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The socio-economic importance of the Apiales

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Abstract: Within the Apiales, the Apiaceae (Umbelliferae) is by far the most important family, both economically and socially. Although it includes the carrot (*Daucus carota*), one of the world's leading root crops, and other widely consumed vegetables such as parsnip (*Pastinaca sativa*), celery and celeriac (*Apium graveolens*), the family is perhaps best known for its remarkable diversity of culinary herbs, flavourings, condiments and spices, such as parsley, dill, coriander, anise, chervil, caraway, and cumin which are extensively used in cuisines across the world. It also contains several gum resins and a number of species are used medicinally, while some are poisonous. Several species play an important role as local food crops such as Arracacha (*Arracacia xanthorrhiza*), a high-value cash crop for poor farmers in the Andes and *Lomatium* species whose starchy edible roots are used as traditional Native American food. On the negative side, the family contains several weeds and a notorious invasive species, *Heracleum* '*mantegazzianum*' which can also cause severe skin blistering. Economically, the Araliaceae contains a number of important ornamental plants grown largely for their attractive foliage such as species of *Hedera* (ivy), *Fatsia japonica*, and *Schleffera.* It is also well known for a group of species known as ginseng, notably *Panax ginseng* and *P. quinquefolia*, which are renowned for their apparent stimulant, tonic and aphrodisiac properties. The other families in the Apiales are of little economic importance. The genetic resources and breeding of Araliaceous crops, except for carrot and ginseng, have received little attention.

Key words: Apiales, Apiaceae, socio-economic, vegetables, condiments, stimulants

Introduction

Since the first international symposium on the Biology and Chemistry of the Umbelliferae was held in 1970 (Heywood, 1971) our knowledge of the taxonomy, systematics and relationships of the family and the

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related Araliaceae has been transformed as a result of detailed molecular and phenetic studies. There have also been considerable advances in our knowledge of the ethnobotany and ethnopharmacology and of the genetic resources and breeding of several groups within the Apiales. In his survey of the ethnobotany of the Umbelliferae [Apiaceae], French (1971) provided an annotated list of the species of ethnobotanical interest which remains essentially valid and so no attempt is made here to revise it but rather focus on those species on which significant research on their uses or ethnopharmacology has been carried out. In addition, advances in our understanding of the genetic resources and breeding of crop species are reported.

Within the Apiales, the Apiaceae (Umbelliferae) is by far the most important family economically and socially and includes vegetable crops such as carrot (*Daucus carota*), one of the world's leading root crops, and other widely consumed vegetables such as parsnip (*Pastinaca sativa*), celery and celeriac (*Apium graveolens*). The family is perhaps best known, however, for its remarkable array of culinary herbs, flavourings, condiments and spices, such as parsley, dill, coriander, anise, chervil, caraway, and cumin which are extensively used in cuisines across the world (Rubatzsky et al., 1999). The Araliaceae on the other hand is best known for its ornamentals grown largely for their attractive foliage such as species such as ivy (*Hedera* spp.), *Fatsia japonica* and *Schleffera* spp and for a group of adaptogenic herbs, especially those known as ginseng, notably *Panax ginseng* and *P. quinquefolia*, which are renowned for their apparent stimulant, tonic and aphrodisiac properties. The other families in the Araliales are of little economic or ethnobotanical importance.

APIACEAE

Although best known for some vegetable crops and for its diversity of herbs and species, on closer examination, the Apiaceae reveals a number of surprises.

Vegetables

Carrot (*Daucus carota*). The cultivated carrot (*Daucus carota* subsp. *sativus*) is the most widely grown crop in the family, and is the second most popular vegetable in the world after the potato. Production in 2013

(aggregated with turnips) was 37,226,639t (FAO, 2015). China, Russia, and the United States are the top 3 producers of carrots globally, contributing almost 50% of the world carrot crop. Most of the carrots consumed are the orange-coloured western carotene type not the eastern anthocyanin type.

Although not sufficiently energy dense to be a major staple food in any part of the world, carrots are considered a primary vegetable in many countries. Their calorific contribution to the human diet is not significant but they do supply nutrition in the form of phytochemicals, such as carotenoids, anthocyanins, and other phenolic compounds and are a useful source of fibre. It is the single, largest primary source of vitamin A precursors (the orange carotenoids of carrot, α – and β –carotene) (Arbizu et al., 2014) and in the United States make carrot the largest single source of provitamin A in the diet, accounting for about half of dietary intake (Simon et al., 2009). The growing popularity of the carrot in recent years may be due to its nutritional value and as a functional food (Arscott & Tanumihardjo, 2010).

Carrots are a suitable target for carotenoid biofortifcation[i] and a dark orange 'high-carotene-mass' carrot has been developed that contains up to 500 ppm carotene and is the highest natural whole food source of β-carotene (Simon et al., 2009). A dark orange "high-carotene-mass" carrot has been has been developed and such carrots have been shown to increase serum β-carotene over typical orange carrots in humans (Tanumihardjo et al., 2009).

A great deal of work has been published on the domestication, development, genetic diversity and breeding of carrots in the past 25 years (for a summary up to 2000 see Simon, 2000), using both morphological and molecular approaches (Vivek & Simon, 1999; Iorizzo et al., 2013; Xu et al., 2014; Grezbelus et al., 2014; Maksylewicz & Baranski, 2013) and phylogenomics[ii] (Arbizu et al., 2014a[iii]), complemented by a morphometric study (Arbizu et al., 2014b).

Although some progress has been made in the classification of *Daucus* and allied genera and in resolving and relationships within the genus *Daucus,* further studies using a broader sampling of material are needed (Vivek & Simon, 1999; Arbizu et al., 2014a, b; Iorizzo et al., 2013; Spooner et al., 2013). The delimitation of taxa especially in the *D. carota* complex,

remains problematic and is complicated by the widespread hybridization that occurs in the wild with other subspecies/races and with landraces and cultivars (Saenz de Rivas & Heywood, 1974; Tavares et al., 2014. Vivek & Simon, 1999). Both molecular and morphometric data (especially of the fruit structure and microcharacters) have helped resolve the problem of which subspecies should be recognized and how they may be reliably recognized morphologically (Saénz de Rivas & Heywood, 1974; Tavares et al 2014; Arbizu et al., 2014b; Mezghani et al., 2014) but the evidence is not always in agreement and doubts remain about the validity of certain taxa. A case in point is *Daucus maximus* Desf. which Saénz de Rivas & Heywood (1974) recognized as a separate species from *D. carota* and not a subspecies of it, on the basis of a series of morphological characters of the fruits and flowers. The djstinctiveness of this taxon from the *D. carota* complex has recently been confirmed on both chemical and morphological grounds by Tavares et al. (2014) and by Mezghani et al. (2014) although the latter still treat it as a subspecies. Much of the material identified as *D. carota* subsp. *maximus* consists of variants of *Daucus carota.*

A major problem is ensuring that the material used in morphometric and molecular studies is correctly identified and it has been found that some of the material in germplasm collections is, not surprisingly misidentified (Spooner et al, 2014). Nor is there a guarantee that herbarium material used to verify accessions is correctly determined. Likewise the material obtained via botanic garden seed lists should always be checked and expert taxonomic advice sought where necessary although it has to be said that there is no agreement between different taxonomists as to which subspecies or species to recognize in the *Daucus carota* complex *sensu lato*.

The time and place of the origins of the domesticated carrot remains uncertain although Iorizzo et al. (2013) conclude on the basis of analysis of molecular studies which strongly separate the cultivated carrot, *D. carota* subsp. *sativus*, from wild carrot and that it was first domesticated from wild populations of *D. carota* subsp. *carota* from Central Asia which are its closest genetic relatives (Iorizzo et al., 2013).

Carrot has a very diverse global base of germplasm which can be drawn on to improve traits. This diversity can be exploited by breeding to develop hybrids with a wide range of shapes and colours (Arscott & Tanumihardjo,

2010) which, in turn, can expand the areas of commercial production and use (see review by Stolarczyk & Janick, 2010).

Parsnip (*Pastinaca sativa*). The parsnip is something of an enigma. It has a long history of cultivation in Europe but has virtually disappeared in some countries yet survives in others. For example, it was commonly grown and eaten in Italy and the Netherlands until the early 18th century but then gradually disappeared yet continued as a kitchen garden crop in France where they became a peasant food but mainly used as cattle feed and in Britain (Riley, 1995) where roast parsnip is an essential component of a Christmas dinner.

Although it appears to have has been cultivated by the Romans, early sources did not distinguish between the parsnip and the carrot and both have been referred to as 'pastinaca' so that it is difficult to trace its history with certainty. The parsnip has never gained as much popularity as a root vegetable although it became a staple crop in parts of Mediaeval Europe before the introduction of the potato as a prolific source of starch and as a sweetener, and was used both as a vegetable and in sweet dishes. Its importance waned when sugar became cheaper and more readily available and now it is mainly consumed in northern Europe but scarcely at all in the south. Outside Europe, it consumption is small. It lack of popularity is partly due to its unusual and characteristic taste and bizarre sweetness which many people find unpleasant or even loathsome. As Stolarczyk & Janick (2010) comment, 'If carrot is the Prince Charming of the root vegetables, then parsnip is surely Cinderella, unloved, ignored, and rejected.' It risks becoming a neglected or orphan crop which is ironic in the light of efforts to find new or underexploited species as sources of starch and sweeteners.

Breeding parsnip is complicated by the slow germination of seeds and their poor storage quality. Despite its limited importance as a crop, some significant progress in parsnip breeding has been made recently by the use of genetic marker technology by a Knowledge Transfer Partnership between the University of Warwick (Wellesbourne) UK and Elsom Seeds Ltd which will reduce considerably the time taken to breed and bring a new F1 hybrid to market.

Arracacha (*Arracacia xanthorrhiza*). Arracacha, Peruvian carrot, is one 25 species of root and tuber crops are native to South America and is

the only umbellifer domesticated in South America, almost certainly in the Andes, and still largely confined to that continent in its distribution. It is used by 30 million people in the Andes (Venezuela, Colombia Ecuador, Peru, Bolivia and Chile), and more than 30 million elsewhere – mainly in southern Brazil where it has been cultivated for some 100 years and provides income to thousands of farm families as a major crop. It is also grown to a lesser extent in Meso-America and the Caribbean. A monographic study of arracacha is given by Hermann (1997). Parsnip has also been the object of organic plant breeding (Horneburg et al., 2009).

The crop comes from the storage roots which are the part of the plant that is consumed consumed and can be marketed in their entirety because the propagules are from above ground parts of the plant. The aerial stems or offshoots are very peculiar structures unique to arracacha and are called 'cormels' by Hermann (1997). Apical sections of these cormels together with the basal part of the petioles are used as propagules which develop by growth and enlargement into the rootstock.

When cooked, its flavour has been described as like a mixture of parsnip, celery and carrot.It grows can be grown between 200m and 3600m but does best between1800m and 2500m and adapts to a wide range of mesothermic and tropical highland environments as well as day length regimes**.**

Although often regarded as an underexploited crop, in considering its potential for further development as a crop through breeding or selection, Hermann (1997) observes that 'With about 30 000 ha dedicated to its cultivation and an annual production value well in excess of US$l00 million, arracacha is actually not a neglected crop' but is 'essentially still a neolithic crop brought into cultivation thousands of years ago'.

Biscuit root, Indian Parsley (*Lomatium* spp)

Lomatium is a genus of 70 to 80 perennial herbs, which are native to western North America. The resinous roots of several species have been used as staples by North American Indians such as *L. cous*, *L. geyeri*, *L. macrocaroum* (*Peucedanum m*.) and *L. dissectum* (Cous root).

L. dissectum is also reputed to have antiviral properties and has been used by many Native American tribes to treat a wide variety of infections, mainly of the chest and lungs. Historical evidence suggests that desert

parsley was used during the influenza pandemic of 1917 with positive results. It has been shown in some studies to inhibit rotavirus and HIV-1 replication. It is a source of antimicrobial tetronic acid.

Herbs and flavourings

The Apiaceae contains a considerable number of species that are widely used in many parts of the world as herbs and flavourings, such as Dill (*Anethum graveolens*), Parsley (*Petroselinum crispum*), Sweet cicely (*Myrrhis odorata*), Lovage (*Levisticum officinale*), Alexanders (*Smyrnium olusatrum*), Coriander (*Coriandrum sativum*), Angelica (*Angelica archangelica*), Chervil (*Anthriscus cerefolium*), Celery (*Apium graveolens*) Caraway (*Carum carvi*) and Anise (*Pimpinella anisum*).

Parsley (*Petroselinum crispum*)

Parsley is the most popular herb in European cooking. It is native to the central Mediterranean and SW Asia. The widespread practice of using parsley as a garnish, can be traced back to the ancient Romans. Today the curly leaf cultivars, are used more as a decorative, garnish than as a flavouring and usually not actually consumed. The flat leaf cultivars are extensively used in continental Europe and in Middle Eastern cuisine in salads such as tabouleh (in which the more flavoursome stalks are used). Neapolitan parsley is a group of larger cultivars (eg 'Gigante d'Italia') up to 1m tall with larger leaves and thicker stems. Hamburg root parsley (*Petroselinum crispum* convar. Radicosum) is common in central and eastern European cuisines.

It has been widely used in ethnomedical systems from northern Europe to the Mediterranean regions, Russia, Iran, India and SE Asia.

Toxicity

Notorious for being the source of the poisonous alkaloid coniine in hemlock (*Conium maculatum*) that killed Socrates, the Apiaceae also contains a range of poisonous species such as Water Hemlock (*Cicuta maculata*) and Cow Parsley (*Aethusa cynapium*) which contain convulsant poisons. Skin irritation and photosensitisation can occur from

contact with Parsnip (*Pastinaca sativa*), Large Bullwort (*Ammi majus*), Chervil (*Anthriscus sylvestris*), Carrot (*Daucus carota*), Giant Hogweed (*Heracleum mantegazzianum*) and related species (see below), Cow Parsnip (*Heracleum maximum*) and (*Heracleum sphondylium*). Furanocoumarins are often the cause of inflammation. When activated by UV light, the sap of Giant Hogweed and related species contains furanocoumarins and causes the skin to blister approximately 15-20 hours after the original contact. This may recur for several years after the initial exposure. Children especially are at high risk. They can be a serious hazard to public health in some countries, especially the UK.

Thapsia

The Mediterranean genus of herbaceous perennials *Thapsia* contains several species used in traditional medicine for their resins and some species such as *T. villosa* and *T. garganica* are known as 'deadly carrot' because of the poisonous effects. The medicinal value of *T. garganica* has been recorded since the times of Hippocrates and Theophrastus c. 300-400 BC as well as the fact that contact with it can lead to skin irritation. The relationships and taxonomy of the genus *Thapsia* are complex (Weitzel et al., 2014) and correct identification of the material used in the drug studies is critical.

Biologically important sesquiterpene lactones are found in several members of the genus which has been the subject of screening for potential drug leads.In in particular, the bioactivity of the sesquiterpemoid thapsigargin extracted from *T. garganica* has been thoroughly investigated and is currently under investigation as a source of anticancer drugs. The first pharmacological effects of thapsigargin were established in 1978 and the full structure was elucidated in 1985. A prodrug has been designed to target the blood vessels of cancer cells and the death of these blood vessels then leads to tumor necrosis. The first clinical trials of this drug were initiated in 2008, and according to Andersen et al. (2015) the potent drug is expected to enter the market in the near future under the generic name Mipsagargin (G-202).

Not only is the focus on the production of the drug thapsigargin continuing but 'new prodrugs are currently being developed towards

certain cancer types, and as a whole, the use of thapsigargin as a drug and chemical compound will increase in the next decade' (Andersen et al., 2015).

Centella asiatica (Gotu kola)

Centella asiatica is a medicinal plant that has been in use for thousands of years in India, China, and Indonesia to treat many conditions. Its active constituents include the pentacyclic triterpene derivatives asiaticoside, asiatic acid, madecassoside and madecassic acid.

Historically, gotu kola has been used to treat syphilis, hepatitis, stomach ulcers, mental fatigue, epilepsy, diarrhoea, fever and asthma and is still used in traditional medicine today . Today, in the U.S. and Europe gotu kola is most often used to treat varicose veins and chronic venous insufficiency, and is also used in ointments to treat skin conditions such as psoriasis and help heal minor wounds. It is sometimes used to treat respiratory infections such as colds, formerly a traditional use in China[iv].

C. asiatica has been the subject of considerable experimental and clinical studies and has been shown it to have a positive effect in the treatment of venous insufficiency and striae gravidarum. *Centella asiatica* also appears to be effective in the treatment of wound healing and burn injuries (Wu et al., 2012). However, clinical studies to test the sedative, analgesic, antidepressive, antimicrobial, antiviral and immunomodulatory effects that have been demonstrated experimentally, still need to be undertaken (Brinkhaus et al., 2000).

Weeds and invasive species

The Apiaceae includes some of the world's worst garden weeds such as *Aegopodium podagraria* (Ground elder) and invasive species such as *Heracleum 'montegazzianum'*.

Ground elder, also known as bishop's weed and goutweed (*Aegopodium podagraria*) is a rhizomatous perennial native to Central Europe and temperate Asia. It is one of the world's worst garden weeds and once established difficult to eliminate or control. It can cover It has been widely introduced by cultivation in other parts of Europe outside its native range

and has become invasive e.g. in Russia, Germany, Finland and Poland. It was apparently used by the Romans as a medicinal and culinary pot herb and they were responsible for its initial spread in Europe. It has spread around the world, most commonly as an ornamental plant, and is invasive in North America, Australia, New Zealand and Japan. It is though that Ground Elder was first brought to North America as an ornamental during the early stages of European settlement and was well established in the U.S. by 18635. It readily establishes by rhizomatous spread and can become an aggressive invasive species. It spreads by vegetative means and seedling establishment is rare. The long white branching rhizomes rapidly form a network and dense patches of the plant are soon established which has led to its use as a ground cover plant.

Giant Hogweed (*Heracleum mantegazzianum*) (and the related species *H. sosnowskyi* and *H. persicum*) has spread rapidly and become invasive in a number of European countries (see Anon, 2009 for details) after repeated introductions as an ornamental from its native area in the Greater Caucasus in Russia and Georgia. Because of its vigorous growth and prolific seed production it can cover wide areas and lead to major changes in vegetation, aa well as obstructing access to river banks and causing soil erosion.

The taxonomy of the species involved far from clear (Anon, 2009; Nielsen et al., 2005; Jahadová, 2007a,b). Conflicting accounts of the identity of the British populations have been published (Sell & Murrell, 2009; Denness et al., 2013): in addition to the presence of *H. montegazzianum* (denied by Sell & Murrell, 2009), and the involvement of *H. sosnowskyi* and *H. persicum* it appears that *H. lehmannianum* Bunge is present in the British populations (Denness et al., 2013) but further sampling research is needed to resolve the position. The situation is further complicated by hybridization with other species of *Heracleum*, the products of which may become invasive.

H. mantegazzianum is one of the group of invasive alien species that was introduced through a botanic garden: it is recorded (under the name *H. giganteum*) in the 1817 seed list of the Royal Botanic Gardens Kew and *Heracleum persicum* was also first listed by Kew in 1819 (Nielsen et al., 2005; Jahodová et al., 2007a,b). This is a good example of the risks of spreading invasive alien species through the exchange of seed via the

Index Seminum mechanism. Seed from plants similar to *H. persicum* cultivated in London were taken to northern Norway in 1836 and the species is now naturalized in Scandinavia (and possibly in Hungary and the United Kingdom) and is spreading rapidly in the Trondheim area of Norway (Fremstad & Elven, 2006). It is also established and spreading in Canada, USA, Australia and New Zealand.

In addition to their widespread and serious impacts on habitats and biodiversity, because of their potential to cause phyto-photodermatitis, the Giant Hogweeds are a serious nuisance and health risk. Not surprisingly, *H. mantegazzianum* was the focus of the European Giant Alien Project (Jahodova et al., 2007b) which had as its aim the use of the Giant Hogweed as a model species for which a sustainable strategy for the control of other invasive alien species could be proposed.

Despite the known risks of growing Giant Hogweeds, they continue to be offered by the trade as ornamentals. This should be strongly discouraged (Heywood & Brunel, 2011).

ARALIACEAE

With the notable exception of some important ornamentals such as *Acanthopanax*, *Fatsia japonica*, *Hedera*, *Polyscias, Schefflera* and a group of adaptogenic herbs such as Ginseng, the Araliaceae is of limited economic or ethnobotanical importance compared with the Apiaceae. It also includes the rice-paper plant (*Tetrapanax papyrifer*), the pith of which source of pith paper, also known as rice paper; it is also a spectacular ornamental plant.

Ornamentals

The genus *Hedera* (Ivy) contains some 17 species, some of which are cultivated as ornamentals worldwide, especially *H. helix* of which than 450 different cultivars are recorded (Hatch, 2015). Other species cultivated include *H. azorica*, *H. canariensis*, *H.colchica* and *H. hibernica.*

Some species of *Hedera*, can become weedy or even invasive. *H. helix*, which is native to Europe, western Asia and northern Africa, is reported to be one of the most abundant and widespread invasive plants in the United State although it has been suggested that some or all of it is in fact *H.*

hibernica (Waggy, 2010; Green et al., 2013)[vi]. It is also invasive in parts of South America, Australia and New Zealand. Its acts by smothering other plants with its rapid and dense growth and this has led to its use being discouraged or even prohibited in some regions of the United States[vii] .. It can change the natural succession patterns of forests, limit understory regeneration by blocking sunlight and shading out other plants. It competes for water and nutrients and if left uncontrolled, it can cover the trunk of trees, reach the tree canopy and shade out deciduous foliage during summer months, leading to serious damage or even loss of the host tree. Leaf extracts of *H. helix* are used as a herbal remedy in Europe as an expectorant.

The intergeneric hybrid × *Fatshedera lizei*, was created by crossing *Fatsia japonica* 'Moserii' and *Hedera helix* at the Lizé Frères tree nursery at Nantes, France. The cross has not subsequently been repeated successfully and the hybrid is kept in cultivation by vegetative propagation.

Ginseng (*Panax* spp.)

The genus *Panax* comprises some 12-13 species. It contains A group of species known as ginseng, notably *P. ginseng* (Asian, Chinese or Korean ginseng) which is native to northeastern China, the Korean Peninsula and the Pacific regions of Russia and *P. quinquefolius* (American ginseng) which is native to eastern North America, are adaptogenic herbs renowned for their reputed stimulant, tonic and aphrodisiac properties (Court, 2000; Taylor, 2006). The name *Panax* is derived from the Greek all-heal or all-cure, hence the term 'panacea' named after the eponymous Greek Goddess of Universal Remedy. The name Ginseng derives from the Chinese 'Jin-chen' and 'Jen-schen'.

Asian Ginseng has been used for thousands of years in the traditional medical systems in China, Korea, and other Asian countries (Choi, 2008) and is one the best-selling medicinal plants in the world (Yun, 2001). The active compounds are ginsenosides, a class of steroid glycosides, and triterpene saponins, unique to the genus. It is the subject of extensive research into its pharmacology, biology, chemistry, cultivation, processing and production. On the other hand the study of American ginseng is relatively limited although some promising advances have been made

in understanding its chemistry, pharmacology and structure-function relationship in the past 15 years (Qi et al., 2011).

The main producers are South Korea, China, Canada and the United States and the most ginseng is consumed in China where it has been esteemed for 5000 years. By the 1900s, the supply of wild ginseng was no longer sufficient to meet the growing demand and commercial cultivation began in Korea (hence the reference to Korean Ginseng) which continues to be major producer. The shortage of supply has led recently to the cultivation of American Ginseng in northern China (Yu et al. 2014) and this has led to the risk of adulteration, with some Asian Ginseng having been found to be labelled as American ginseng. Various to the southern portions of Ontario and Quebec in Canada and the midwestern, southern and eastern parts of the United States approaches to the chemical identification of ginseng have been developed including molecular markers (Lo et al., 2015). Asian/ Korean ginseng contains 38 types of ginsenosides, which is substantially more than the 19 ginsenosides found in American ginseng (Choi, 2008).

American ginseng (*P. quinquefolius*) is native to Canada in the southern parts of Ontario and Quebec to the United States in the midwestern, southern and eastern parts. Its traditional use by native American tribes was minor but when its relationship with Asian ginseng was confirmed by Jesuits in the early 18th century, its value was recognized and this led to wild harvesting on a massive scale for export. It is reported that 'in one typical year (1841), more than 290,000 kg of dry ginseng roots were shipped from North America to the Asian continent' (McGraw et al., 2013). This led eventually to its listing in Appendix II of CITES in 1975.

It is now cultivated in the USA, mainly in Wisconsin since 1904 (Cheng & Mitchell, 2009) and in Canada, where Ontario is the main centre of production in North America, with some 1,540,000 kg exported in 1998. It has been a traded commodity since 1715 and most of Ontario's ginseng is shipped as whole root and processed elsewhere, mainly to China.

Eleuthero Root (Siberian ginseng) (*Eleutherococcus senticosus*)

Eleuthero Root, sometimes called Siberian ginseng, is also a member of the Araliaceae. Like ginseng, it is considered to be an adaptogenic herb. The active compounds in Siberian ginseng are eleutherosides, not

ginsenosides. Instead of a fleshy root, Siberian ginseng has a woody root.

Conclusions

Since the review of the ethnobotanical uses of the Umbelliferae (Apiaceae) in (1971), a very substantial amount of research has been published on the family and its sister family Araliaceae which has greatly enhanced our understanding of this important order. Highlight of this research are summarized. The Araliales provides us with a cornucopia of foods, herbs, flavourings, spices, poisons, stimulants, medicinal and ornamentals that many cultures exploit around the world. Without these, our lives would be much duller.

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(Endnotes)

i. Biofortification is the enrichment of staple food crops with essential micronutrients (Nestel et al., 2006).

ii. 'the use of genome-scale genetic data for phylogenetic analyses' (Arbizu et al., 2014)

iii. The first phylogenomic analysis of *Daucus, using next-generation sequencing technology*

iv. For supporting references see Gotu kola | University of Maryland Medical Center http://umm.edu/health/medical/altmed/herb/gotu-kola#ixzz36mgChDvU

v. Plant Conservation Alliance's Alien Plant Working Group. http://www.nps.gov/plants/alien/fact/aepo1.htm

vi. The taxonomy of *Hedera remains controversial and species such as H. hibernica and H. canariensis are regarded by some authors as part of the variation of H. helix although there is evidence suggests that they should be kept as distinct species (Ackerfield & Wen, 2003; Green et al., 2011)*

vii. e.g. Weed Bulletin - King County Noxious Weed Control Programyour.kingcounty.gov/dnrp/library/water-and.../english-ivy-control.pdf (accessed 15 April 2015); Reichard S. (2000) *Hedera helix. In: Bossard CC, Randall JM, Hoshovsky MC (Eds.), Invasive Plants of California's Wildlands. University of CA Press, Berkeley. pp. 212-216.*