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NOTES ON NEGLECTED AND UNDERUTILIZED CROPS

Swedish coffee (*Astragalus boeticus* L.), a neglected coffee substitute with a past and a potential future

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Abstract Swedish coffee (*Astragalus boeticus*) seeds have been used as a coffee substitute, in particular during the nineteenth century and in times of scarcity. *A. boeticus* is found in the wild in a wide range of environments in the Mediterranean and Middle Eastern regions and is able to grow in areas with low and irregular rainfall. It is well-adapted to cultivated and disturbed environments, has indehiscent pods and high yield potential, and is therefore pre-adapted to cultivation and domestication. Swedish coffee is an annual that flowers in spring and produces small (3–6 mm × 3–5 mm) kidney-shaped seeds that can be harvested in summer. The genetic diversity of the species has not been studied, but evidence (wide range of environments, insect pollination) suggests that considerable diversity exists in the species. The genetic resources of Swedish coffee conserved in germplasm banks are very limited, with only 49 accessions conserved in six genebanks. Although no cultivated varieties exist at present and no breeding studies are underway, evidence suggests that limited breeding could result in considerable genetic advances. The cultivation of *A. boeticus* was very important during the nineteenth century in several countries of Europe, in particular in Sweden, where the cultivation was promoted as a coffee substitute by the monarchy. Several reports exist on its cultivation in several countries of Northern, Central and Southern Europe during the nineteenth century and beginning of the twentieth century. However, its cultivation gradually lost importance and was eventually abandoned. Swedish coffee can be grown in different types of soils as a regular winter or spring legume crop, and thanks to symbiosis with rhizobia may be able to perform well with reduced N fertilization. Several historical accounts report an excellent quality of the coffee substitute prepared with roasted Swedish coffee seeds. However, no investigations have been carried out to study the process of roasting and its influence on the final quality. The information presented here indicates that limited efforts in *A. boeticus* breeding, cultivation, and industrial processing potentially might result in the recovery of this neglected coffee substitute.

Keywords *Astragalus boeticus* · Coffee substitute · Crop history · Neglected crops · Swedish coffee

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Introduction

Members of the legume family (Fabaceae or Leguminosae), fill critical niches in most terrestrial biomes. This is one of the few plant families whose species are capable of fixing nitrogen from the air, through association with specialized soil bacteria, thus reducing fertilizer requirements. The family has traditionally been divided into three subfamilies: Caesalpinioideae, Mimosoideae, and Papilionoideae or Faboideae (Bresinsky et al. 2013). This latter subfamily contains most of the major cultivated legumes, including crops such as soybean (*Glycine max* (L.) Merr.), common bean (*Phaseolus vulgaris* L.), peanut (*Arachis hypogaea* L.), pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris* Medik.), fababean (*Vicia faba* L.), alfalfa (*Medicago sativa* L.), lupine (*Lupinus* spp.), cowpea (*Vigna unguiculata* (L.) Walp.), pigeonpea (*Cajanus cajan* (L.) Millsp.), mung bean (*Vigna radiata* (L.) Wilczek), clovers (*Trifolium* spp.), birds-foot trefoil (*Lotus corniculatus* L.), lima bean (*Phaseolus lunatus* L.), fenugreek (*Trigonella foenum-graecum* L.), indigo (*Indigofera tinctoria* L.), jicama (*Pachyrhizus erosus* L.), licorice (*Glycyrrhiza* spp.), rooibos (*Aspalathus linearis* (Burman f.) Dahlgren), guar (*Cyamopsis tetragonolobus* (L.) Taub.), and many other minor and neglected crops (Hanelt 2001).

One of these neglected crops from the subfamily Papilionoidae is Swedish coffee (*Astragalus boeticus* L., Fabaceae), also called yellow milk vetch or Andalusian astragalus. Swedish coffee is a member of the largest genus of vascular plants (*Astragalus*), which contains around 3,000 annual and perennial species included in more than 250 sections (Mabberley 1997; Maassoumi 1998; Podlech 1998). Within this complex genus, *A. boeticus* is the only member of the monotypic section *Cyanmodes* Bunge, within subgenus *Trimeniaeus* Bunge (Maassoumi 1998; Taeb et al. 2007). Morphologically and molecularwise it is related to other species of the genus, such as *A. edulis* L. (Podlech 1999; Taeb et al. 2007; Peñas and Morales-Torres 2011).

Several species of *Astragalus* have been used in pastures and grown for fodder (Townsend 1993; Hanelt 2001), for medicinal uses, mostly derived from their content in bioactive polysaccharides (astragalans I, II, and III) and saponins (Ríos and Waterman 1997); for ornamental purposes (Bailey 1942), and for obtaining tragacanth gum (Hanelt 2001; Balaghi et al. 2010). In addition, a few species have been occasionally cultivated or harvested from the wild for human consumption (Hanelt 2001). Among the latter, *Astragalus boeticus* has been harvested and cultivated for its seeds, which after roasting can be used as a coffee (*Coffea arabica* L.) substitute (Hanelt 2001 Shurtleff and Aoyagi 2012). Many names in different languages (English: Swedish coffee; German: Kaffeewicke, Schwedischer Kaffee, Stragelkaffee, Astragalkaffee; Swedish: kaffevedel; Norwegian. Kaffemjelt; Italian: caffè messicano, caffè selvagio, caffè francese, caffè sardo; French: vesce à café; Spanish: café de los pobres; Catalan: cafè bord, cafè de pobre, cafè mallorquí; Sardinian: caffeèdd, caffeiburdu; Maltese: kaffé messican) refer to this use as coffee substitutive (Podlech 1999; Hanelt 2001; Peñas and Morales-Torres 2011). However, despite the good reputation as an excellent coffee substitute in the nineteenth century (Vogel 1827; Fergusson 1831; Porcher 1868), its cultivation as coffee substitutive was largely replaced by chicory (*Cichorium intybus* L. var. *sativum* Lam. et DC.) coffee. Another minor use of Swedish coffee is for the unripe seedpods, which are edible (Kunkel 1984; Tanji and Nassif 1995). Attempts have been also made to use Swedish coffee plants as fodder for cattle and goats (Campos-Vidal 2001).

Distribution and ecology

The genus *Astragalus* is a clear example of adaptive radiation, and presents a wide distribution in many environments of the northern hemisphere and South America (Mabberley 1997; Maasoumi 1998; Podlech 1998). Although the greatest diversity of *Astragalus* is found in Southwest Asia, many *Astragalus* species, including *A. boeticus*, are also distributed in the Mediterranean region (Pretel and Sañudo 1978, Podlech 1998, 1999, Badr and Sharawy 2007; Taeb et al. 2007; Peñas and Morales-Torres 2011). Contrary to many *Astragalus* species, which are endemics with a narrow distribution, *A. boeticus* presents a wide distribution in the Middle East, North of Africa and Southern Europe (Podlech 1999; Taeb et al. 2007; Peñas and Morales-Torres 2011).

In the wild or weedy state, *A. boeticus* can be found from sea level to 1,000 m asl (Podlech 1999; Peñas and Morales-Torres 2011; Taeb et al. 2012). It prefers light and porous soils with no shade, but it grows in all kind of soils, including slightly salty and sandy soils (Bailey 1942; Podlech 1999; El-Bana et al. 2002; Peñas and Morales-Torres 2011; Taeb et al. 2012). It is commonly found in pastures dominated by annual species, and in disturbed environments (Podlech 1999; El-Bana et al. 2002; Peñas and Morales-Torres 2011). Like other legume species, *A. boeticus* can fix nitrogen through symbiosis with rhizobia (Fig. 1) which confers a competitive advantage in nitrogen-depleted soils (Zahran 1999). The existence of genetic variation in N-fixation response to abiotic stresses among and within legume species opens a real possibility for enhancing N-fixation tolerance to them through selection and breeding. It has been reported that nodulation, growth, and N-fixation in some legumes can be improved by inoculating plants with competitive and stress-tolerant rhizobia (Zahran 1999). About 90 *Astragalus* species forming symbioses with root nodule bacteria have been recorded, involving *Rhizobium* spp., *Mesorhizobium* spp. and *Sinorhizobium* spp. (Wei et al. 2008). *A. sinicus* L. the Chinese milk vetch, is the most studied species, but no research has been published with regard to the symbiotic system in *A. boeticus*.

As it is common in *Astragalus* species (Karron 1987), Swedish coffee is cross-pollinated by bees (Hymenoptera), including honey bee (*Apis mellifera* L.; Fig. 1) and bumble bees (*Bombus* spp.). This has important implications for the production of seeds as well as in the genetic structure of populations and cultivars, and in the conservation and multiplication of germplasm.

Astragalus boeticus presents several traits that facilitate its adaptation to cultivation. In this respect, it is commonly found in meadows, as a weed in cultivated fields, and in disturbed sites (Tanji and Elgharous 1998; Podlech 1999; Peñas and Morales-Torres 2011). Therefore it appears to be well adapted to agricultural environments. Also, its indehiscent ripe pods (Fig. 1), which as in other wild legumes indicate a pre-adaptation to harvesting (Sonnante et al. 2009), lack of seed dormancy (Huxley 1992), and its high yield potential per plant are characteristic features of a pre-adaption to domestication (Hammer 1984).

Botanical description

Astragalus is a morphologically very diverse genus, and considerable variation is found in vegetative traits and pod structure (Mabberley 1997; Maassoumi 1998; Podlech 1998, 1999; Taeb et al. 2012). Despite the large number of species and considerable diversity, *A. boeticus* can be easily distinguished from other species of the genus on the basis of a combination of gross morphology traits (Fig. 1). *A. boeticus* is an annual plant that in its wild habitat germinates during autumn–winter and flowers during spring. The seeds mature from early to late summer, depending on the climatic conditions. In general, *A. boeticus* plants are branched at the base (Podlech 1999; Peñas and Morales-Torres 2011; Taeb et al. 2012). The stem, inflorescences and branches are covered by hairs of up to 1 mm long. The stem and branches have a length of up to 70–100 cm, a diameter of 5–10 mm, are reddish or green in colour, and are ascending to procumbent (Fig. 1). The stipules are triangular, with a length of 7–15 mm. Full-grown leaves are 8–20 cm long, with a petiole of 0.5–2 cm long, and are im paripinnate with 8–16 pairs of leaflets, which measure 8–35 × 4–10 mm (Fig. 1) (Podlech 1999; Peñas and Morales-Torres 2011; Taeb et al. 2012). Inflorescences are elongated racemes with a peduncle of 2–15 cm long and 6–40 flowers (Fig. 1). The floral bracts are 4–8 mm long, and the calyx is 6–8 mm long, tubular and hairy. Petals are usually white and measure 8–12 mm long. Pods are indehiscent, bilocular, triangular in section, straight or somewhat curved, 2–6 cm long having a hooked beak 2–4 mm long (Fig. 1) (Podlech 1999; Peñas and Morales-Torres 2011; Taeb et al. 2012). Each pod contains 4–10 kidney-shaped seeds, which are 3–6 mm long and 3–5 mm wide (Fig. 1). The weight of 1,000 seeds is 2.6–3.0 g.

Contrarily to most of the *Astragalus* species of the Old World, which usually have a basic chromosome number of x = 8 (Badr 1996), *A. boeticus* has a basic chromosome number of x = 6 and is a pentaploid with a diploid chromosome number of 2n = 30 (Pretel and Sañudo 1978; Badr and Sharawy 2007). The differences in chromosome number with other *Astragalus* suggest that gene flow of *A. boeticus* with other *Astragalus* species is impaired and therefore its genetic integrity is maintained by reproductive barriers.

Diversity, genetic resources, and breeding

The intraspecific genetic diversity of *A. boeticus* has not been studied. However, in other *Astragalus*

Fig. 1 Swedish coffee (*A. boeticus*) young plant growing in a field in fallow (**a**), plant cultivated in a home garden (**b**), roots with naturally occurring rhizobia (**c**), inflorescence with honey bee (*Apis mellifera*) pollinating (**d**), young shoot with leaves and inflorescences (**e**), unripe pods on the plant (**f**), indehiscent ripe pods (**g**), and seeds (**h**). *Scale* (**g** and **h** pictures) in cm

species, including endangered endemics, the inter- and intra-population genetic diversity, as assessed with molecular markers, has been found to be high (Vicente et al. 2011; King et al. 2012). Given that *A. boeticus* has a wide range of distribution and thrives in many different environments (Podlech 1999; El-Bana et al. 2002; Peñas and Morales-Torres 2011; Taeb et al. 2012), we estimate that a large genetic diversity must exist in the species. Also, the fact that *A. boeticus* is cross-pollinated by insects is an indication that considerable diversity is probably found within natural populations. Among the biotic components of the agro-ecosystems, diversity, pollinators are a key component because the yield of many crops (fruits, vegetables, nuts, seeds, herbs) is directly dependent on insects. The use of Swedish coffee pollinator-friendly cultivars able to give the highest reward to pollinators meanwhile taking advantage of an increased heterozygosity and heterosis consequent to crossing, would also benefit both pollinator populations and yield. However, previous legume breeding has largely neglected this area (as current breeding strategies have largely disregarded the interface crop plant—pollinators) and the development of legume cultivars that explicitly support bee pollinator conservation is in its infancy still even in important crops (Palmer et al. 2011).

Most of the economically important cultivated legume species are well represented in gene banks and germplasm collections worldwide. For example, the common bean (*Phaseolus vulgaris* L.) is the most important legume crop worldwide for direct consumption and has been exhaustively studied and improved (Singh 1999). On the contrary, neglected crops and their wild and weedy forms are often underrepresented in germplasm collections (Hammer et al. 2003). Among Fabaceae, Swedish coffee is no exception, and few accessions of this crop are conserved in germplasm banks. A search in the Genesys database (www.genesys-pgr.org), which contains information on more than 2.3 million accessions stored in germplasm banks of all around the world, returned 49 accessions stored in six genebanks (Table 1). The largest collection is maintained at the International Centre for Agricultural Research in Dry Areas (ICARDA), in Syria, with 33 accessions (67.3 % of the total), and the countries with greatest representation in the collections are Morocco and Syria, with 10 accessions each.

Although no formal breeding efforts have been done for Swedish coffee, Townsend (1981, 1993) has shown that considerable yield improvement can be achieved in the related forage species *A. cicer* L. using standard breeding techniques. This suggests that, as in other crops that have not been subjected to scientific breeding, considerable genetic advances can be achieved in *A. boeticus* with a limited effort based on the exploitation of available genetic diversity (Prohens et al. 2003). Advances in legume genomics may also facilitate the breeding of neglected crops such as Swedish coffee.

History of cultivation

Swedish coffee has been used at least since the beginning of the nineteenth century as a coffee substitute in different parts of Europe, North of Africa and Middle East (Hanelt 2001). Its cultivation has also been frequent in times of scarcity and coffee prohibition. The English term "Swedish coffee" reflects the early cultivation at the beginning of the nineteenth century in the Scandinavian region (Fergusson 1831; Hedrick 1919). In this respect, the cultivation of *A. boeticus* was encouraged in Sweden during the three coffee ban periods in the periods 1794–1796, 1799–1802 and 1817–1822 (Niles 1821; Burke 1822). Apparently, one reason for the first ban on coffee was the belief of Swedish King Gustav III (reigned 1771–1792) that coffee was a threat to public health, but also the impact of coffee importation on national trade balance was a cause for the prohibition (Weinberg and Bealer 2001). In fact, King Charles XIV John of Sweden (reigned 1818–1844) ordered the extensive cultivation of *A. boeticus* on his estate at Rosenberg in order to produce seed for distribution among farmers (Niles 1821). German agronomist Josef Carl Bayrhammer, who was impressed by the pursuit of self-sufficiency policies in Sweden, promoted the cultivation of Swedish coffee in Prussia and Bavaria (Bayrhammer 1821). Somewhat later, Loudon (1826) reports that it was an important crop in Germany and that its seeds had become an article of commerce as coffee substitute, like the roots of chicory or carrot. This same author (Loudon 1826) mentions that the price of the Swedish coffee was around one-third of that of real coffee and similar to that of chicory. Fergusson (1831) also indicated that it

Table 1 Accessions of Swedish coffee (*A. boeticus*) conserved in germplasm banks according to the Genesys database (www.genesys-pgr.org)

Institute code (Country)	Institute/Genebank	Country of origin	Number of accessions
DEU146 (Germany)	Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Greece	1
		Portugal	1
		Spain	1
		Unknown	3
		Total	6
GBR004 (Great Britain)	Millennium Seed Bank Project- Seed Conservation Department-Royal Botanic Gardens-Kew-Wakehurst Place (MSBP)	Greece	2
		Total	2
ESP004 (Spain)	Centro de Recursos Fitogenéticos. Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (CRF-INIA)	Spain	2
		Unknown	1
		Total	3
SYR002 (Syria)	International Centre for Agriculture Research in Dry Areas (ICARDA)	Algeria	2
		Italy	1
		Jordan	3
		Morocco	10
		Spain	1
		Syria	10
		Tunisia	3
		Unknown	3
		Total	33
USA022 (USA)	Western Regional Plant Introduction Station. USDA. ARS (WRPIS)	France	1
		Israel	1
		Serbia and Montenegro	1
		Unknown	1
		Total	4
USA971 (USA)	Desert Legume Project. University of Arizona (DELEP)	Unknown	1
		Total	1
All genebanks/Institutes		Total	49

was cultivated to a large extent in Germany and adjacent countries. Almost 40 years later, Porcher (1868) reported that Swedish coffee was planted in Germany and England and that was considered as the best coffee substitute yet tried. At the end of the nineteenth century, Lecomte (1899) indicated that it is cultivated in England. Moreover, at the beginning of the twentieth century, Hedrick (1919) reported its cultivation in certain parts of Germany and Hungary.

In France, it was cultivated in Napoleonic times during the continental blockade as coffee substitutive and for adulteration of real coffee (Anonymous 1858; Hanelt 2001; Shurtleff and Aoyagi 2012). Hanelt (2001) indicates that its cultivation was maintained in Switzerland, Croatia and Dalmatia at the beginning of the twentieth century and that had been occasionally cultivated in Ethiopia. Grisard (1885) reports its cultivation in Austria and Italy during the second half of the nineteenth century. In Spain, it was grown in Northeast Spain during the second half of the nineteenth century (Podlech 1999). Also, at the end of the nineteenth century it was also grown in the tiny Columbretes islands by the lighthouse keepers, and was also frequently cultivated in the Balearic Islands (Von Salvator 1895). Its cultivation in Spain was resumed after the Spanish civil war (1936–1939) during the autarchy times. Also, during World War II it was cultivated in several countries as a coffee substitute (Vascellari 1940). However, after the 'Golden Age' of Swedish coffee cultivation as a coffee substitute during the nineteenth century, its cultivation declined and largely got into oblivion. A similar situation occurred with other coffee surrogates derived from minor legumes, like the *Lupinus pilosus* L. 'Altreier Kaffee', which is endemic to the Altrei village (South Tyrol, Italy) and was important there in the nineteenth century but was almost lost during the second half of the twentieth century (Heistinger and Pistrick 2007).

Cultivation

Little is known of the cultivation techniques appropriate for Swedish coffee. However, it seems that it does not have specific cultivation requirements and can be grown and harvested using the established techniques for other pulses (Campos-Vidal 2001). In this respect, Hedrick (1919) indicates that it is cultivated in the same way than pea.

According to its distribution in the wild as well to the reports of cultivation in regions with different soils, it seems that it can be successfully grown in many soil types, including siliceous and calcareous soils, although it thrives better in light soils (Bailey 1942; Podlech 1998, 1999; Peñas and Morales-Torres 2011). Wild *A. boeticus* has also been found in sandy soils and desert areas (Podlech 1998; El-Bana et al. 2002; Mossallam et al. 2009), which may be an indication that it might be grown in areas where availability of water is low. Also, thanks to symbiosis with rhizobia the fertilization with N may be reduced (Huxley 1992).

Campos-Vidal (2001) studied the cultivation of Swedish coffee in Majorca Island (Spain) for producing fodder for goats. In 1 year in which the rainfall was of 425 mm, he found that yields were of 8,000 kg/ha of hay, while in another year in which the rainfall was very low (182 mm) he obtained 3,208 kg/ha of fodder. This confirms that Swedish coffee can successfully thrive with very low rainfall (Mossallam et al. 2009). In mild climates with low and erratic rainfall, like those typical of the Mediterranean region and Middle East, sowing should be made in autumn, so that flowering takes place in early spring and harvesting in the early summer. Although Swedish coffee can resist temperatures of up to −10 °C (Huxley 1992), it has been reported that frosts can affect negatively the development of the plant (Fergusson 1831). Therefore, in cold climates, like those of Central and Northern Europe, it is recommended to make sowings during spring so that harvesting can be made by the end of the summer (Fergusson 1831).

No reports are available on the yield of Swedish coffee under cultivation. However, one of us (R.P.) was able to obtain 800 g of seed from a single plant, which occupied an area of around 1 m^2, grown in a home garden. This suggests that the yield potential is quite high and that under optimal conditions it may be possible to reach at least 8,000 kg/ha of seed yield. In other *Astragalus* species used for fodder, like *A. cicer*, seed yields of between 500 and 1,200 kg/ha have been reported (Richards and Myers 1997). Taking into account that, unlike Swedish coffee, *A. cicer* is not cultivated for its seeds we estimate that Swedish coffee seed yields of 1,000–3,000 kg/ha may be obtained under standard cultivation conditions in Europe. These yields probably could be improved by the development of improved cultivars and growing techniques specifically adequate for Swedish coffee.

Composition and quality

The only report know to us in which the composition of Swedish coffee seeds has been studied is that of Tanji and Elgharous (1998). These authors evaluated the mineral composition of 43 weeds, including Swedish coffee. They found that Swedish coffee seeds presented a mineral composition (P: 0.37 %; K: 0.84 %; Ca: 0.16 %; Na: 0.20 %; Fe: 0.005 %, and Zn: 0.005 %) similar to the seeds of other herbs of the Fabaceae family. In this same study, the N content was of 4.14 %, from which it can also be inferred that the protein content (Nx6.25) in the Swedish coffee samples was of 25.9 % (Tanji and Elgharous 1998).

No reports are known to us on the composition and quality of the beverage produced from the roasted Swedish coffee seeds. In this respect, the roasting process is very important for obtaining a coffee substitute with good quality (Clarke 1987). The traditional process involves roasting the Swedish coffee seeds in a pan or in an oven and grinding the roasted seeds with a domestic coffee mill. As with real coffee, depending on the degree of roasting, lightly to

Fig. 2 Lightly (*above*) and heavily (*below*) roasted Swedish coffee (*A. boeticus*) seeds (*left*) and the respective milled coffee substitutes (*right*). *Scale* in cm

heavily roasted seeds of Swedish coffee can be obtained (Fig. 2). Lightly roasted seeds result in a clear coloured and mildly flavoured beverage, while heavily roasted seeds produce a dark coloured and bitter beverage (Fig. 3).

The organoleptic quality of the coffee substitute obtained from Swedish coffee has not been studied, but there are several reports from the nineteenth century that indicate that it is possible to obtain a good quality coffee substitute. In this respect, in the early nineteenth century, Fergusson (1831) stated that it greatly surpassed any coffee substitute known in Great Britain in quality. Vogel (1827) indicated that it was a perfect coffee substitutive. Somewhat later, Porcher (1868) also indicated that it was the very best substitute for coffee yet tried. Other studies found that the use of Swedish coffee as coffee substitute in mixtures with real coffee results in a good beverage. Loudon (1826) indicated that the seeds of Swedish coffee and real coffee were mixed at a ratio 2:1, roasted together and stored until ground. Similarly, Vogel (1827) found that a 1:1 mixture of real coffee and Swedish coffee made an excellent beverage. Mixtures of *A. boeticus* with seeds other than coffee have also been reported to produce a good coffee substitute. In this way, during the Second World War, Vascellari (1940) indicated that a mixture of soybean and Swedish coffee at a ratio 68:32 (soybean:Swedish coffee) produced a very good coffee substitute. The technology for producing high quality coffee and coffee substitutes has advanced considerably in the last decades. Therefore, studies on the technology of roasting Swedish coffee seeds are needed in order to produce a high quality coffee substitute. Also, it is worth mentioning that coffee substitutes are a healthy alternative for groups vulnerable to caffeine consumption (Higdon and Frei 2010). Some studies have shown that caffeine-free coffee substitutes like chicory or

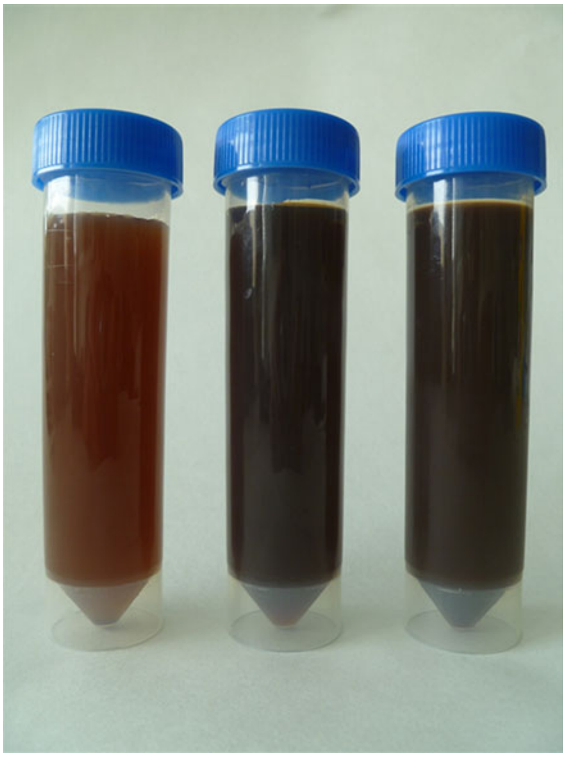

Fig. 3 Colour of the infusions obtained with the coffee substitute obtained from lightly (*left*) and heavily (*center*) roasted Swedish coffee (*A. boeticus*) seeds compared to real *Coffea arabica* coffee (*right*)

malt may have positive effects on human health, mostly derived from their antioxidant activity (van Boekel et al. 2010; Sartorelli et al. 2010). Studies on the advantages of the caffeine-free Swedish coffee for human health would provide relevant information for the enhancement of this neglected coffee surrogate.

Conclusions

More than 100 species have been used as coffee substitute (Hanelt 2001). Among these, Swedish coffee was an important coffee substitute in Europe during the nineteenth century (Bayrhammer 1821; Niles 1821; Loudon 1826; Anonymous 1858; Porcher 1868). However, during the twentieth century it was replaced by other substitutes and no regular plantations or cultivated varieties exist. Few information exists on the genetic diversity, breeding, cultivation techniques, and technology for processing the seeds in order to produce a high quality coffee substitute. However, given the wide range of environments in which Swedish coffee grows in the wild (Podlech 1999; El-Bana et al. 2002; Peñas and Morales-Torres 2011; Taeb et al. 2012), genetic diversity is probably high, which could facilitate selection and breeding works in order to obtain cultivars with improved performance. We consider that, as in other crops (Prohens et al. 2003), limited efforts in the breeding, cultivation, and industrial processing of Swedish coffee could result in the potential recovery of the cultivation of a neglected coffee substitute. The increasing demand of traditional foods (Trichopolou et al. 2007), including almost forgotten coffee surrogates such as the lupine 'Altreier Kaffee' (Heistinger and Pistrick 2007), together with the capacity of Swedish coffee to grow in marginal environments (salty and sandy soils), including areas with low and irregular rainfall (Bailey 1942; Campos-Vidal 2001; El-Bana et al. 2002; Mossallam et al. 2009), and N fixation due to symbiosis with rhizobia (Zharan 1999) may stimulate the recovery of its cultivation in a context of climate change.

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