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RESEARCH ARTICLE

Cultivation, and Production for Enhanced Commercial and Pharmaceutical Applications of Kariyat (*Andrographis paniculata*) Products, Phayao Thailand

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ABSTRACT

The primary objectives of this research were to promote the production of Kariyat (*Andrographis paniculata*) that meets standardized quality criteria and to enhance and optimize the productivity of Kariyat for commercial viability. These objectives were pursued through a series of participatory meetings, crop evaluations, soil and chemical residue analyses, and the preparation of raw materials for the production of capsules and extracts. The findings of this study demonstrate that Kariyat thrives optimally in loam soil with electrolytic conductivity levels below 2 dS/m and under light intensities ranging from approximately 968.4 to 1936.8 lux. These conditions were found to be conducive to the production of critical bioactive substances within the plant. Specifically, analysis of the active compounds revealed that 100 grams of dried Kariyat contain 2.32 grams of andrographolide, sufficient for the development of product prototypes, including Kariyat capsules, a neck spray, and other formulations eligible for modern drug registration. Furthermore, an economic analysis of the production costs and profitability associated with Kariyat cultivation was conducted. The total production cost was estimated at 85,402.5 baht. The profitability analysis indicated that selling Kariyat of grade B (with over 2% andrographolide content) yields a profit of 1,334 baht, while grade A Kariyat (with over 3% andrographolide content) yields a profit of 1,601 baht. This represents a profit margin approximately 30% lower than that achieved through cultivation practices.

INTRODUCTION

Kariyat or Fah Talai Jone in Thailand has leaves consisting of several kinds of significant substances, particularly lactone groups such as andrographolide, neo-andrographolide, and 14-deoxy-andrographolide (Hossain et al., 2014; Santos-Neto et al.,2006), and China has utilized this herbal leaf for a long time, using anti-bacterial and anti-fungus (Mishra et al., 2013). In addition, pharmaceutical experiments illustrated that Fah Talai Jone was of therapeutic importance including anti-inflammatory (Chandrasekaran et al., 2011), anti-cancer, immunostimulatory (Ajaya Kumar et al., 2004), and anti-malarial (Guan et al., 2011). In the same way, Banphaeo-hospital (2011) examined the therapeutic effect of diarrhoeal disease, dysentery, and bacterial illnesses compared to tetracyclines in 200 patients (16-55 years old) who were investigated the amount of stool duration, diarrhoeal times, and saline solution replaced between Kariyat extract and tetracyclines. As a result, Kariyat extract plummeted the amount of diarrhea, and saline water was satisfactorily replaced, which a statistical experiment would be insignificant whereas decreasing cholera in Kariyat extract was not as effective as tetracycline. Moreover, some local hospitals offer Kariyat to maintain throat Inflammation suitably, and it is similar to penicillin when compared to conventional medicine (Banphaeo Hospital, 2011). Specialists have been dramatically interested in using this herb to retain

several illnesses, especially COVID-19 in the past periods, and scientists have provided it for tertiary care, including distributing drugstores and 7-Eleven

Advocating agriculturists to plant Kariyat trees in the past revealed the outcomes of Kariyat leaves that were grown by farmers, resulting in the performance of significant substances and increased value of agricultural products. Therefore, the authors emphasized the importance of improving and expanding the planting areas in Phayao province dramatically and provided knowledge of University of Phayao to develop agriculturists for manufacturing product quality as well as processing products that have safety standards according to criteria and methods for producing modern medicines in 2011 that comply with the GMP PIC/S (Pharmaceutical Inspection Cooperation Scheme) (PIC/S Secretariat, 2024); the quality classification of raw material, standard capsules, sanitary laboratories, the high standard assessment of machines, and analyzing products during the pharmaceutical manufacturing process until they become complete pharmaceutical products because we have determined in the manufacturing modern medicine with high standard correspond to legal benchmarks and modern medicine registration for obtaining productive response in order to demands of consumers, including productively expanding product distribution channels.

MATERIALS AND METHODS

Planting Kariyat trees

Young trees of approximately 8,800 were planted with organic agriculture in an area equal to 1,600 square meters, which consisted of 7 positions in Ban Tun, Mueang Phayao, Phayao province. After that, all 7 plots were scientifically investigated for soil assessment and pesticide residue. In addition, when Kariyat aged roughly 120 days, they would be measured in height rate, the number of leaves, and the number of branches.

Kariyat manufacture and processing

After Kariyat aged roughly 120 days, agriculturists would harvest raw materials by using standard procedures according to the GMP PIC/S (Pharmaceutical Inspection Cooperation Scheme), which is an official medicine production standard (PIC/S Secretariat, 2024) and followed by Kariyat manufacture and processing in Figure 1. In the next step, Kariyat leaves were ground in a blender until they were a rough powder. Then, Kariyat powder was soaked in 25% ethanol for 7 days, and the solution was filtered with filter paper No. 5. After that, the extract was evaporated in a rotary evaporator at 60 °C until the ethanol solution was completely evaporated. Finally, the extracted powder of approximately 100 g was measured andrographolide by HPLC-DAD/MSD and repeated five times (Chougule et al., 2018). Moreover, the extracted powder was manufactured into prototypes of two products, quantity: 100 pieces each, as well as one product, could be the certificate of modern drug registration, including calculating production costs and net income.

Figure 1: Kariyat manufacture and processing.

RESULTS

The growth of Kariyat trees

Figure 2 depicts planting Kariyat trees in the shaded areas, in all 7 plots, and it was illustrated that Plot 3 had a percentage of height, number of leaves, and number of branches as 6.12, 11.02, and 6.96%, respectively, which had the highest rate when compared to other positions, and following by Plot 7 revealed that stem heights were 5.55%, 8.64% of leaves growth, and 5.98% of branches growth, and Plot 1 illustrated that 4.79, 9.31, and 4.89%, sequentially. Furthermore, the lowest growth rate of Kariyat trees was plot 6 at 2.15, 3.29, and 1.28%, respectively.

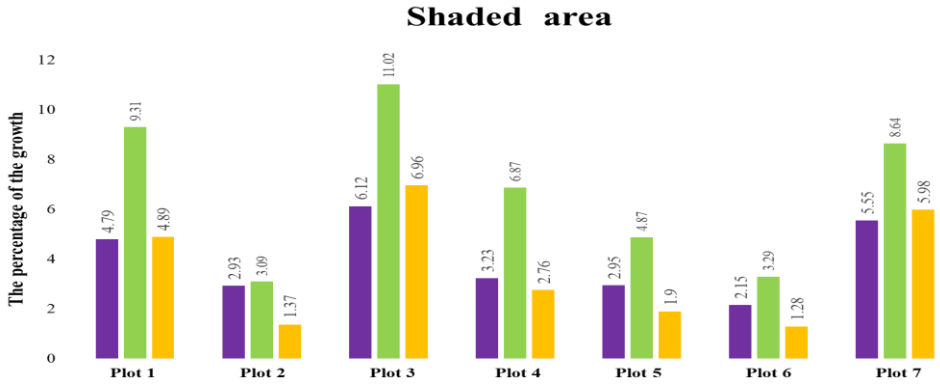

Figure 2: The growth of Kariyat trees in the shaded areas.

Note: Purple bar chart = the percentage of Kariyat height.

Green bar chart = the number of Kariyat leaves.

Orange bar chart = the number of Kariyat branches.

Furthermore, the provided graph compares information associated with the percentage of height, number of leaves, and number of branches exhibited that the swiftly high growth of Plot 1 had stem lengths of approximately 6.81%, leaves of about 16.03%, and petioles of 10.42%, and following by Plot 2 demonstrated that the development rates of all 3 parts of plant offered 7.14, 14.49, and 8.79%. In terms of Plot 4, Plot 5, and Plot 7, the growth rate remained steady and was equal, Plot 5 was 4.05, 7.77, and 2.88%, sequentially. In addition, the lowermost growth rate of Kariyat trees was Plot 4 at 3.53, 7.31, and 3.08%, followed by Point 7 had the percentage of stem height, leaves, and petiole improvement at 3.82, 6.30, and 2.08%, respectively)Figure 3).

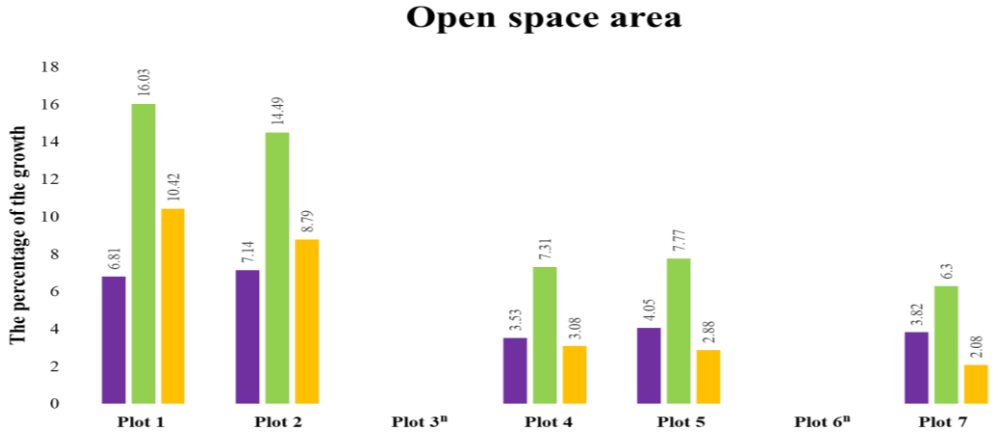

Figure 3: The growth of Kariyat trees in the open space areas.

Note: Purple bar chart = the percentage of Kariyat height.

Green bar chart = the number of Kariyat leaves.

Orange bar chart = the number of Kariyat branches.

n = Kariyat was not planted in the open space areas

Kariyat manufacture and processing

The extracted powder of approximately 100 g was measured andrographolide by HPLC-DAD/MSD and repeated five times, illustrating that 100 g of the extracted powder provided andrographolide roughly 2.32 g/100g, according to Table 1. Furthermore, other parts of the plant were examined for andrographolide, which showed 0.751%w/w of the stem, 3.572%w/w of the leaf, and 0.159%w/w of the sheath (Table 2).

Table 1: An examination result of Andrographolide in the Kariyat powder

Item	A result	Unit	LOD	Method
Andrographolide)AP1(	2.32	g/100g	-	HPLC-DAD/MSD

Table 2: An examination result of Andrographolide in other parts of the Kariyat

Item	Andrographolide)%w/w(
stem	0.751
leaf	3.572
sheath	0.159

Production costs and profit of manufacturing Kariyat products

The authors schemed to manufacture Kariyat products as well as deposit a budget for evocating this project, revealing that the initial cost of manufacturing Kariyat products was 69,850 THB, which consisted of 3,500 THB of tractor fuel costs, 3,500 THB of labor costs of driving a tractor, almost 3,000 THB of labor costs (times one), 800 THB of labor costs (times two), 750 THB of cutting grass and associating with using fertilizers approximately 13,700 THB, including 44,000 THB of young trees (Figure 4).

The middle cost of manufacturing Kariyat products (preparing raw materials) comprises cutting off roots (62.1 kilograms), trimming (59.87 kilograms), and incubation (6.67 kilograms), which could compute several costs, such as raw material (purchase 25 THB per kilogram: 25 THB x 62.1 kilograms equal to 1,552.5 THB) as well as an incubation price of 7 days x 2,000 THB as 14,000 THB, and calculated as the total cost of manufacturing Kariyat products in the middle way was 15,552.5 THB.

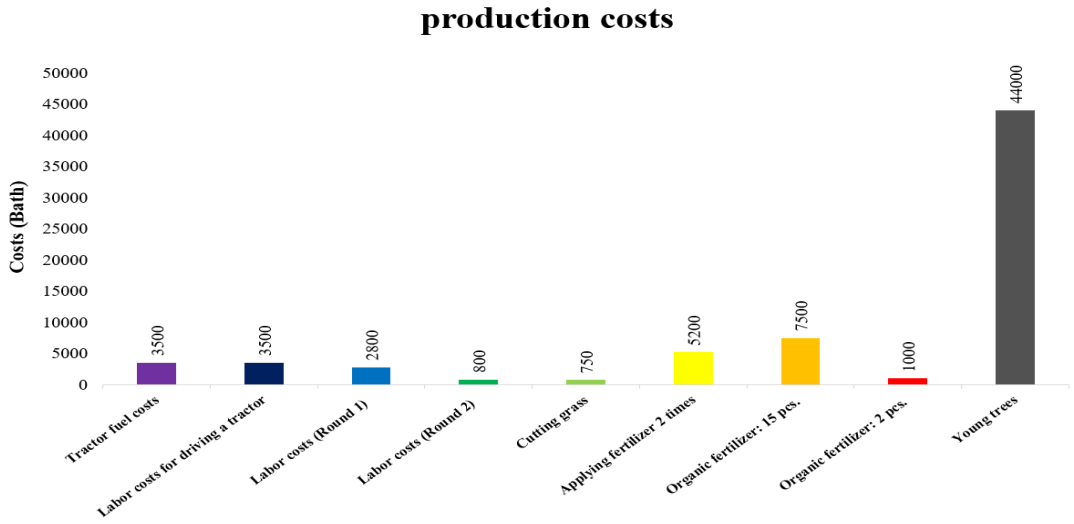

Figure 4: Production costs of Kariyat trees

In terms of destination, raw material purchasing depicted that Kariyat outputs were sold with Bantak Hospital and Tipco that would obtain a profit of approximately 1,334 THB when we offer to sell B-Grade (Andrographolide > 2%) from production costs 85,402.5 costs per 1600 square meters (THB) or 733.1 costs per kg (THB) according to Table 3. Moreover, when we provide to sell A-Grade (Andrographolide > 3%) from production costs 85,402.5 costs per 1600 square meters (THB) or 733.1 costs per kg (THB) according to Table 4, Kariyat products were sold with Bantak Hospital and Tipco that would obtain a profit of approximately 1,601 THB.

Table 3: Production costs of manufacturing Kariyat products and profit from selling B-Grade (B > 2%)

Planting	Cost/ 1,600 square meters)THB(	Cost/kg)THB(	Fresh weight (kg(	Trimming weight)kg(	dry weight)kg(	B-Grade B > 2%)	Profit)THB(
Phayao province	85,402.5	733.1	116.5	59.87	6.67	200	1,334
Department of Agriculture	15,000	37.5	400	200	25	200	5,000

Table 4: Production costs of manufacturing Kariyat products and profit from selling A-Grade (A > 3%)

Planting	Cost/ 1,600 square meters (THB)	Cost/kg)THB(	Fresh weight (kg(	Trimming weight)kg(	dry weight)kg(	A-Grade A > 3%)	Profit)THB(
Phayao province	85,402.5	733.1	116.5	59.87	6.67	240	1,601
Department of Agriculture	15,000	37.5	400	200	25	240	6,000

DISCUSSION

The growth of Kariyat trees

As aforementioned the growth of Kariyat information exhibited that all plots had several different growths, which relied on four factors, such as physical factors, air factors, chemical factors, and nutrient content, and the physical factors of 7 plots revealed that soil characteristics of Plot 1, Plot 2, Plot 3, Plot 4, Plot 5, and Plot 7 were Loam Soil, which had black soil surface and thick soil, and the soil characteristics of Plot 6 were mostly silt and clay that dense topsoil and high humidity, and some points are sandy soil that is factor influenced the lower growth than other beds, according to Leeson)1979(and Strand)1972) mentioned that the most significant factor influencing the levels of impact is the fragility of the soil substrate. In terms of electrical conductivity (ECe), each plot had less than 2 dS/m which was appropriate for developing different parts of the plant. Furthermore, climate factors consist of light, temperature, and relative humidity, and it was found that each location had light-intensity ranges from approximately 1000-2000 foot-candles or about 968.4- 1936.8 lux (Subsorn, 1998) to induce Kariyat growth better than other locations that have less light. We observed that Plot 1, Plot 2, and Plot 5 had some points that had high light intensity, which could induce effectively suitable growth more than the shaded areas. Followed by temperature, and relative humidity in all plots were between 16-30 degrees Celsius and 60-80 percent, respectively, which were greatly suitable for increasing the Kariyat growth, according to Chia and Lim (2022) examined that the optimal relative humidity that could induce the plant growth is 85±2%, including chemical factors and nutrient content found that some beds had roughly 6.7-7.0 pH and nitrogen (N), phosphorus (P),

and potassium (K) were more productive to motivate the growth of Kariyat. According to Parish (1971), the soil should have fertile nutrients and availability.

As said before, it illustrated that *Andrographis paniculata* planting by agriculturists in Phayao Province and Kariyat could generate the prototypes of the products accurately, particularly remedy or inhibited extract of andrographolide from the root, the stem, the leaf, and the branch. Extract properties can treat acute diarrhea, gastritis, ulcerative colitis, throat Inflammation, tonsillitis, etc. Moreover, the growth data of Kariyat can be knowledge to improve and extend outputs that can distribute forward commercial trade worldwide. However, potential challenges or limitations encountered during the cultivation of Kariyat fluctuate the atmosphere in that the agricultural individuals are affected by increasing temperatures, especially the drought, which influences the growth of Kariyat trees. Hence, addressing these drawbacks is the alteration in current farm management, changing appropriate Kariyat species with climate change, changing in planting young trees during new schedules, and using plants and materials for soil improvement (Nirote et al., 2016(, including reducing CO_2 emission from fuel and gases manufacturing products. those addressing are sustainability, and mitigating the environmental impact of Kariyat cultivation and any potential negative effects.

Kariyat manufacture and processing

The planting total of Kariyat was 8,800 young trees per 1,600 square meters in Ban Tun, Mueang Phayao, Phayao province. When plants were approximately 120 days old, Kariyat would be harvested using a benchmark procedure that examined each structure's weight (leaves, stems and pods) equal to 116.5 kilograms. After that, cutting the root and trimming the stem found that the remaining weights were 62.1 and 59.87 kilograms, respectively, and then plants were cleaned and incubated into dry products, resulting in a dry weight of about 6.67 kilograms, and all dry outputs would be entered the Kariyat processing and extraction of essential elements. As a result, dry products of 100 grams provided 2.32 g/100g or 0.0232 g/g of andrographolide which was similar to Kumoro and Hasan (2007). They investigated extraction levels were roughly 0.0174 g of andrographolide per gram in the leaves, and Ge et al. (2002) reported that they obtained 3.81×10^{-3} g andrographolide per gram of dry leaves, which the aforementioned information revealed that Kariyat had high essential substances and efficient inhibition, and could elevate an agriculture product value. Hence, researchers were interested in advocating a certificate of modern drug registration and extending planting areas to other locations in Phayao Province because extracts of this plant and andrographolide exhibit pharmacological activities such as those that are immunostimulatory)Kumar et al., 2004; Rajagopal et al., 2003(, antiviral)Calabrese et al., 2000(, and antibacterial)Singha et al., 2003(. In addition, andrographolide offers biological activities, especially anti-inflammatory, antibacterial, antitumor, antidiabetic, antimalarial, and hepatoprotective)Jarukamjorn and Nemoto, 2008). Nevertheless, analyzing extract with the HPLC-DAD/MSD method has expensive costs, and Kariyat manufacturing and processing has to utilize mountainous production costs of approximately 85,400 THB due to using standard production. Therefore, addressing these challenges would have to adjust appropriate cultivation areas, particularly soil characteristics because Plot 6 is silt and clay, and sandy soil that is a factor influences the lower growth than other beds owing to minor nutrient content, the consequence of using fertilizers for approximately 13,700 THB. Moreover, Kariyat's manufacturing and processing funding should be advocated by numerous organizations that are interested in enhanced commercial and pharmaceutical applications in order to enhancing productive products.

Production costs and profit of manufacturing Kariyat products

From meeting organizations and stakeholders with manufacturing Kariyat products, which provided excellent knowledge associated with developing production processes and improving how to plant efficiently for decently advocating the growth rate of Kariyat, and farmers in Phayao Province obtained knowledge related to improving yield formula and analyzing standard to be in accordance with marketing needs, including value products and safety. Moreover, we offered knowledge associated with the advantages of Kariyat planting in organic farming type and chemical fertilizers. The aforementioned information on the production costs of *Andrographis paniculata* can be used as a guideline for future budget planning for stakeholders or farmers in Phayao Province and other

districts in the Kariyat planting, the production processes, and examining the quality, including the appropriate budget allocating for improving manufactural methods and effectively enhancing cultivation means in the next periods.

In addition, the manufacture and commercial processing of herbal products according to the Phukamyao Model that the researchers have productively desired using worthy resources, cost plummeting, and production efficiency elevating, and we have anticipated in this project into the remarkable guideline and applying knowledge from the university to develop agriculturists to produce quality Kariyat products, as well as processing products that generate safety standards in Phayao Province and other provinces in the future. Furthermore, selecting products to be in accordance with medical standards, such as the planting process to supplement the number of important substances, the sanitary harvesting process, and precise scientific processes, and the researchers expect that this project will be a good guideline to generate income for farmers, as well as widely expanding product distribution channels, particularly drug stores, 7-11 convenience stores, food and drug companies, and online applications, etc.

From the information on the production process of Kariyat from root cutting (62.1 kg), trimming (59.87 kg), and drying (6.67 kg), then grinding into powder for distribution, including andrographolide extract with HPLC-DAD/MSD method, resulting in 2.32 g/100g by accurately scientific analyzing and safety, and the leaf of Kariyat contains the highest andrographolide content, equivalent to 3.572 percent weight/weight. Hence, the researchers have demanded to escalate the outputs, which impact good lucre and are in demand in the commercial market, involving processing numerous forms, such as fresh leaves, powder, and extract. Those processing products have different production systems, so the commercial price of each type of Kariyat product is different as well.

Kasikorn Research Center (2020) reported that the price of fresh leaves was 36.8 THB per kilogram, the price of powdered products was 300-600 THB per kilogram, and the price of extracts was 2,500-3,500 THB per kilogram. The extract product is more expensive than others owing to precisely scientific processes, complexity, and safety, involving high costs, advanced technologies, and difficult extraction methods.

CONCLUSION

As a result, Kariyat can grow greatly in Loam Soil, and the soil should have an electrical conductivity (EC) which is less than 2 dS/m, including the light intensity, resulting in approximately 968.4- 1936.8 lux. These factors induced Kariyat leaves, stems, and branches to generate essential substances effectively, especially andrographolide, which found that 100 grams of dry Kariyat will contain 2.32 grams of andrographolide extract as well as the extract could manufacture the prototypes of products, such as one box of Kariyat capsules, Kariyat neck spray patterns, and one product, which cloud be the certificate of modern drug registration. Moreover, the production costs of manufacturing Kariyat products depicted the total cost as 85,402.5 THB and the profit of selling Kariyat (B grade with more than 2 percent of andrographolide extract), obtain a profit of 1,334 THB, and Kariyat (A grade with more than 3 percent of andrographolide extract), receive a profit of 1,601 THB. Nevertheless, the profit from selling Kariyat was less profit than the Department of Agriculture planting at approximately 30 percent.

Practical and theoretical implications

The study provides significant practical and theoretical implications by highlighting enhancing commercial and pharmaceutical applications of Kariyat products in Phayao Thailand, and it encourages farmers to produce standard-quality Kariyat, developing and maximizing the productivity of Kariyat to be commercially available, raising the quality standard of Kariyat product according to the GMP PIC/S, and allowing certificate of modern medicine registration. The results depict that stakeholders, especially agricultural individuals, and workers who are in Ban Tun, Mueang Phayao, Phayao Province, were offered knowledge associated with production improvement and developing how to plant efficiently for decently advocating the growth rate of Kariyat. They could cultivate Kariyat effectively in 1,600 square meters, involving extract analysis in order to produce product prototypes, such as Kariyat capsules, a neck spray, and modern medicine registration, which could elevate income according to the set targets.

LIMITATIONS AND FUTURE DIRECTIONS

This study reflects the farmers' perspectives and our opinions that the study should elevate several guidelines for future Kariyat manufacture and processing for stakeholders or farmers in Phayao Province and other sub-districts of roughly 14 sub-districts, such as Wiang, Mae Tam, Mae Na Ruea, Ban Tam, Ban Tom, Mae Puem, Mae Ka, Ban Mai, Cham Pa Wai, Tha Wang Thong, Mae Sai, Ban Sang, Tha Champi, and San Pa Muang. In addition, the researchers expect that Kariyat products will be distributed in several channels on social media as well as it will generate income for farmers more than before.

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REFERENCES

Banphaeo-hospital, (2011). *Andrographis paniculata* and modern medicine. Searched on 24 July 2024 from https://bphosp.or.th/journal/Journal40.pdf.

Calabrese C., Berman S. H., Babish J. G. et al.,)2000(. A phase I trial of andrographolide in HIV-positive patients and normal volunteers. Phytotherapy Research, 14)5(: 333–338. https://doi.org/10.1002/1099-1573(200008)14:5<333::AID-PTR584>3.0.CO;2-D

Chandrasekaran, C. V., Thiyagarajan, P., Deepak, H. B., and Agarwal, A., (2011). In vitro modulation of LPS/calcimycin induced inflammatory and allergic mediators by pure compounds of *Andrographis paniculata* (King of bitters) extract. International Immunopharmacology, 11(1): 79-84. https://doi.org/10.1016/j.intimp.2010.10.009

Chia, S. Y., and Lim, M. W., (2022). A critical review on the influence of humidity for plant growth forecasting. In IOP Conference Series: Materials Science and Engineering, 1257(1): 012001. *Doi:* 10.1088/1757-899X/1257/1/012001

Chougule, N. B., Nitve, S. A., and Koumaravelou, K., (2018). Phytochemical investigation and screening for inflammatory bowel disease activity of ethanolic extract of Kariyat. Pharmacognosy Journal, 10(3). *Doi:* 10.5530/pj.2018.3.99

Ge, F.H., Lin, X.X., Huan, X.F., Shi, Q., Liang, B., Li, J., and Zhong, G., (2002). Study on extraction of active ingredients from *Andrographis paniculata* using orthogonal experiment with supercritical carbon dioxide. Journal of Chinese Medicinal Materials, 25(2): 101—102. https://europepmc.org/article/med/12599406

Guan, S. P., Kong, L. R., Cheng, C., Lim, J. C., and Wong, W. F. (2011). Protective role of 14-deoxy-11, 12-didehydroandrographolide, a noncytotoxic analogue of andrographolide, in allergic airway inflammation. Journal of Natural Products, 74(6): 1484-1490. https://doi.org/10.1021/np2002572

Hossain, M.S., Urbi, Z., Sule, A. and Hafizur Rahman, K.M.,)2014(, *Andrographis paniculata*)Burm. f.(Wall. ex Nees: A review of ethnobotany, phytochemistry, and pharmacology, The Scientific World Journal, 2014(1): 274905-27490. https://doi.org/10.1155/2014/274905

Jarukamjorn K. and Nemoto N., (2008). Pharmacological aspects of *Andrographis paniculata* on health and its major diterpenoid constituent andrographolide. Journal of Health Science, 54(4): 370–381. https://doi.org/10.1248/jhs.54.370

Kasemsri Subsorn, K. S.,)1998). Agronomy. Bangkok: NANA Printing. https://opac.lib.kmitl.ac.th/catalog/BibItem.aspx?BibID=b00136853

Kasikorn Research Center, (2020). *Andrographis paniculata* raises the standard of herbal production in the pharmaceutical industry. Searched on 24 July 2024 from https: //www. Kasikornresearch.com/th/analysis/k-social-media/Pages/ThaiHerb-FB200420.aspx.

Kumar, R. A., Sridevi, K., Kumar, N. V., Nanduri, S., and Rajagopal, S., (2004). Anticancer and immunostimulatory compounds from *Andrographis paniculata*. Journal of Ethnopharmacology, 92(2-3): 291-295. https://doi.org/10.1016/j.jep.2004.03.004

Kumoro, A. C., and Hasan, M., (2007). Supercritical carbon dioxide extraction of andrographolide from *Andrographis paniculata*: Effect of the solvent flow rate, pressure, and temperature.

Chinese Journal of Chemical Engineering, 15(6): 877-883. https://doi.org/10.1016/S1004-9541 (08)60018-X

Leeson, B. F., (1979). Research on wildland recreation impact in the Canadian Rockies. In Recreational Impact on Wildlands: Conference Proceedings, October 27-29, 1978, Seattle, Washington, Forest Service, USDA, Pacific Northwest Region, 28(3): 430-432.

Mishra, P. K., Singh, R. K., Gupta, A., Chaturvedi, A., Pandey, R., Tiwari, S. P., and Mohapatra, T. M., (2013). Antibacterial activity of *Andrographis paniculata* (Burm. f.) Wall ex Nees leaves against clinical pathogens. Journal of Pharmacy Research, 7(5): 459-462. https://doi.org/10.1016/j.jopr.2013.05.009

Nirote, S., Kritsada, P., Boonset, M., Prajate, A., and Sugun T.)2016). The Adaptation of Farmer for Model Community Development into Climate Change Context of Rice Seed Production Farmer Group. Journal of Community Development Research (Humanities and Social Sciences), *9*(3): 114-126. https://www.journal.nu.ac.th/JCDR/article/view/1600

Parish, D. H., (1971). Soil conditions as they affect plant establishment, root development, and yield. in Barnes, Carleton, Taylor, Throckmorton, and Vandenberg (eds.), Compaction of agricultural soils. ASAE, St. Joseph, Michigan, 277-312

PIC/S Secretariat. PIC/S GMP GUIDE [Online]. Accessed 20 August 2024. Available from https://picscheme.org/en/publications

Rajagopal S., Kumar R. A., Deevi D. S., Satyanarayana C., and Rajagopalan R.,)2003(. Andrographolide, a potential cancer therapeutic agent isolated from *Andrographis paniculata*. Journal of Experimental Therapeutics and Oncology, 3)3(: 147–158. https://doi.org/10.1046/j.1359-4117.2003.01090.x

Santos-Neto, L. L. D., de Vilhena Toledo, M. A., Medeiros-Souza, P., and de Souza, G. A., (2006). The use of herbal medicine in Alzheimer′ s disease—a systematic review. Evidence-Based Complementary and Alternative Medicine, 3(4): 441-445. https://doi.org/10.1093/ecam/nel071

Singha P. K., Roy S., and Dey S., (2003). Antimicrobial activity of *Andrographis paniculata*. Fitoterapia, 74)7-8(: 692–694. *Doi:* 10.1016/S0367-326X(03)00159-X

Strand, S.,)1972(. An investigation of the relationship of pack stock to some aspects of meadow ecology for seven meadows in Kings Canyon National Park. Master's thesis, California State University, San Jose.