Sea-buckthorn oils are also believed to have a biological protective capacity. The tocopherols and carotenoids can trap and reduce the formation of UV-B induced toxic products in skin cells. Due to these UV-B absorptive properties, sea buckthorn oils may be used by industry as a natural sun screen.

Research has indicated that extracts isolated from the bark of sea buckthorn may inhibit tumour growth and there are reports that it has successfully treated gingivitis.

The leaves of the sea buckthorn plant also contain many nutrients and bioactive substances. Leaves harvested from the male plant can be used to produce tea, tea extracts, tea powder and animal feed.

Production and Harvesting Costs

Production of fruit can vary considerably. A natural sea buckthorn habitat can yield from 750 to 1,500 kilograms per hectare (kg/ha) of berries, shelterbelt plantings 4-5 tonnes/hectare (t/ha) and orchards up to 12 t/ha.

Currently there are few sea buckthorn orchards in Canada. Until such time that orchards can be established, all potential supplies will need to be harvested from plantations which were originally seeded for farmstead protection, erosion control and wildlife habitat.

The cost of production on these plantations with average yields of about 6 kg per plant, using hand harvesting and without irrigation costs is estimated to be $2.30/kg after the seventh year when fruit production has stabilized. The majority of the cost of production for sea buckthorn is the hand harvesting component which is estimated to be about $1.65/kg. This could be significantly lowered if orchards with thornless high yielding varieties were established. Savings would be realized by more fruit producing female plants per acre (/ac), higher yields per plant, increased harvesting rates per hour as a result of thornless varieties, and by reducing the added costs that are involved with coordinating harvest for plantations that are widely dispersed.

Hormonal treatment which decreases the force required to detach berries from the branches and mechanical harvesters are currently being studied and developed as additional ways to lower harvesting costs. Both are looking promising as additional methods which may help to make sea buckthorn production more economically feasible. In a Canadian sea buckthorn technology mission to Germany, the use of a mechanical shaker to separate the berries from cut branches was observed. A nine worker harvesting team was reported to be able to harvest about 3,240 kg of berries per day (kg/day). This equates to about 360 kg/day per worker. Comparatively, hand harvesting of plantation berries is estimated to collect roughly 10 kg/day per worker, while with higher yielding thornless varieties a worker can harvest about 50 kg/day. It should be noted that cutting the branches as a method of berry picking, limits harvesting to every second year.

Because sea buckthorn products have not been on the market sufficiently long, it is difficult to determine the market price of fresh picked berries. Market price estimates range from $3 to $10/kg of berries depending upon supply and demand factors. Assuming a conservative market price of $3/kg, with yield at 5,000 kg/ha and a production cost of $2.30/kg, a plantation would be able to net approximately $3,500/ha [(5,000 x $3.00) - (5,000 x $2.30)], excluding transportation costs. Therefore, assuming the market determines a price of $3.00/kg, it would appear that the production of sea buckthorn could be highly profitable for growers.

Economics of Processing

Because of the relatively high cost of purchasing sea buckthorn berries, (due mostly to harvesting costs) it is unlikely that the processing industry can be profitable if the oils within the berry are not segregated and targeted for the lucrative nutraceutical and functional food industries.

A processing plan proposed by AAFC's Pacific Agri-food Research Centre could be adopted as a practical way to segregate sea buckthorn into its various products. In this processing plan, the sea buckthorn berries are separated into five end-products (juice, pulp-oil, powdered nutrient supplement, seed oil, and animal feed) using several existing technologies which can vary in cost depending upon the volume and the desired market. (For example, using supercritical carbon dioxide as a seed oil extraction method is very expensive and may only be feasible if oil is produced in sufficient quantities and targeted for specialty markets.) The

SEA BUCKTHORN JUICE

Sea buckthorn juice produced from the pulp of the berry is best consumed whole in order to obtain all of the active bio-compounds and elements within the berry. The juice contains varying levels of suspended oils which will float to the top and suspended solids which will gravitate to the bottom creating a "three-phase" juice when allowed to stand beyond a few minutes. From the consumers point of view this floating oil ring is undesirable. Clarifying centrifuges, a relatively inexpensive process that operates similar to cream separators, can be used to remove the suspended solids and the oil layer from the juice. This could be one method to produce sea buckthorn juice. The remaining separated solids and oils could then be further processed to extract the remaining nutritional components and provide additional value-added possibilities.

Preserving the juice to increase shelf life is critical to marketing. Because the juice is high in vitamin C which can be destroyed by prolonged exposure to heat, a high temperature-short time (HTST) process is recommended. HTST will retain the high vitamin C content, stabilize the juice and reduce the chances of "off-flavours" from occurring.

products once separated could either be sold on their own merits, for example, sea buckthorn juice with a high vitamin C level, or sold as a natural additive, for example to boost the source of vitamin C within some other fruit drink.

The profitability of sea buckthorn commercialization is complex and an in-depth analysis to determine all processing/marketing costs and returns needs to be completed to determine if a sea buckthorn industry can be economically viable.

Food and Nutraceutical Industries

Sea buckthorn products will generally fall into the nutraceutical or functional food categories. Health Canada has defined nutraceuticals and functional foods as follows: "a nutraceutical is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food and is demonstrated to have physiological benefit or provide protection against chronic disease; and a functional food is similar in appearance to, or may be a conventional food, is consumed as part of a usual diet and is demonstrated to have physiological benefits and or reduce the risk of chronic disease beyond basic nutritional function."

In a study prepared for AAFC, it is argued that functional foods could become a cornerstone of a preventive model for managing chronic diseases. The preventive model is based on early disease detection and functional food-based control of moderate risk factors. Research into these new possibilities for agriculture is one of the key pillars of the APF. The APF is the federal-provincial plan to encourage innovation in the agriculture industry and help it respond to increasing global demands for healthy, safe food, produced in an environmentally friendly fashion.

Within the nutraceutical and functional food market categories, sea buckthorn products are likely to be sold as 1) herbs and botanicals (oil), 2) sports meal and specialty supplements (juice) and 3) natural personal care products (lotions). In an edition of the *Nutrition Business Journal* it was estimated that the herbs and botanicals market is expected to grow between 16-18% per year, sports meal and specialty supplements by 8-10% per annum and natural personal care products between 8-12%.

Recent consumer surveys in Europe have confirmed that 75% of consumers believe there is a link between health and food; 79% believe diet is an appropriate way to prevent diseases and 62% are constantly watching their diet and looking for new products which can promote health.

Outlook

Sea buckthorn as a commercial crop is well suited for production in Canada. Favourable soil and climatic conditions produce a high quality, nutrient rich berry. Further, a large supply of high quality water for processing, technical expertise in oil extraction and the commitment by all levels of government through the APF to establish new and diversified value-added products combine to create very good potential for sea buckthorn.

As a single fruit, sea buckthorn contains impressive levels of nutrients. However, economics and competitiveness will dictate whether sea buckthorn and its components will be able to penetrate a particular market. For example, can sea buckthorn compete with soybeans as a source of tocopherol when soybeans have approximately 1,000 mg/1,000 g in comparison to sea buckthorn fruit pulp oil at 330 mg/1,000 g or with other oils for antioxidants, when flaxoils have about 50% linolenic acid and sea buckthorn in the 30% range?

Current estimates indicate that there may be a North American demand for 10,000 kg of processed sea buckthorn oil. This would require a supply of approximately 1.5 Mkg of fruit annually. The export potential of sea buckthorn products and fruit to Europe is also estimated to be significant. Due to production problems, current European demand is exceeding supply and could provide a potential export market of up to 100,000 kg of berries per annum.

Efficient harvesting methods, the establishment of productive orchards and the development of improved thornless cultivars that focus on improved yields and higher nutrient and oil content need to be developed to make the establishment of a sea buckthorn industry in Canada more competitive and viable.

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