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MORINGA OLEIFERA LAM. IDENTIFICATION OF OPPORTUNITIES FOR THE BRAZILIAN MARKET THROUGH PATENT LANDSCAPE ANALYSIS

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Abstract

Moringa oleifera Lam. is an arboreal species originated from the northwest if the Indian subcontinent. This species is cultivated due to its high protein content, its perceived medicinal use, and multiple other applications, including as forage plant. More recently, moringa has been recognized as a potential source of drop-in biodiesel and of biodiesel stabilizing agents. Given these and other characteristics, moringa has great economic potential and possible applicability in many areas. This work presents a brief introduction to the plant itself and its uses. In order to investigate its potential and current uses, with an eye for encumbrances to, and opportunities for, their implementation in the Brazilian market, an intellectual property (IP) landscape analysis was carried out. Sources of data used were the EPO (Europe), USPTO (US), WIPO (Global Portal), INPI (Brazil), CPTO (China) and TIPO (Taiwan). Of especial interest are those applications for which patent protection does not exist at all or, at least, IP protection in Brazil has not been sought. Data in this article is limited of utility patents and patent applications directed at the use of moringa and forms of plant protection were not considered.

Keywords
Moringa oleifera; protein; patent landscape; biodiesel; horseradish tree

Introduction

Moringa oleifera Lam. is an evergreen species of the genus *Moringa*, family Moringacea. It is known in English[1] by several names including horseradish tree, drumstick tree and benzoil tree. In Portuguese[1] it is known as *moringa, moringueiro, muringueiro* and *quiabo-da-quina*. According to Rolloff (2007), The name is derived from the Tamil word *murungai* and thus bears no etymological relationship with the Portuguese words *moringa* and *moranga*, often used colloquially to identify *Cucurbita maxima* and some of its relatives.

According to Pio Corrêa (1984) and Duke (1978), moringa is widely distributed, with economic planting in India, Egypt, the Phillipines, Sri Lanka, Thailand, Malaysia, Myanmar, Pakistan, Singapore, Jamaica, and Nigeria. Since the publications by Pio Corrêa and Duke, the list of countries has grown to encompass most of Asia south of Russia, the Sub-Saharan Africa, the whole of Central America, Mexico, most of South America, and parts of Oceania (Trees for Life International 2013). In the USA, to date, planting is limited to Florida (in only two counties, Manatee and Miami-Dade), Hawai'i, the US Virgin Islands and Puerto Rico (USDA-NRCS 2013).

The species is widely adaptable to different climates, including dry subtropical, wet subtropical, both dry and humid tropical, and wet forests. It tolerates drought and blooms even in semi-arid conditions (Palada 1996, de Saint-Sauveur 2010), but does not tolerate near-freezing temperatures (Duke 1978). Dalla Rosa (1993) stated that the plant grows best in dark, well-drained, neutral or slightly acidic soils. A complete manual for cultivation and exploitation of moringa has been published by the Moringa Association of Ghana (de Saint-Sauveur 2010) and provides information on optimal conditions for plant growth.

In Brazil, cultivation of moringa is more prominent, in relatively low scale, in the semi-arid regions of the Brazilian Northeast, aiming primarily the plant's ability to purify water (Serra 2002) and, more recently, as forage (Vieira 2008), in traditional medicine (Pasa 2010) and the seed oil used as domestic fuel, lubricant and in the artisanal manufacture of soaps and perfumes (Morton 1991). In light of de Saint-Sauveur work (2010), climatic, hydrogeological, and topographical conditions of the

[1] USDA's Germplasm Resource Information Network (**GRIN**) is a valuable resource for both scientific and colloquial – in many languages – taxonomies of plants (www.ars-grin.gov)

Brazilian territory can be inferred to favor this species' adaptability to most of the Brazilian Midwest, Southeast (north of São Paulo city), Northeast (NE) and most of North. In multiple areas in the Brazilian NE, additional irrigation would be necessary to reach the plant's ideal conditions that require a minimum of 50cm/year of precipitation

Given its many uses, high protein and nutritional content, and adaptability to multiple climates, it has been lauded as a miracle tree and the "Mighty Moringa" (Shyr 2012). Of its many potential uses, the ones due to the plant's nutritional content are prevalent, and its use in culinary is ubiquitous in Asia and Africa (Thuma 2011).

Seed pods, seeds, roots, leaves and flowers are edible and, together with the tree bark find use in traditional medicine due to its natural anti-helmintic (Hakkar 2007) and anti-inflammatory (Mahajan 2007) properties. The past two decades have witnessed an increase interest in the plant's possible medicinal properties and both *in vitro* and *in vivo* activities of certain extracts have been demonstrated or inferred in numerous publications (Bharali 2003, Bose 2007, Fahey 2005, Ghasi 2000, Karadi 2003).

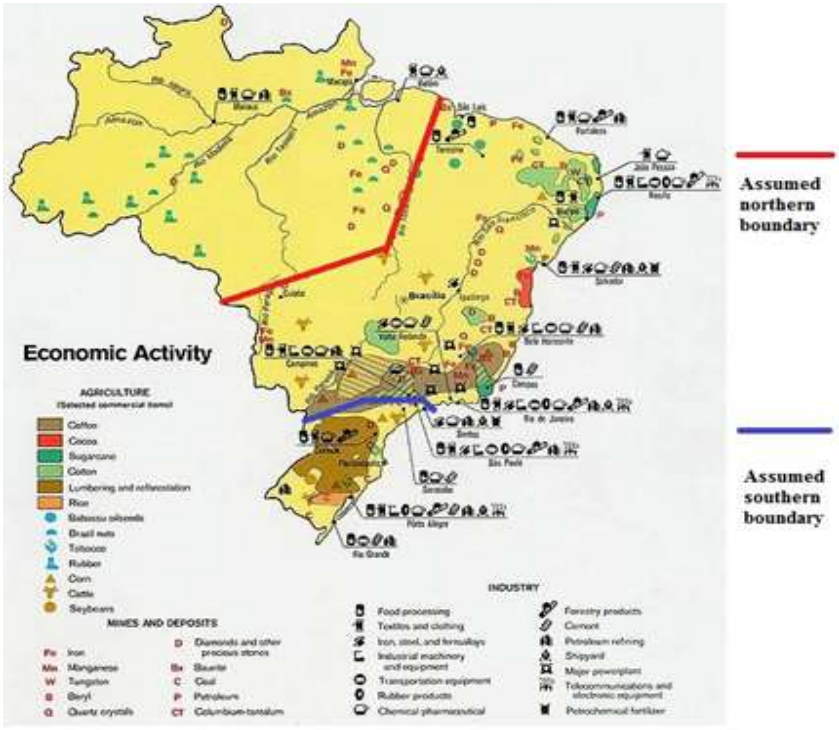
The protein content is very high and competitive with those of traditional sources such as grains and milk (Table 1), which is a strong indicative of the potential of this plant as a nutritional supplement, malnutrition relief and meals ready to eat (MRE).

Table 1- Protein content of *Moringa oleifera* and comparison with selected grains and milk (g/100g or wt.%)

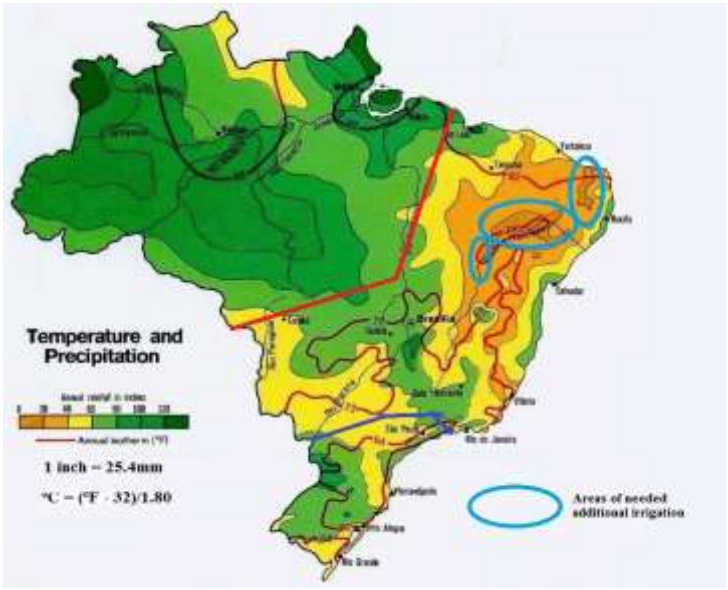
Moringa oleifera Lam.				
Raw leaves[2]	Raw pods[2]	Dry leaves (Lima 2013)	Dry leaves (Passos 2012)	Raw leaves (Passos 2012)
9.40	2.10	29.0 – 40.6	22.85	7.34
		Milk[2]		
	Raw	Dry		
	3.28	26.32		
		Soybean[2]		
	Raw	Cooked	Roasted	
	12.95	12.35	35.22	
		Black Beans[2]		
	Raw	Cooked	Baked	
	21.60	8.86	5.54	

[2] USDA's National Nutrient Database for Standard Reference (Release 26) is a comprehensive database listing the nutritional profile of approximately 9,000 food items, often in multiple forms (*e.g.,* dry, raw, cooked). Ndb.nal.usda.gov/ndb/search/list

Figure 1. Favorable areas for cultivation of *Moringa oleifera* in Brazil, based on optimal climatic conditions reported by de Saint-Sauveur. In (a) overlap with other economic activities, including agricultural. Note adaptability of the plant next to other crops; in (b) as function of precipitation and temperature. The red line indicates the assumed northern boundary and the blue line the assumed southern boundary of optimal conditions for the economically viable exploitation of moringa. Light blue ellipses mark areas where additional irrigation is needed to reach the desirable 50cm /year level for optimal growth.



(a)



(b)

Source: Maps generated by US Central Intelligence Agency. Adapted by the authors for purposes of this Article.

Two recent publications (Passos 2012, Lima 2013) using moringa grown in Brazil, indicate a protein content between 22% and 41%, and support previous work by Moyo (2011) based on Africa-grown plants which reports a protein content of 30.29 wt.%. Recent work by Brazilian researchers, using Fisher rats as model organisms, indicated that degummed moringa oil had the same Food Efficiency as soybean oil (standard) while crude moringa oil had superior nutritional value vs. the standard (Andrade 2011).

More recently, interest has risen in the use of oil produced from the seeds as a stabilizing additive to esterified biodiesel and at least one publication dealing with IP prospecting in this area has appeared (Filho 2012). That study was prompted by emerging research addressing uses of moringa as the source of materials for bioenergy generation and production of high-quality bio-oils (Muhl 2011A, Muhl 2011B, Kivevele 2013, Rashid 2008, Kafuku 2010). High oil content from seeds was determined by various extraction techniques and determined to be in the range between 25 wt.% and 36% wt.% (Tsakinis 2009) while dehusked seeds yielded nearly 42 wt.% in crude oil (Ogbunugafor 2011).

The versatility of this plant is further illustrated by the commercial production of a blue dye (*mouringhy*) from its bark, wood and sap (Cooke 1936) which is still widely used in the cottage textile industry in India, Senegal and Jamaica.

It is within this context - of a plant with multiple uses and a source of many commodities - that the motivation for this work resides, and it is the authors' intent to identify open areas of economic, industrial and scientific opportunities -involving moringa- in Brazil. Current uses of moringa that are the subject of industrial interest were identified by means of a systematic prospection of associated patents and mapping the results therefrom.

Methodology

Quintella (2009) asserted that intellectual property (IP) prospection has contributed significantly to the formulation of long-term policies, strategies and plans in the realm of Research, Development and Innovation (RD&I). This is a more prominent reality in Latin America and – in particular – Brazil, where investments in RD&I increased substantially since 2004.

In the context of Quintella's assertions, and in order to investigate current and potential opportunities for the commercial exploitation of moringa, the status of the IP associated with this species

was investigated. In order to do so, the patent offices of Brazil, Europe, WIPO, US, China, Korea and Taiwan were queried using several adjunct key terms in association with "moringa*" as the master term. Adjunct terms used were "pharmaceutical*", "oil*", "fatty*", "food*", "protein*", "nutrition*" and "fuel*". In these terms "*" functions as wildcard. The terms were translated to Portuguese in order to search Brazil's INPI. Queries were performed directly at an Office's webpage, or through the aggregator PatSnap™ (www.patsnap.com) or Derwent™ (http://thomsonreuters.com/derwent-world-patents-index/).

Results are presented in function of subclasses of the International Classification of Patents (ICP), these used as identifiers of specific uses of moringa in related applications. Results were also correlated with both the country of priority (*i.e.*, country of origin of the assignees) and the filing year of those applications. Data and results are current as of December 2013, however it must be noted that, since results of such queries will include only published applications, and PCT applications only publish 18 months after (**i**) the filing date or (**ii**) the priority date, data for 2012 and 2013 will be skewed downward since a number of applications with filing (or priority) date after July 2012 may not be included in the results.

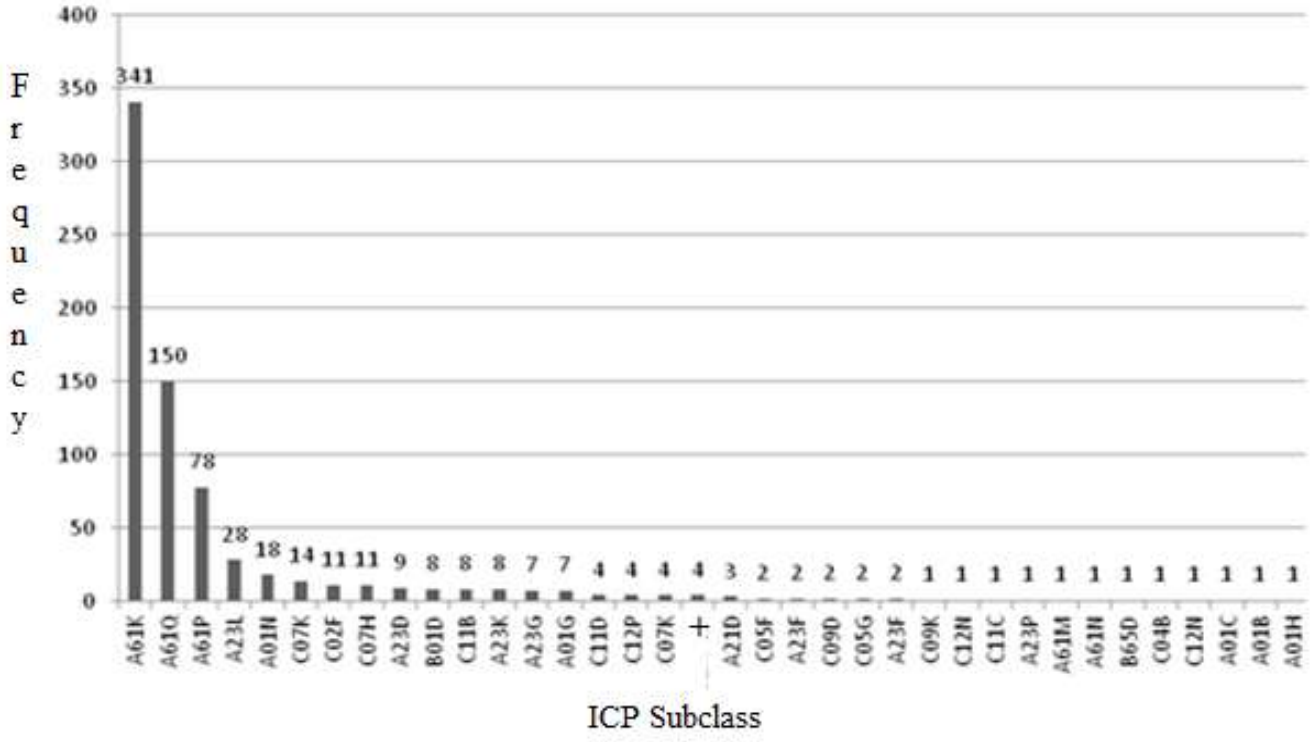
Results and Discussion

According to data from the WIPO database, based on the search of the term "moringa*", 135 patent applications were filed and published between 01/1994 and 11/2013, with 2012 being the year with the largest number (20) of filed applications. Of those 135 applications, 40 (29.6%) were PCT applications while the remainder (70.4%) were comprised of National Applications (Nationalized PCT Applications and direct National Filings). In the same period, only 5 (3.7%) originated from Brazil, 4 of which were drawn to uses based on the nutritional aspects of the plant and one drawn to the preparation of congealing agents – derived from the plant – for the purification of water. China (CN) led in number of filed applications (20, 14.8%), followed by the US with 11 (8.2%).

ICP data, not surprisingly, shows a predominance of applications classified under Section A (Human Necessities), followed distantly by Section B (Performing Operations; Transporting) and Section C (Chemistry; Metallurgy). Subclasses A61K (Preparations for Medical, Dental or Toilet Purposes) was the most frequently used classification appearing in 46.1% of the total classifications. This was followed by A61Q (Specific use of Cosmetics or Similar Toilet Preparations) with 20.3%, and

A61P (Therapeutic Activity of Chemical Compounds or Medicinal Preparations) with 10.6%. Classes B and C appear in 1.2% and 9.3% of all occurrences, respectively, noting that Class C includes inventions related to water treatment, Figure 2.

Figure 2 – Absolute frequency of occurrence of subclasses in the applications resulting from querying the WIPO database with the term "moringa*". Four instances were not associated with an ICP subclass, denoted by + above.



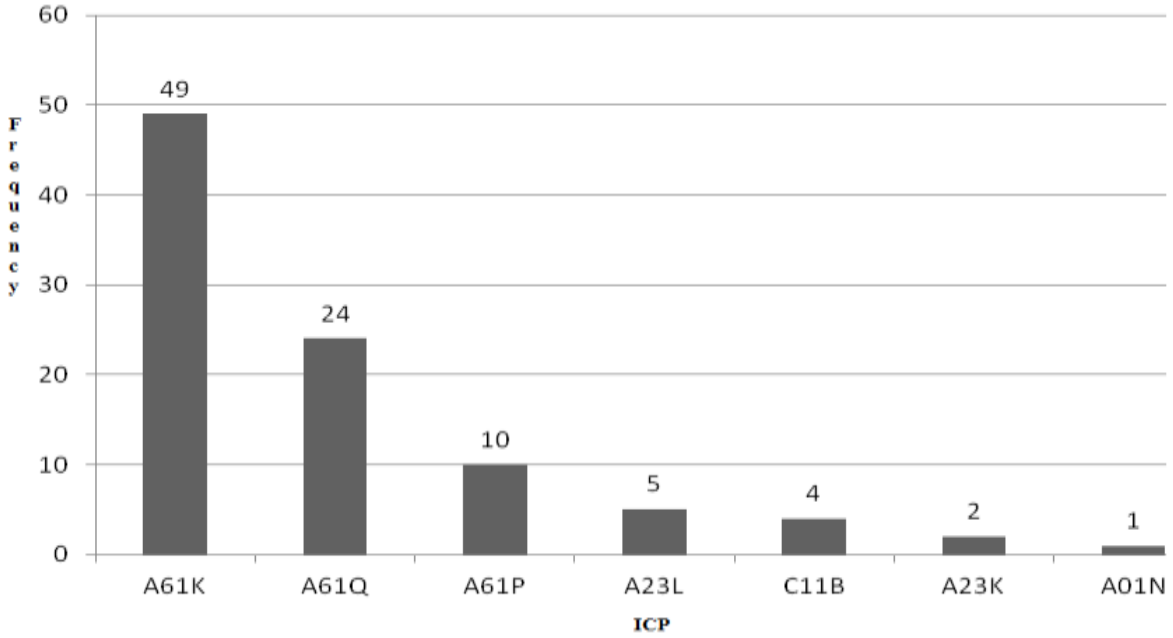
The majority of the identified applications containing the term "moringa*" were PCT Applications (n = 40, 29.6%), followed by National Applications in CN (n=28, 20.7%), US (n=25, 18.5%), EPO (n=16, 11.9%) and JP (n = 11, 8.1%).

Application of moringa and its products as therapeutic agents was investigated by querying the databases with the combination ("moringa*" AND "pharmaceutical*") leading to the identification of 15 patent applications, 10 of which were filed in or after 2004. From this total, 9 (60%) of the applications were filed by assignees from US, EP and KR. Again, subclasses A61K (Preparations for Medical, Dental

or Toilete Purposes) and A61Q (Specific Uses of Cosmetics or Similar Toilet Preparations) were the predominant classifications with a combined frequency of 73 (76.8% of the total), Figure 3.

The industrial use of moringa (and of its by-products) as food, feed, or due to its nutritional value, was assessed through the use of three composite queries: ("moringa*" AND "food*"); ("moringa*" AND "nutrition*"); and ("moringa*" AND "protein*"). The results are presented in Table 2.

Figure 3 – Absolute frequency of occurrence of subclasses in the applications resulting from querying the WIPO database with the composite argument ("moringa*" AND "pharmaceutical*").



It is interesting to note, in Table 2, the occurrence of subclasses C07K (Production of Peptides), B01D (Separation Processes), and C11B ("Producing, Refining or Preserving Fats, Fatty Substances, Essential Oils and Perfumes"). These are indicative of multiple identified uses of the plant, which are exploited by many of the 15 applications. The appearance of these subclasses together with those under Class A, illustrate the applicability of moringa extracts in, for instance, the cosmetic industry, since peptides find use in skin care (see, for instance, Reddy 2012A, Reddy 2012B, Nakatsuji 2012), nutrition and as biocidal agents. Moreover, the composition of the plant's oil, which is rich in palmitic, lauric, stearic, linoleic, myristic and linolenic acids, enable the oil to be used as raw material in the cosmetic

industry, especially in skin care (Ashraf, 2007). These are applications involving high-value commodities, *i.e.*, compounds and extracts that can be sold in small amounts at premium prices.

Finally, the use of moringa as a source of biofuels or of biofuels additives was considered. Whilst IP related to the use of moringa extracts as biodiesel stabilizers was previously investigated (Leite 2012) due to the overlapping breadth of the queries used in this and the previous work, there is the possibility of overlapping results.

The mining of existing IP drawn to the uses of the plant in the fuels industry was carried out by using the master keyword in conjunction with one of the following adjunct terms: "oil*", "fatty*", "fuel*", "biofuel*", "ester*" [3] and "biodiesel*". The super-composite query ("moringa*" AND "fuel*" AND "ester*") applied to the fields "Title" or "Abstract" or "Claims" was also carried out.

Table 2 - Identified Patent Applications drawn to uses of *Moringa oleifera* due to its nutritional value. Priority Year, Priority Countries and IPC Subclasses

Priority Years:

Search Argument	**Year**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**	**'13**
"moringa*" + "food*"		1	1	1	1	1	1	1	1	1	1	3
"moringa*" + "nutrition*"		1	0	1	1	1	1	2	2	2	1	1
"moringa*"+ "protein*"[4]		3	4	1	3	4	1	1	2	2	1	0

Priority Country (or Region):

Search Argument	**Country**	**CN**	**EP**	**BR**	**US**	**JP**	**KR**	**RU**
"moringa*" + "food*"		3	1	0	0	1	0	0
"moringa*" + "nutrition*"		5	0	0	1	1	3	0
"moringa*"+ "protein*"		6	0	0	6	0	0	1

Most Frequent Classifications (Total Count = 256):[5]

Class	A61K	A23L	A61D	A23D	C11B	A61Q	A01G	C07K	B01D	A23G	C02F
Abs. Frequency (n)	104	28	12	4	4	44	3	18	6	7	5
Rel. Frequency (%)	40.6	10.9	4.7	1.6	1.6	17.2	1.2	7.0	2.3	2.7	1.9

Somewhat predictably, the use of the adjunct terms "oil*" and "fatty*" led to the identification of applications predominantly classified under Sections A and C of the IPC, due to the ubiquitous use of plant-

[3] The logic for including this keyword relates to the nature of biodiesel and of natural additives to diesel, all of which include esters of C_8 to C_{21} acids (National Biodiesel Board 2014).
[4] Prior to 2003, 7 applications were identified through this query, for the period between 1999 and 2002. No applications were identified prior to 1999
[5] A single patent application may be associated with multiple subclasses.

derived oils and fatty acids and esters in both the food and the cosmetic industries. The super-composite query did not lead to the identification of any patent applications. These results are summarized in Table 3.

Table 3 - Identified Patent Applications drawn to uses of oils derived from *Moringa oleifera*. Priority Year, Priority Countries and IPC Subclasses.

Priority Year:

	Year:									
Search Argument	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**
"moringa*" + "oil*"[6]	2	0	0	0	0	0	0	3	1	5
"moringa*" + "fatty*"	7	8	6	11	17	23	31	22	30	33
"moringa*" + "fuel*"	0	0	1	0	2	0	2	2	3	2
"moringa*" + "biofuel*"	0	0	0	0	0	0	1	0	1	1
"moringa*" + "biodiesel*"	0	0	0	0	1	0	2	2	1	0

Priority Country (or Region)[7]:

	Country:																			
Search Argument	**AU**	**BE**	**BR**	**CO**	**DE**	**DK**	**EP**	**ES**	**FR**	**GB**	**HU**	**IB**	**IL**	**IN**	**JP**	**KR**	**MY**	**PH**	**SE**	**US**
"moringa*" + "oil*"	0	1	0	0	0	0	0	0	1	5	0	0	0	0	0	2	0	0	0	3
"moringa*" + "fatty*"	1	0	1	1	22	2	19	4	10	1	1	1	1	0	5	5	1	1	1	13
"moringa*" + "fuel*"	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	11
"moringa*" + "biofuel*"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
"moringa*" + "biodiesel*"	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5

Most Frequent Classifications (Total Count = 429)[4]:

Class	**A61K**	**A23D**	**A61P**	**A61L**	**A61Q**	**C07K**	**A45D**	**A01N**	**C02**
Abs. Frequency (n)	171	25	25	17	102	11	11	20	7
Rel. Frequency (%)	39.9	5.8	5.8	4	23.8	2.8	2.6	4.7	1.6

[6] A total of 27 applications filed prior to 2003 were identified.
[7] Two Chinese applications also appear in the search, but are directed to hair cleansing compositions.

Notably, India (IN, from where *Moringa oleifera* originated) does not appear as a significant contributor to the overall IP landscape. Noting that the Indian Patent Office was not queried in this work (which, in part, justifies our observations), the absence of significant IP originating from that country may be consequent of the use of the plant being dominated by centuries-old traditional practices and most of the pertinent industrial activity being associated with either cottage industry or scale up of techniques used in that industry.

Conclusions

This work illustrates that the development of technologies based on the use of *Moringa oleifera* is in tandem with academic research substantiating the uses of this plant. Industrial R&D involving this species is mostly aimed at applications in nutritional supplements and food and animal feed (oil and leaves) as well as the basis for cosmetics and skin care products (oil). However, it appears that - at least so far - very little effort has been devoted to the development of industrial methods to use of moringa oil as fuel.

The global patent landscape is somewhat crowded and primarily geared to uses of moringa as a nutritional source. Most of the intellectual property was developed and protected in CN, US and EP, with China being by far the leading priority country. Until December 2013, no patent application originating from a foreign priority country had a counterpart filed in Brazil, with the country holding a modest and endogenic IP position in this field, revealing the absence of applied, IP-oriented research involving the plant in the country.

Notably absent from these results are genetic methods for improvement of the plant, *e.g*., for increased production of oil, resistance to high-levels of soil salinity, higher yield in areas with less than 500 mm/year of precipitation (*i.e.*, drought resistance*)*. This may reveal that the wild-type plant may be feasible to commercial exploitation without the need for improvement, or that the industrial-scale exploitation of the plant has not yet reached levels that would call for such improvements.

While IP protection in Brazil (or by Brazilian entities), *for certain uses*, will face considerable hindrance by the significant prior art identified herein, the commercial use of the plant as food, feed and as a natural source of cosmetic materials is not precluded, given the absence of any exclusivity holder that could be identified through the Brazilian Patent Office (INPI).

Approximately 30% - 40% of the Brazilian territory appears to be suitable for the economic growth of moringa and, given the plant's character as a source of many commodities, moringa may be poised to have a positive impact in the Brazilian agriculture. As such, the commercial development of nutritional supplements and animal feed additives, which stemmed from the cottage industry and domestic uses, is not subject to IP hindrances and is based upon natural characteristics of the plant itself. Thus, these uses are immediately available for exploitation by the Brazilian industry. For instance, dried leaves may be used, in combination with grains and legumes, as an inexpensive, high-protein, additive to school lunches and as a nutritional supplement to low-income families. The plant may also be of special interest to the domestic cosmetic industry, greatly geared toward the use of "green", sustainable products.

The high contents of usable oil may also be a factor promoting RD&I geared toward the use of moringa as a source of biofuel, in partial replacement of diesel oil, an area of high priority for the Brazilian economy.

In conclusion, RD&I opportunities involving the use of moringa, its parts and extracts for the development of new products and technologies are abundant, and fit well with the Sc&T profile of the country. Moreover, this new crop may provide a rich opportunity for the establishment of industry-university partnerships in many areas of research, predominantly in nutrition, energy and transportation.

Bibliography

ANDRADE, G.F.; MELO, T.M.C.; GUEDES, C.D.; NOVACK, K.M.; SANTOS, R.C.; SILVA, M.E.: Biological Evaluation of Crude and Degumed oil from Moringa oleifera Seeds. *Braz. Arch. Biol. Technol.* 54(5), 1003-1006 (2011)

BHARALI, R.; TABASSUM, J.; AZAD, M.R.H.: Chemomodulatory effects of *Moringa oleifera* Lam on hepatic carcinogen metabolizing enzymes, antioxidant parameters and skin papillomagenesis in mice. *Asian Pac. J. Cancer Prev.* 4, 131-139 (2003)

BOSE, C.K.: Possible role of *Moringa oleifera* Lam root in epithelial ovarian cancer. *Medscape Gen. Med.*, 9 (1), 26 (2007)

COOKE, M.C.: The blue dyes of China and India in SIMMONDS, P.L. (Ed.), *The Technologysts.* Kent & Co. (London) 121-129 (1936)

DALLA ROSA, K. R. Moringa oleifera: a perfect tree for home gardens. Hawaii: NFTA, *Agroforestry Species Highlights*, 1993, v.1, 2p.

DE SAINT-SAUVEUR, A.; BROIN, M.: Growing and Processing Moringa Leaves. Moringa Association of Ghana (Accra), (2010). www.anancy.net/documents/file_en/moringawebEN.pdf (ISBN: 9-789290-814528)

DUKE, J. A. The quest of tolerant germplasm. In: YOUNG, G. (Ed.) Crop tolerance to subtropical land conditions. Madison. American Society Agronomy Special Symposium, 1978, v.32, p.1-16.

DUKE, J. A. Moringaceae: horseradish-tree, drumstick-tree, sohnja, moringa, murunga-kai, mulungay. In: BENGE, M. D. (Ed.) Moringa a multipurpose tree that purifies water. *Boston, Science and Technology for Environment and Natural Resources*, 1987, p.19-28.

FAHEY, J.W.: Moringa oleifera: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Part 1. *Trees for Life Journal*, 1:5 (2005)

FILHO, D.B.O.; FRANÇA, F.R.M.; SANT'ANNA, M.C.; DE SANTANA, M.F.S.; LEITE, N.S.; GAMA; G.J.; DA SILVA, G.F.: *Revista GEINTEC – Gestão, Inovação e Tecnologias*, 2(5), 490-504 (2012)

GHASI, S.; NWOBODO, E.; OFILI, J.O.: Hypocholesterolemic effects of crude extract of leaf of *M. oleifera* Lam in high-fat diet-fed Wistar rats. *J. Ethnopharmacol.* 69, 21-25 (2000)

HAKKAR, H.P.; FRANCIS, G.; BECKER, K. : Bioactivity of Phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. *Animal* 1(9): 39-47 (2007)

KAFUKU, G.; MBARAWA, M.: Alkaline catalyzed biodieslel production from *Morina oleifera* oil with optimized production parameters. *Appl. Energy* 87(8), 2561-2565 (2010)

KARADI, R.V.; GADGE, N.B.; ALAGAWADI, K.R.; SAVADI, R.V.: Effect of *Moringa oleifera* Lam. root-wood on ethylene glycol-induced urolithiasis in rats. *J. Ethnopharmacol.* 86, 191-195 (2003)

KIVEVELE, T.T.; MBARAWA, M.M.; BERECZCKY, A.; ZÖLDY, M.: Evaluation of the Oxidation Stability of Biodiesel Produced from Moringa Oleifera oil. *Energy Fuels* 25(11), 5416-5421 (2011)

LIMA, L.A.L.C.; COSTA, D.G.; NUNES, T.P.; JUNIOR A.M.O.: Evaluation of protein concentrate production by fermentation from *Moringa oleifera* Lam. *Revista GEINTEC – Gestão, Inovação e Tecnologias*, 3(5) 292-297 (2013)

MAHAJAN, S.G.; MALI, R.G.; MEHTA, A.A.: Protective effect of ethanolic extracts of seeds of *Moringa oleifera* Lam. against inflammation associated with development of arthritis in rats. *J. Immunotoxicol.* 4(1), 39-47 (2007)

MAKKAR, H.P.S.; BECKER, K.: Nutrients and antiquality factors in different morphological parts of the Moringa oleifera tree. *Journal of Agricultural Science*, Cambridge, v.128, p.331-322, 1997.

MORTON, J. The horseradish tree, Moringa pterygosperma (Moringaceae). A boon to arid lands?. *Economy Botany*, v.45, n.3, p.318-333. 1991.

MOYO, B.; MASICA, P.J.; HUGO, A.; MUCHENJE, V.: Nutritional characterization of moringa leaves. *African J. Biotechnol.* 10(60) 12925-12933 (2013)

MUHL, Q.E.; DUTOIT, E.S.; ROBBERTSE, P.J.: *Moringa oleifera* (horseraddish tree) leaf adaptation to temperature regimens. *Inter. J. Agr. and Biol.* 13(6), 1021-1024 (2011)

MUHL, Q.E.; DUTOIT, E.S.; ROBBERTSE, P.J.: Temperature effect on seed germination and seedling growth of *Moringa oleifera*. Lam. *Seed Sci. and Technol.* 39(1), 208-213 (2011)

NAKATSUJI, T.; GALLO, R.L.:Antimicrobial peptides: old molecules with new ideas. *J. Invest. Dermatol.* 132 (3, pt 2), 569-575 (2012)

NATIONAL BIODIESEL BOARD: What is Biodiesel? (www.biodiesel.org/what-is-biodiesel/biodiesel-basics) (2014)

OGBUNUGAFOR, H.A.; OZUMBA, A.N.; ENCH, F.U.; IQUO-EZIKPE, M.N.; OKPUZOR, J.; IGWILO, I.O.; ADENAKAN, S.O.; ONYEKWELU, O.A.: Physicochemical and antioxidant properties of Moringa oleifera Seed Oil. *Pak. J. Nutrit.* 10(5), 409-419 (2011)

PALADA, M.C. Moringa (Moringa oleífera Lam.): a versatile tree crop with horticultural potential in the Subtropical United States. *Hort. Science*, v.31, n.5, p.794-797, 1996

PASA, M. C.; GONÇALVES, K. G.; SOUZA, S. S. S.; SILVA, G. R. G. Abordagem Etnobotânica de Moringa oleífera Lam.: do cultivo ao uso da espécie em Rondonópolis, Mato Grosso. *Flovet*, n.2, p.1-68. 2010.

PASSOS, R.M.; SANTOS, D.M.C.; SANTOS, B.S.; SOUZA, D.C.L.; SANTOS, J.A.B.; SILVA, G.F.: Qualidade pós-colheita da moringa (*Moringa oleifera Lam.)* utilizada na forma *in natura* e seca. *Revista GEINTEC – Gestão, Inovação e Tecnologias* 3(1), 113-120 (2012)

PIO CORRÊA, M. Dicionário das plantas úteis do Brasil e das exóticas cultivadas. Rio de Janeiro: MA/IBDF, v.5, p.233-234. 1984.

QUINTELA, C.M.; C.M., TEIXEIRA; L.S.G., KORN M.G.A.; NETO, P.R.C.; TORRES, E.A.; CASTRO, M.; JESUS, C.A.C. (2009). Cadeia do Biodiesel da Bancada à Indústria: uma visão geral com prospecção de tarefas e oportunidades para P&D&I. *Quimica Nova*, Ed. Especial."

RASHID, U.; ANWAR, F.; MOSER, B.R.; KNOTHE, G.: Moringa oleifera oil – A possible source of biodiesel. *Bioresource Technol. 99(17)*, 8175-8179 (2008)

REDDY, B.; JOW, T.; HANTASH, B.M.: Bioactive oligopeptides in dermatology: Part I. *Exp. Dermatol.* 21(8): 563-568 (2012)

REDDY, B.; JOW, T.; HANTASH, B.M.: Bioactive oligopeptides in dermatology: Part II. *Exp. Dermatol.* 21(8): 569-575 (2012)

ROLOFF, A; WEISBERGER, H.; LANG, U.M.: "*Moringa oleifera"* in *Enzyklopädie der Holsgewächse: Handbuch und Atlas der Dendrologie* (2007), Wiley-VCH, 978-983

SERAFINI, M. R.; PAIXÃO, A. E.; JUNIOR, A. M. O.; SILVA, G. F. Avaliação de tecnologias em dessalinização de água a partir da análise dos pedidos de patentes. Universidade Federal de Sergipe. (2011)

SERAFINI, M. R.; SILVA, G. F. Prospecção Tecnológica no Brasil: Características da Propriedade Intelectual no Nordeste. Universidade Federal de Sergipe. (2011)

SHYR, L.: The mighty moringa: *National Geographic*, 222 (5), 48 (2012)

TREES FOR LIFE INTERNATIONAL: Countries where Moringa Grows (2013) (www.tressforlife.org/our-work/our-initiatives/moringa)

THUMA, S.: "Drumstick" in Vah Reh Vah (www.vahrehvah.com/indianfood/drumstick)

TSAKINIS, J.; LALAS, S.; GERGIS, V.; DOURTOGLOU, V., SPILIOTIS, V.: Characterization of Moringa oleifera Variety Mbololo Seeds. *J. Agric. Food Chem.*, 47, 4495-4499 (1999)

USDA-NRCS: National Resources Conservation Service (2013). (Plants.usda.gov/core/profile?symbol=MOOL)

VIEIRA, H.; CHAVES, L. H. G.; VIÉGAS, R. A.; Crescimento Inicial de Moringa (Moringa Oleífera Lam) Sob Omissão de Nutrientes. *Revista Caatinga*, Universidade Federal Rural do Semi-Árido (UFERSA). Caatinga (Mossoró, Brasil), v.21, n4, p.51-56. 2008.

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