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## HerBChain, a blockchain-based informative platform for quality assurance and quality control of herbal products

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### ABSTRACT

The use of medicinal plants is popular worldwide. Correct herbal authentication is of paramount importance to the safety and best interest of consumers. On the market, there is no comprehensive blockchain-based system to track the processes from plantation to manufacturing and to the sale. With the advancement of information technology, an open and transparent blockchain-based platform, *HerBChain*, was created to enhance the quality control of herbal products. The implementation of blockchain technology is to minimize the manipulation of recorded information. *HerBChain* is an information platform for recording the six important processes of herbal product manufacturing and marketing, which include plantation base, TCM processing factory, TCM manufacturer, testing laboratory, distributor and retailer. By duly recording the parameters and data essential for product quality in manufacturing and supply chain, the traceability and reliability of the products can be ensured.

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### 1. Introduction

Traditional Chinese Medicine (TCM) has been used in China and nearby countries over thousands of years for both treatment and health maintenance. In 2019, the World Health Organization (WHO) officially adopted TCM into the 11th version of the International Statistical Classification of Diseases and Related Health Problems (ICD). Recently, TCM also played a role for the treatment and prevention of COVID-19.<sup>1</sup> According to the statistical report from the General Administration of Customs in China (<http://www.cnpharm.com/c/2020-04-08/721445.shtml>, accessed on July 19, 2021), the herbal industry in China grows rapidly with the value of trading reaching USD 6.17 billion in 2019. Hong Kong is the third largest exporter of Chinese herbal material worldwide. The number

of establishments in the industry were 1310 and the sales amounted to USD 1 billion in 2019.<sup>2</sup> The booming herbal market has increased the number of sub-standard and adulterant herbal materials and caused the diminished efficacy in treatment and even occasional life-threatening poisonings.

A TCM technical committee ISO/TC 249 formed by the International Organization for Standardization (ISO), a consortium of various national standards organizations, works on the quality and safety of raw materials and manufactured products. In 2019, the Chinese government has amended the “Drug Administration Law” to establish traceability system for decoction slices. This traceability system is to comprehensively monitor the decoction slices through their manufacturing and supply chain.

To promote Hong Kong as a high quality herbal products trading centre, we established a blockchain-based informative platform, *HerBChain*, for duly recording the parameters and data from the plantation to the manufacturing and supply chain. *HerBChain* will be operated as a non-profit company, to ensure impartiality and credibility.

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**List of abbreviations**

TCM	Traditional Chinese Medicine
WHO	World Health Organization
ICD	International Statistical Classification of Diseases and Related Health Problems
ISO	International Organization for Standardization
BTC	Bitcoin
XRP	Ripple
LTC	Litecoin
ETH	Ethereum
GACP	Good Agricultural-Collection Practice
GMP	Good Manufacturing Practice
GDP	Good Distribution Practice
GCP	Good clinical practice
GLP	Good laboratory practice
HOKLAS	Hong Kong Laboratory Accreditation Scheme
QR code	Quick response code
VM	Virtual machine

**1.1. The blockchain**

The concept of blockchain was first introduced by Satoshi Nakamoto in a publication titled 'Bitcoin: a peer-to-peer electronic cash system' in 2008.<sup>3</sup> He has proposed a system for electronic transactions without relying on trust. Bitcoin (BTC), ripple (XRP), litecoin (LTC) and ethereum (ETH) are the typical cases for the application of blockchain technology in the financial industry. The advent of Blockchain, with its unique characteristic for records, including (1) independent site-server (decentralized network), (2) tamper-proof (distributive immutable ledger), (3) lock-stepped (chained), (4) dated statement (time stamped), and (5) highly encrypted (asymmetric cryptography),<sup>4</sup> could be extended the scope to a range of other data-driven domains; for example, the biomedical and health care sectors.<sup>5</sup> There are three kinds of blockchain, (1) Public Blockchain (operated by all miners), (2) Consortium Blockchain (operated by set of nodes) and (3) Private Blockchain (operated by organization).<sup>6</sup> *HerBChain*, uses the Consortium blockchain, which requires the selection of stakeholder (also known as "nodes" in blockchain system) through a set of admission criteria before entering records to the system.

**1.2. Workflow of HerBChain**

*HerBChain* is operated through four steps.

**Step 1. Selection of stakeholders**

Admission criteria is employed to select potential users to join the platform. The potential user is assessed by using a set of measurable standards already set up by the government or recognized organizations, such as "International Organization for Standardization" and "World Health Organization". In the platform, there are six 'nodes' with the corresponding international requirements, which include:

- (1) Good Agricultural-Collection Practice (GACP) for 'Plantation base';
- (2) Good Manufacturing Practice (GMP) for 'TCM processing factory' and 'TCM manufacturing factory';
- (3) Good Distribution Practice (GDP) for 'Distributor' and 'Retailer';

- (4) Good clinical practice (GCP), Good laboratory practice (GLP) and Hong Kong Laboratory Accreditation Scheme (HOKLAS) for 'Testing laboratory';

The admission of users to these 'nodes' must meet prescribed levels of proficiency set by these standards, so as to ensure data quality and the blockchain to operate professionally and effectively.

**Step 2. Data Entry**

An account is set up for the executive staff of the admitted stakeholder assigned for data entry. The account authority will be restricted based on the 'nodes' joined by the company. Taking 'Plantation base' as an example, the executive staff is authorized to add new plantation record of herbal material to the system. Data include seven areas: procurement, plantation base location, seedling, field management, harvest, storage location and internal testing. After submission, the system will generate a unique ID number for that specific record. The record will then be validated.

**Step 3. Data Validation**

A personal account is set up for the supervisory staff for data validation. The supervisory staff of 'Plantation base' uses the unique ID number to search for the corresponding record input by the executive staff. The personnel may approve or reject the record. If the record is rejected, the system will notify the executive staff for revision. Release of data record is required after approval and a notification will be sent to the executive staff for printing the quick response (QR) code for the product. This process is to safeguard data accuracy and quality.

**Step 4. Generation of QR code**

After receiving the approval notification, the executive staff can retrieve the record using a unique ID. A unique QR code corresponding to the record is automatically generated from the system. The QR code can be downloaded and include in the products for reference. An application-based platform (*HerBChain* App) named "中藥溯源" is established for scanning the QR code and retrieving the information.

**1.3. Characteristics of HerBChain**

*HerBChain* is developed from an open-sourced blockchain system, Openchain. The platform focuses on information records (ledgers) and no transaction of asset is included. Users can therefore get access the data without waiting for data verification.

At present, at least three server nodes are being hosted in several virtual machine (VM) created in third party cloud hosting service provider. Cloud hosting servers provide the flexibilities for scaling up after the number of users have increased.

Data entered into the platform cannot be altered or deleted easily, leaving no chance for manipulation. The blockchain network is secured by a number of computers (decentralized) which only support create and read functions, which helps to confirm the data accuracy. In addition, recorded data is secured and privatized by the use of cryptographic algorithms.<sup>7</sup> This helps to enhance the platform reliability and security.

Clients or users who need to read the information stored in *HerBChain* require to use a specific mobile application designed for decoding the QR code generated by the platform. Other QR code reading application will only results in meaningless text strings to prevent direct copying of the stored information.

**2. Discussion**

Blockchain is a peer-to-peer, decentralized database management system. It is being used in multiple industries, for example,

food<sup>8</sup> and healthcare<sup>5</sup> sectors. *HerBChain* is the pioneer of using blockchain technology in the herbal market.

### 2.1. Advantages for using *HerBChain*

Blockchain allows users to collaborate without ceding control to a central management.<sup>9</sup> In the herbal industry, companies are independently operated. The use of blockchain-based platform, *HerBChain*, helps to share data in the manufacturing and supply chain. The flow of information and data sharing improve communication and foster collaboration. In addition, the sources and records can be traced, this increases the application of verified data for business planning. The chance of purchasing fraudulent herbal material from upstream stakeholders can be lowered. This increases the commercial value to the downstream products, and enhances the brand and company reputation. This will also promote the quality assurance and quality control of the herbal products and reduce the number of adulterated herbal material cases in the market.

Apart from ensuring the herbal product quality, the blockchain-based platform provides a way for bridging the herbal industry and consumers. In selecting the product, consumers can simply scan the QR code on the label of the herbal product with the *HerBChain* App to retrieve the relevant data, from plantation, processing, manufacturing, testing to wholesale. Consumers can also find the test reports, to know more about the quality of the product and make a safe and informed choice. In addition, blockchain favors the robustness and availability of record. As blockchain data are stored in more than one servers, it does not suffer from single-point-of-failure, and the record is continuously available for viewing.<sup>10</sup> As a result, the consumer confidence and the value of the industry can be enhanced.

### 2.2. Areas planned for improvement

To further develop, a third-party validation scheme will be established to further enhance the data quality. Nowadays, the ecommerce world is becoming increasingly competitive. In Hong Kong, revenue in the e-commerce market is projected to reach USD 7.598 billion in 2021. To meet the emerging trends in the e-commerce industry, smart contract function will be also deployed to further facilitate trading via a e-transaction platform. This helps to boost the herbal market via online shopping.

## 3. Conclusion

Generation and marketing high quality herbal slices and products are the keys to maintain the competitiveness of the herbal industry. The newly established *HerBChain* system is an advanced approach to rectify the inherent imperfections of the herbal market with false claims and misrepresentations. *HerBChain* serves to thwart fraudulence and deceptions through its immutability within a highly vigilant environment and promotes Hong Kong as a major centre for trading high quality herbal products.

This article is dedicated to the late Dr. Albert Wong, Founding Chairman of Modernized Chinese Medicine International Association. His vision in promoting Hong Kong as a high-quality herbal product manufacturing and trading centre has led to the establishment of *HerBChain*.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

1. Zhao Z, Li Y, Zhou L, et al. Prevention and treatment of COVID-19 using Traditional Chinese Medicine: a review. *Phytomedicine*. 2021;85:153308.
2. Department HKCaS. *Statistics on Chinese Medicine in Hong Kong*. 2019:2018.
3. Nakamoto S. Bitcoin: a peer-to-peer electronic cash system [Online]. Available <https://bitcoin.org/bitcoin.pdf>; 2008.
4. Bhattacharya S, Singh A, Hossain MM. Strengthening public health surveillance through blockchain technology. *AIMS Public Health*. 2019;6(3):326–333.
5. Agbo CC, Mahmoud QH, Eklund JM. Blockchain technology in healthcare: a systematic review. *Health Care*. 2019;7(2).
6. Hasselgren A, Kralevska K, Gligoroski D, Pedersen SA, Faxvaag A. Blockchain in healthcare and health sciences-A scoping review. *Int J Med Inf*. 2020;134:104040.
7. Satamraju KP. Proof of concept of scalable integration of internet of things and blockchain in healthcare. *Sensors*. 2020;20(5). M. B.
8. Patelli N, Mandrioli M. Blockchain technology and traceability in the agrifood industry. *J Food Sci*. 2020;85(11):3670–3678.
9. Kuo TT, Kim HE, Ohno-Machado L. Blockchain distributed ledger technologies for biomedical and health care applications. *J Am Med Inf Assoc*. 2017;24(6):1211–1220.
10. Liao I-CLT-C. A survey of blockchain security issues and challenges. *Int J Netw Secur*. 2017;19(5):653–659.