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한국 약용작물의 기술 동향 및 특허 전망

최지원* · 김수연** · 유고은*** · 김창국***†
*농촌진흥청 국립원예특작과학원, **농업기술실용화재단, ***농촌진흥청 국립농업과학원

Technology Trends and Patenting Prospects of Medicinal Plants in Korea

Ji Weon Choi*, Su Yeon Kim**, Go Eun Yu*** and Chang Kug Kim***†
*National Institute of Horticultural and Herbal Science, RDA, Wanju 55365, Korea.
**The Foundation of Agricultural Technology Commercialization and Transfer, Suwon 16429, Korea.
***National Institute of Agricultural Sciences, RDA, Jeonju 54874, Korea.

ABSTRACT

Background: Medicinal plants are widely used in Asia. They have proven to be an invaluable asset in modern drug discovery and their demand has been steadily increasing across various industries.

Methods and Results: Using 4,867 valid patents related to 12 oriental medicinal plants of 10 country groups, the growth and development potential of patents was evaluated. The cites per patent (CPP) and patent family size (PFS) indices were used to evaluate the market capability and technological level of the collected patents. Meanwhile, the patent impact index (PII) and technology strength (TS) were used to compare the technological competitiveness of patents among various technology types and markets. Both CPP and PFS indices showed that magnolia-vine and balloon flower have numerous core or original patents. Furthermore, an increase in both PII and TS indices was observed. A newly designed intellectual property multi-layer (IPM) model predicted that the medicine, genome and cosmetic categories have a high possibility of patent application growth.

Conclusions: The IPM model can be used to provide the scope of particular technology fields for patent development. In addition, this study can assist patents to advance in the international market and guide the development of a national industrial strategy.

Key Words: Chinese Medicine, Medicinal Plants, Patent Index

INTRODUCTIONS

Medicinal plants, source of life-saving drugs, are used in medicine to prevent disease, maintain health, and cure sickness. Currently, eighty percent of the world's population uses herbal medicine for some aspect of primary health care (Lu *et al*., 2011). The world market for medicinal plants is estimated to be $60 billion annually (Yu *et al*., 2018). Traditional medicinal plants have proven to be an invaluable asset in modern drug discovery and their demand is increasing in pharmaceutical, cosmetic and food industries with trends favoring products based on natural substances (Amaral and Fierro, 2013; Serafini *et al*., 2014).

Claims of intellectual property (IP) rights to traditional knowledge of medicinal plants have been made (Timmermans and Berg, 2003). IP is a strategic asset for economic and technology development by industries (Smith Richard *et al*., 2009) and governments (Choi *et al*., 2011). Its analysis provides the information necessary to prevent overlap among competing research efforts and misguided investment (Han, 2010).

Indices of technology levels, research trends, and international competitiveness associated with different types

†Corresponding author: (Phone) +82-63-238-4555 (E-mail) chang@korea.kr
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of patents are used in IP analysis (Yoon *et al*., 2012). Generally speaking, patents are the most important type of IP protection. Patent law protects new products, processes, and uses related to medicinal plants. Many existing patents are focused on the use of medicinal plants in therapies and foods (Sahoo *et al*., 2011). Geographical indicators identify products as having characteristics associated with their place of origin. The World Intellectual Property Organization (WIPO, 2018) is primarily concerned with IP protection of traditional medical knowledge against unauthorized use by third parties. IP protection of traditional medical plants does not deal specifically with genetic resources, however, holders of traditional medical knowledge may fail to obtain patents because of a lack of novelty in their patent applications.

In Korea, researchers are applying modem chemical and pharmacological methods to conduct research on specific compounds extracted from medicinal plants (Kim *et al*., 2018; Seong *et al*., 2018). Oriental medicine differs from Western medicine in its basic medical orientation, physiological theories, etiologies, diagnostics, therapeutics, and pharmacology (Fang, 2003). There have been several reviews of IP prospects for oriental medicinal plants in various countries (Fang, 2003; Hsiao, 2007; Pan *et al*., 2011; Sahoo *et al*., 2011). It remains unclear, however, how patents for oriental medicinal plants could best be developed.

The study attempted to use patent indices in identifying the most promising fields for innovations based on 12 oriental medicinal plants by analyzing the patenting trends of 10 country groups.

MATERIAL AND METHODS

1. Collection of patents

Patents of 12 oriental medicinal plants using worldwide intellectual property service and patent cooperation treaty of World Intellectual Property Organization issued from January 2006 until December 2017 in 10 country groups were collected (PCT, 2018; WIPS, 2018).

The top 12 plants based on production rankings in Korea were selected namely: (KOSIS, 2018) magnolia-vine (*Schisandra chinensis*), balloon flower (*Platycodon grandifloras*), Cynanchi wilfordii radix (*Cynanchum wilfordii*), Hasuo (*Pleuropterus multiflorus*), Tian ma (*Gastrodia elata*), Sheng di huang (*Rehmannia glutinosa*), Chinese liquorice (*Glycyrrhiza uralensis*), Chinese boxthorn (*Lycium chinense*), Chinese yam (*Dioscorea polystachya*), Milk vetch (*Astragalus mongholicus*), Korean angelica (*Angelica gigas*), and Korean blackberry (*Rubus coreanus*).

Meanwhile, the 10 country groups were China, Europe Union (EU), India, Indonesia, International patents (PCT), Japan, Korea, Taiwan, USA, and Vietnam. The EU collects patents from its 31 member states, including France, Germany and the United Kingdom, which are also members of the European Patent Treaty.

2. Classification and screening of patents

In order to remove noise from the collected patent data, the collected patents were verified in four steps. First, representative technical keywords related to the 12 selected plants were selected by performing a reference search. Second, a total of 9,182 patents were collected from national patent registries based on the selected keywords. Third, a total of 3,498 redundant patents were removed based on the application number and title. In addition, based on the title, abstract and contents of the patents, duplicate patents were manually removed using the country-specific patent searching systems in China (SIPO, 2018), India (IPI, 2018), Indonesia (MLHR, 2018), Japan (JPO, 2018), Korea (KIPRIS, 2018), Taiwan (TIPO, 2018), and Vietnam (NOIP, 2018). Lastly, the specification and demand scope of the patents were analyzed. Eight hundred seventeen patents that were not related to the 12 selected plants after consultation with medicinal plant experts were removed.

The four-step verification process left us with 4,867 effective patents. The effective patents were classified into five technology categories such as genome, manufacture, food, medicine, and cosmetics. When a patent was duplicated in two or more technology categories, it was classified into only one core category based on its importance.

3. Intellectual property portfolio (IPP) model for technology growth evaluation

The IP portfolio (IPP) is a collection of IPs owned by a single entity. IPP analysis can suggest strategies to reduce investment risk in the future (Lin *et al*., 2006).

An IPP model was established to evaluate the growth stage of technologies related to the 12 medicinal plants, which were classified into five categories: beginning, growth, maturity, decline, and recovery.

For each medicinal plant in each country group, an IPP value (IPP_t) was determined, where t has a value from I to V corresponding to five time periods: I (2006 - 2007), II (2008 - 2009), III (2010 - 2011), IV (2012 - 2013), and V (2014 - 2015). The IPP_t was calculated by dividing the number of patents existing in the registries by the number of applicants during each period interval. However, the IPP value for the period 2016 - 2017 was not computed because of closed patents within that period. The IPP model was obtained from equation (1)

$$IPP_{st} = \frac{\sum_{j=1}^{m} p_j}{\sum_{i=1}^{n} A_i}, \quad s = 1 \text{ to } 12,\ t = 1 \text{ to } 5 \qquad (1)$$

where (s) are the 12 medicinal plants, (t) is the period interval, P_j is the total number (m) of patents (j), and A_i is the total number (n) of applicants (i).

4. Intellectual property emerging (IPE) model for the technologies development potential

The IPE values were used to estimate the development potential and competitive advantage of the medicinal plants in the five technology categories (genome, manufacture, food, medicine, and cosmetics) based on strategic positioning (Grimaldi *et al.*, 2015) and patent growth rate (KIPI, 2005).

The strategic positioning of each patent was represented by the patent share ratio which is the ratio of each technology category to the total number of patents. The patent growth rate was represented by the growth rate which is the annual increase ratio of patents in the each technology category. The IPE values (IPE_s) for each plant from 2006–2015, where s has a value from 1 to 12 corresponding to the 12 medicinal plants were computed using the equation (2)

$$IPE_s = 100(TC_i/TP) \cdot (AI_i), \quad s = 1 \text{ to } 12,\ i = 1 \text{ to } 5 \qquad (2)$$

where (s) are the 12 medicinal plants, (i) is each technology category (i.e., genome, manufacture, food, medicine, and cosmetics), TC_i is the number of patents owned by each technology category (i), TP is total number of patents, and AI_i is the annual increase ratio of patents owned by each technology category (i).

Using the IPE_s, five technology categories were positioned into four quadrants of a scatter plot: upper right, continuous application; upper left, increase in recent applications; lower left, infancy applications; and lower right, decrease in recent applications.

5. Intellectual property indices for technology level and competitiveness

The level of technology development related to the 12 medicinal plants using a cites per patent (CPP) and patent family size (PFS) indices were assessed.

The CPP gives the number of citations for patents to estimate the effect that patents have on technology development. A high CPP value suggests that a core patent or original patent has a high quality level. However, if the technology was developed recently, the CPP value may be lower because of fewer citations regardless of the importance of the technology (KIPI, 2005). The CPP index is an indicator of which patents in the target group (or country) have had a significant impact on subsequent innovation activities. The CPP was calculated using equation (3)

$$CPP_s = \frac{P_i}{R_i}, \quad s = 1 \text{ to } 12 \qquad (3)$$

where (s) are the 12 medicinal plants, P_i indicates the cited numbers of patent (i), and R_i indicates the registered numbers of patent (i).

The PFS shows the importance of patents in commercial markets (Choi *et al.*, 2014). The “patent family” indicates that the same patent remains in one or more patent offices of the country and this factor is interpreted as the degree of effort put forth to commercialize patents (Harhoff *et al.*, 2003). A high PFS value is presumed to indicate an important patent with a high market power (Hicks *et al.*, 2001). PFS was obtained from the equation (4)

$$PFS_s = \frac{\sum_{i=1}^{m} F_i}{\sum_{i=1}^{n} P_i}, \quad s = 1 \text{ to } 12 \qquad (4)$$

where (s) are the 12 medicinal plants, F_i is the number (m) of parent family owned by patent (i) in a given country, and P_i is the total number (n) of patent (i) in that country.

The patent impact index (PII) and the technology strength (TS) index was used to evaluate the technological competitiveness of the 12 medicinal plants. The PII gives the degree to which other patents cite a given patent after it is registered. A high PII value indicates high technological competitiveness 3 (Huang *et al*., 200). The PII is a relative importance index that considers the technical level of the other patents that cite a given patent. It is generally used to identify relative skill levels that cannot be identified by the CPP index (KIPI, 2005). The PII is obtained from equation (5)

$$PII_s = (SP_a/SR_a)/(TP_i/TR_i),\ s = 1 \text{ to } 12 \quad (5)$$

where (s) are the 12 medicinal plants, SP_a is the number of forward citations of specific patent (a), SR_a is the number of registrations of the specific patent (a), TP_i is the number of forward citations of total patents (i), and TR_i is the number of registrations of total patents (i).

The TS index simultaneously evaluates the quality and quantity of each patent. A high TS value means that a patent has strong technical power. The TS index can give an unbiased estimate of the level of technology, because it uses both registered and cited patents (Chen *et al*., 2007). The TS index for the 12 medicinal plants was calculated using equation (6)

$$TS_s = PII_s \times \Sigma_{i=1}^{t} TP_i,\ s = 1 \text{ to } 12 \quad (6)$$

where (s) are the 12 medicinal plants, PII_s is the patent impact index for 12 medicinal plants, and TP_i is the total numbers (t) of patent (i).

6. Intellectual property multi-layer (IPM) model for patent strategy

In order to present the best direction for research and development in each country group, a multi-layer patent model was developed with three factors. The IPM model was obtained from equation (7)

$$IPM_s = (B \cdot E \cdot F)_i\ s = 1 \text{ to } 12,\ i = 1 \text{ to } 5 \quad (7)$$

where (s) corresponds to each of the 12 medicinal plants, and is the blank technology (B), entry barrier (E), and future growth (F) of patent category (i).

Although the definition and scope of B, E and F were partly previously reported, in this equation, the following components were still defined. B represents the patent share ratio (for a specific category field or country group) relative to the total number of patents. It indicates the existence of undeveloped technologies with few related patents and few major applicants. B was classified according to the number of patents in a given category registered in the official patent office. If the patent registration rate is low, the relevant technology is widely developed, thus there is a risk of failing to develop a new patent in the related field. E represents how many patents were registered in the technology category. Meanwhile F reflects the rate of increase in the number of patents in a given category. If the number of registered patents in a given category increased rapidly during the period 2014 - 2015, it is assumed that the potential for future growth is high. A distribution-free ordinal logistic regression was used to complete the model (Endresen and Janda, 2015). The three factors of the model (i.e., B, E, and F) were quantified using a Likert scale with five ordinal levels (Sullivan and Artino, 2013; Wu and Leung, 2017).

The points were assigned on the Likert scale based on a survey of 30 members of the patent committee of the Foundation of Agricultural Technology Commercialization (https://www.fact.or.kr/) and Rural Development Administration (http://www.rda.go.kr/) in Korea. Ordinal logistic regression analysis were conducted using the SAS/STAT 12.1 software (SAS Korea, Seoul, Korea).

RESULTS

1. International patent trends for medicinal plants

Of the 4,867 effective patents selected through the verification process of the collected patents, Korea had the highest number of effective patents at 2,424 (49.8%), followed by China at 1,958 (40.2%), USA at 159 (3.2%), and Japan at 120 (2.5%). Of the 12 medicinal plants, magnolia-vine and balloon flower accounted for 71% of the total patents. The proportional representation of the five technology categories among all of the patents was 38% medicine, 32% food, 17% manufacture, 8% cosmetics, and 5% genome. China, Japan, Korea and USA accounted for 95% of the total patent applications which

Table 1. Classification of effective patents between 12 medicinal plants and 10 country groups.

Category	Groups			Classifications[2)]					Periods[3)]				
	Korea	China	Others[1)]	G	Ma	F	Me	C	1	2	3	4	5
Magnolia-vine	1,188	497	296	71	226	1,013	507	164	292	353	391	417	392
Balloon flower	200	1,262	56	83	73	250	1,075	37	90	199	330	594	255
Cynanchi wilfordii	39	9	1	6	19	6	14	4	1	4	6	7	15
Hasuo	73	0	4	5	20	14	12	26	11	15	18	14	12
Tian Ma	125	68	1	26	92	51	22	3	21	24	33	46	37
Sheng Di Huang	20	17	14	0	9	8	21	13	6	5	8	10	17
Chinese Liquorice	161	25	56	12	85	44	58	43	42	47	46	41	48
Chinese boxthorn	85	22	13	8	41	31	23	17	14	18	23	27	24
Chinese yam	50	21	7	4	25	22	19	8	10	11	19	14	13
Milk vetch	88	2	20	6	38	19	30	17	18	25	17	20	21
Korean angelica	191	14	16	12	96	42	41	30	27	45	38	39	54
Korean blackberry	204	21	1	11	109	64	28	14	43	38	28	46	51
Total	2,424	1,958	485	244	833	1,564	1,850	376	575	784	957	1,275	939

[1)]Others; EU, India, Indonesia, PCT, Japan, Taiwan, USA, and Vietnam, [2)]Classification; G (genome), Ma (manufacture), F (food), Me (medicine), C (cosmetics), [3)]Periods; 1 (2006 - 2007), 2 (2008 - 2009), 3 (2010 - 2011), 4 (2012 - 2013), and 5 (2014 - 2015). Period 6 (2016 - 2017) is omitted because of closed patents.

is largely attributable to the fact that the investigated plants are oriental medicinal plants produced and consumed mainly in Asia.

The number of patents registered per year increased until 2012 and then decreased in the latter period. The magnolia-vine and balloon flower had the highest number of registered patents in all of the periods, but recently there was an increase in the number of patents for Korean angelica (Table 1).

2. Evaluation of technology growth

In order to evaluate the technology growth of each plant, the growth stage of technologies using IPP model based on the correlation between the number of existing patents and the number of patent applications were investigated. China and Korea are the leading countries in whole technology growth related to the 12 medicinal plants.

For example, the magnolia-vine plant is in the decline stage because the numbers of patents and applicants continually increased from the first time period to the fourth time period, but they subsequently decreased in the fifth time period [Fig. 1 (A)]. The growth pattern of the

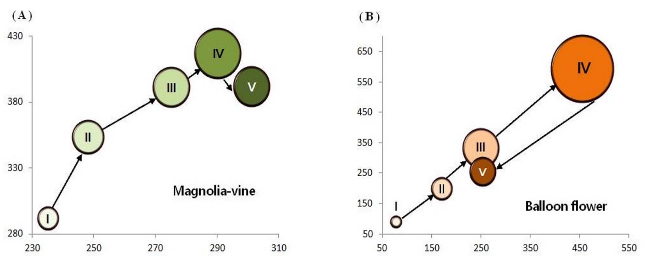

Fig. 1. Landscape of technologies related to two medicinal plants based on the IPP model of magnolia-vine (A) and balloon flower (B). The time periods were; I (2006 - 2007), II (2008 - 2009), III (2010 - 2011), IV (2012 - 2013), and V (2014 - 2015). x-axis; number of applicants. y-axis; number of patents. The arrow direction is the time flow of periods. The circle sizes indicate the relative correlation between numbers of patents and applicants while the circle color indicates each medicinal plant.

balloon flower is similarly in the decline stage [Fig. 1 (B)]. However, trend of remaining 10 plants was unclear because of fewer patents or too few applicants.

In each country group, IPP model indicates that all country groups are at the beginning stage of technology growth except for China, Japan, Korea and USA. China is in the maturity stage of technology growth; the

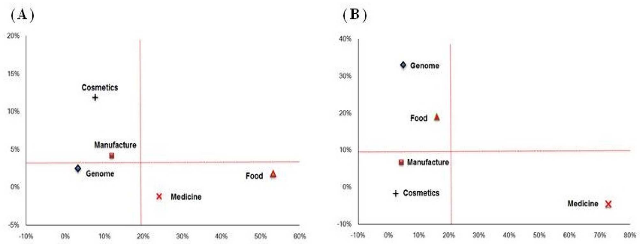

Fig. 2. IPE model landscape of the potential for technology development based on magnolia-vine (A) and balloon flower (B). x-axis; share ratio of patent. y-axis; increasing ratio of patent. The red line is average value of share ratio of patent (x-axis) and increasing ratio of patent (y-axis). The red line indicates the quadrants, upper right; continuous application, upper left; increase in recent applications, lower left; infancy applications, lower right; decrease in recent applications.

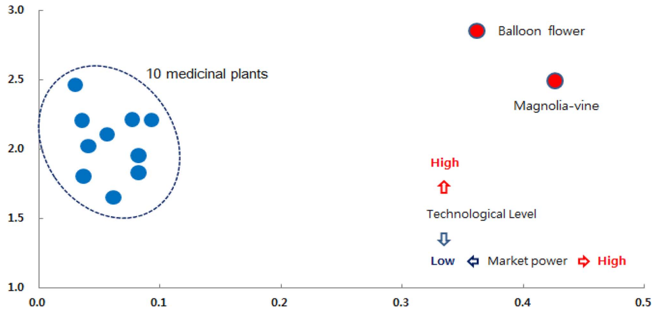

Fig. 3. The graph shows the distribution of technological levels and market power based on the CPP and PFS indices for the 12 medicinal plants. The magnolia-vine and balloon flower have level of technology and strong market capability. The 10 medicinal plants have an average technology level with low market capability. x-axis; patent family size (PFS), y-axis; cites per patent (CPP).

numbers of patents and applicants continually increased from the first time to the fourth time period and subsequently declined in the fifth time period.

The changing of patents indicates that rapid technological progress occurred between the third and fourth time periods. Korea is in the growth stage of technology growth because the numbers of patents and applicants both increased in the all of the time periods. Japan and USA are in the decline stage since the numbers of patents and applicants steadily decreased in all the time periods.

3. Potential development

In the 12 medicinal plants, IPE model indicated an increase in recent applications for cosmetics technologies, an infancy stage for genomics technologies, and continuous applications for medicine and food technologies.

For the magnolia-vine, there was an increase in applications for cosmetics technology and a decrease in applications for food and medicine technologies [Fig. 2 (A)]. On balloon flower, there was an increase in applications for genome technology and food technologies [Fig. 2 (B)]. However, the category is expected to have high potential for development due to an increase in the use of materials in natural products such as pharmaceuticals and cosmetics (Pan *et al*., 2011). In the other 10 plants, Tian ma and Milk vetch showed an increase in applications for food technology. The sheng di huang, Chinese liquorice, Chinese boxthorn showed an increase in applications for medicine technology.

In the 10 country groups, IPE model was not meaningful because of small numbers of patents except in magnolia-vine and balloon flower. However, China and Korea had the greatest numbers of patents and applicants in all of the technological categories. For the magnolia-vine, China had a high growth and market share in food category while Korea had an increasing applications in the cosmetics category. For the balloon flower, China and Korea were the most active in food technology development. The other country groups had no meaningful rise in technology categories because of the small numbers of patents.

4. Technological level and competitiveness

In order to evaluate the technological level of the 12 plants, the CPP and PFS indices were used. The CPP index evaluates the quality level of technology development and technological influence while PFS index evaluates the market capability and power.

The magnolia-vine and balloon flower had a lot of core patents or original patents which together had both high level of technology and strong market capability. The other plants had an average technology level with low market capability (Fig. 3).

In order to evaluate the technological competitiveness of the 12 plants, the PII and the TS index were used (Table 2). The magnolia-vine and balloon flower showed increases in both indices. For the balloon flower, the TS index increased despite stagnation in the PII. This was

Table 2. Classification of the number of patents, patent impact index (PII), and technology strength (TS) index in two intervals for the 12 medicinal plants.

Category	Patents		PII		TS	
	Before[1)]	After[2)]	Before	After	Before	After
Magnolia-vine	371	485	0.77	1.03	490.4	1,132.7
Balloon flower	112	443	1.17	1.18	337.0	1,375.9
Cynanchi wilfordii	2	16	0.90	0.79	3.6	26.1
Hasuo	17	21	0.69	0.88	18.0	36.2
Tian Ma	28	77	0.73	0.67	32.7	77.6
Sheng Di Huang	8	11	0.51	1.36	4.6	44.7
Chinese liquorice	46	66	0.68	0.83	46.8	100.3
Chinese boxthorn	21	28	0.69	1.07	22.0	70.3
Chinese yam	8	32	0.90	0.65	14.5	29.9
Milk vetch	36	25	0.54	0.80	23.2	35.0
Korean angelica	54	77	0.60	0.72	43.4	87.4
Korean blackberry	58	61	0.63	0.88	51.1	110.3

[1)]Before; (2006 - 2010), [2)]After; (2011 - 2015).

possible since the balloon flower was more influenced by the quantitative number than the qualitative level.

PII considers only the qualitative level of technology, whereas the TS index reflects both the qualitative level and quantitative measures. The other plants require aggressive marketing because of the average quality of the technology along with low market capability. The Sheng di huang plant had the highest PII despite its low TS index, indicating that it had the highest-quality patents among the 12 medicinal plants. The *Cynanchi wilfordii* radix plant had the greatest increase in TS index despite a decrease in its PII and low number of patents meaning there is a recent and rapid increase in the number of patents although there is a decrease in the level of technology.

5. Patent development strategy

In order to present a patent development strategy, a newly designed IPM model based on three factors (i.e., blank technology, entry barrier, and future growth) was used.

Our model predicted the best technology category for future patent development. For magnolia-vine, cosmetics technology was predicted as the proposed field for patent applications and medicine technology as the high-risk field for investment because of little blank technology and a high entry barrier [Fig. 4 (A)].

The ordinal logistic regression analysis for magnolia-vine showed that two factors have statistically significant p - values: blank technology and entry barrier (p - value $<$ 0.01 for each factor), although the future growth factor was not significant (p - value = 0.17). Although various technology categories are predicted the best field for patent applications, ordinal logistic regression of the three factors was not significant in other plants except magnolia-vine and balloon flower.

In the technology categories for all medicinal plants the comparison of 12 plants was not significant due to some medicinal plants having small number of patents. The best medicinal plant was screened based on each technology category using a low entry barrier with two high factors (i.e., blank technology and future growth).

Our model indicated that medicine, genome, and cosmetic categories had high possibility of growth for patent applications while food and manufacture categories had low possibility for future patent development. For medicine category, the Korean blackberry, Chinese boxthorn, and Korean angelica were predicted to be the most valuable medicinal plants while balloon flower and Chinese yam will have high risks in future patent development [Fig. 4 (B)].

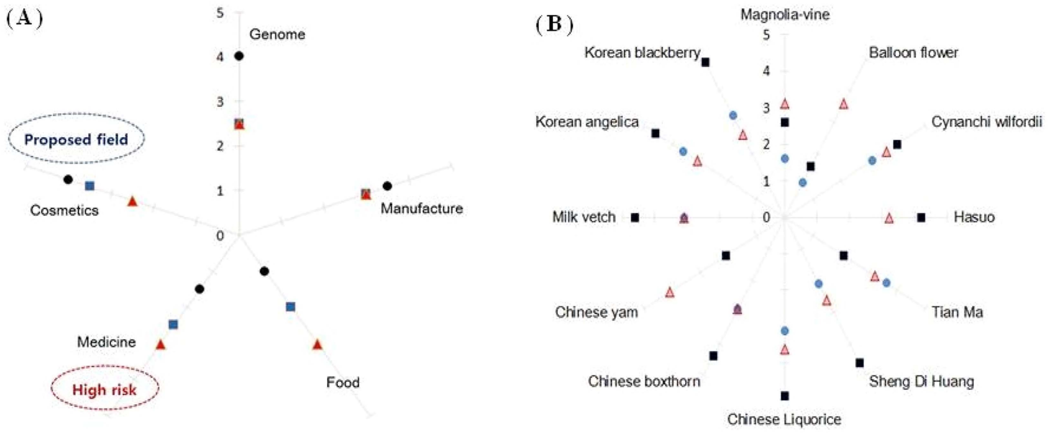

Fig. 4. Radar chart of the relative Likert scale [0 (lowest) to 5 (highest)] with three technical factors (i.e., blank technology, entry barrier, and future growth). Blue circle; blank technology, Black square; future growth, Red triangle; entry barrier. (A) Evaluation of magnolia-vine based on three factors in country groups, (B) Graph plot of medicine technology category based on three factors in 12 medicinal plants.

DISCUSSIONS

The international patent trends for 12 medicinal plants showed that patents increased until 2012 and then continually decreased. The decrease coincided with the onset of financial crises in the USA and EU which started in 2008 and had a lingering impact on the economies of Asia. Such international crises are likely to have significant effects on various economic and industrial sectors (Kahler, 2013; Felix and Roy, 2014). However, decreasing trends of registered patents after 2016 was related to the patent rule that keeps patents closed for 18 months after registration (Yun *et al*., 2011).

In recent years, the production of medicinal plants increased as they have become increasingly popular as health foods and natural medicines in Asia (KOSIS, 2018). Chinese herbal medicine industry has been selected as a top growth engine and its market size is continuously growing with the help of support policies in Asia (Lin *et al*., 2018).

Currently, China is implementing policies to develop traditional medicines in global markets for medicinal resources (NDRC, 2016). On the other hand, Korea is attracting attention on high-value-added industrial materials that complement shortcomings in modern medicines (Kim *et al*., 2015).

Japan, is only focusing on the commercialization and safety of imported products since other country groups are considered to have low interest in medicinal plants due to low domestic market size (Iwase *et al*., 2012).

In the technological level with CPP and PFS indices, magnolia-vine and balloon flower had a lot of core patents while other plants had an average technology level with low market capability. Although the technological level has dropped, Sheng di huang and *Cynanchi wilfordii* radix plant increased in the number of patents. The result is consistent with the rapid increase in the demand in the Korean market and the introduction of health foods containing *C. wilfordii* radix in Japan (Sato-Masumoto *et al*., 2017). Therefore, it is assumed that the technology level of those medicinal plants will increase in the future since the number of patents associated with those plants were increasing rapidly (WIPS, 2018).

In addition, it is suggested that patent development for 10 medicinal plants is more important in acquiring many patents for consumers and marketing even though the patent has a low technology level. In the technological competitiveness with PII and the TS indices, 10 medicinal plants except magnolia-vine and balloon flower required aggressive marketing because of the average quality of the technology along with low market capability.

For the patent development strategy for each medicinal plant, IPM model predicted the developmental possibility of specific technology category. In the case of magnolia-vine, the model indicated that cosmetics technology is the best field for patent applications. The magnolia-vine continues to grow in the natural premium and multi-functional cosmetics market (Kumar, 2005).

Cosmetics field is advantageous for opening new markets because it does not require large-scale clinical trials and long-term investment (Evans, 2009). The proposed cosmetics category is similar to the increasing trends identified using the previous IPE model.

In the possibility of future patent development for all medicinal plants, three technology categories (i.e., medicine, genome, cosmetics) were predicted to have a high possibility of growth for patent applications. However, the ratio distribution of patent registration showed that the food and medicine categories were the lowest areas having low growth potential due to many existing patents. Nevertheless, the development of patents in the medicine category is expected to increase because of the increased demand for new drug development in traditional medicinal plants.

Its, for medicine category, Korean blackberry, Chinese boxthorn, and Korean angelica were predicted to be the most valuable medicinal plants. These three plants are mainly used as functional teas in Asia with high potential for patent development because of projected increase in global tea consumption and production (FAO, 2018).

On the other hand, patent development for balloon flower and Chinese yam has a high risk. Chinese yam has a high level of patented technology despite the small numbers of patents and balloon flower had the highest level of technical competence based on the PII and the TS index. Hence, the risk associated with developing new technologies in balloon flower is high because of intense competition.

The study collected 4,867 valid patents issued from January 2006 to December 2017 for 12 oriental medicinal plants by screening the patenting trends in 10 country groups. Using various methods of IP analysis, patent indices, and multi-layer modeling, the competitiveness of technology categories for development based on oriental medicinal plants in the world market were predicted. This prediction of future trends in patent technologies can help governments and enterprises formulate research and development strategies for rapidly expanding markets. New insights were provided using a newly designed intellectual property multi-layer model based on blank technology, entry barriers, and future growth factors. The model can be used to provide the scope of particular technology fields and to increase patent holders' competitiveness given their patent development strategy.

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