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Research Article

Historical Evolution and Transfer of Tea Technology from South China and South India to Ceylon During the British Colonial Era 1824-1947

Dr Vithiyapathy Purushothaman[1*], Prof. Shi Yun Li[2]

[1*]Doctorate from the School of Humanities and Social Sciences, University of Science and Technology of China.

[2]Head and Dean, School of Humanities and Social Sciences, University of Science and Technology of China

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ABSTRACT

The Ceylon tea industry began as an alternative to the coffee blight and thrived to become an icon for the island. The world tea market recognised it for its unique tea taste. It began with the efforts of James Taylor and British researchers during the colonial era. Through the transfer of tea seeds farmers and by learning manufacturing methods from China and India, the Ceylon Tea industry has progressed extensively. It also adopted the advanced CTC methods developed in India during the colonial era. Meanwhile, the island innovated its tea machinery through an indigenous and collaborative approach. The innovations gained patents for its advanced machines that strengthened tea production. Gradually, Ceylon excelled in its innovation to develop its own LTP method of tea manufacturing. Thus, the Ceylon tea industry even surpassed the tea production of China and India through its innovation in tea machinery and thrived to become a leading tea exporter in South Asia. Therefore, the paper will first study how the Ceylon Tea Industry was established during British Governance in Sri Lanka. Secondly, it examines the innovative tea machines of Ceylon that have contributed to the world tea market. Finally, the paper inquires how the advancement of the tea machinery has contributed to the growth of Sri Lanka since the colonial era.

Keywords: Sri Lanka Tea Industry; Tea machines; Tea Making Technology

1 INTRODUCTION

According to the Food and Agriculture Organisation of the United Nations, Sri Lanka shares 17% of global tea exports. Sri Lanka's Tea Industry contributes to over 2% of the nation's GDP (Abhiram, 2023) and 15% of total exports (Thasfiha, 2020) by employing over one million people. Camellia Sinesis is commonly known as Tea, Cha or Chai. (Burgess, 1996). It was spread across the Himalayan region and planted in the British colonies for production. In 1920, it was identified that the genus Camellia had 40 species categories (Mondal, 2004). Ceylon is located in the Indian Ocean, like a pearl pendant that became a colony of Western nations during the colonial era. Following the Dutch and Portuguese invasion, the British East India Company, named the Presidency of Fort St. George (Madras Presidency) from Southern India, began administering the northern part of Sri Lanka in 1793. On February 12, 1796, the Madras Presidency (British administration) entered into a treaty with the King of Kandy to safeguard the island's peace (Aitchison, 1909). Thus, Robert Andrew established trade and economic agreements with the Ceylon Kingdom to administer the island (Mills, 1934, pp.16–17). Through the lens of historical theories, the transfer of tea technology, the establishment, and the growth of the Sri Lankan tea industry are analysed. As per the Diffusion of Innovations Theory, the practice of tea-making technology spread from China to India and Sri Lanka. Notably, the transfer of the tea seeds, plants and tea manufacturing methods is seen as a process of diffusion. The diffusion process was influenced by the Chinese and Indian tea planters, and the British administrators facilitated the transfer. The Technology Determinism Theory analyses the impact of economic development based on the transfer of tea technology, such as Chinese traditional tea cultivation methods and the CTC method of tea making in India. It examines how the tea technology transfer and innovations have facilitated the expansion of the tea industry in Sri Lanka. The technological innovations led to the increased production and expansion of the tea market of the Sri Lankan tea industry. Thus, as per the Dependency Theory, the relationship between tech transfer, manufacturing methods and trade was analysed. The World-Systems Theory provides an understanding of the global demand for tea and how the Sri Lankan tea industry progressed to become a leading tea exporter. It

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studies how the transfer of tea-making technologies and the industry's growth impact the economic engagement of these countries. The Social Construction of Technology Theory emphasises how technology is shaped by Sri Lanka's social, political, and economic factors. The tea-making technologies adopted in Sri Lanka were influenced by the social context of the country, including the roles of British administrators, Indian tea planters, and local farmers. These technologies were adapted to the specific needs and conditions of the Sri Lankan tea industry, reflecting the social construction of technology.

James Taylor and the British Administrator imported tea seeds and plants from Southern China and Assam hybrid Jats from India to thrive the cultivation of tea on the island. The tea technology was also learnt through the tea cultivators from Southern India to kickstart the Sri Lankan tea industry during the British Colonial era. It adopted the traditional method of tea making from China in the beginning stages and shifted to the CTC method of tea production from India. Through the striving innovation of tea farmers and researchers, the Ceylon tea industry invented its tea machines indigenously and in collaboration with Indian tea researchers. Further, it also innovated the LTP tea-making method that boosted its production. Hence, due to its constant innovation in the tea machinery, tea production in Ceylon exceeded 100,000 metric tons in 1927 and reached 200,000 metric tons of yield in the 1960s (Thasfiha, 2020).

Sri Lanka became the world's largest tea exporter in 1966 for the first time through its constant upgrades in manufacturing methods and tea machinery innovations. Moreover, it is noted that 44% of tea is produced by the CTC method, whereas the traditional method of tea production is 31% worldwide (Kasturiratne, 2008). Hence, in 2024, the compound annual growth rate (CAGR) of Sri Lanka's tea sector is poised for steady expansion at 5.3%. Thus, it is worthwhile to examine how the tea machines were innovated in Ceylon and to analyse how the tea cultivation and manufacturing practices were transferred from China and India to Sri Lanka. Therefore, the paper will analyse how the transfer of tea manufacturing methods from China and India enabled the establishment of the tea industry in Ceylon. Secondly, it will analyse the shift in tea manufacturing practices and the development of tea machines in Sri Lanka. Finally, it will study the growth of the Ceylon tea industry by examining how modern machinery improved the production and yield of tea in Sri Lanka.

2 BACKGROUND OF TEA MANUFACTURING METHODS IN SRI LANKA

The development of tea machines in Ceylon began during the colonial era (Wijayasiri, 2018, p.14). However, the foundation for the development of the machinery has grown progressively based on the development of tea manufacturing methods that were gradually developed to produce a unique taste and flavour of tea. The expansion of tea production and tea manufacturing was understood through the analysis of how tea cultivation evolved on the island, which tested the various tea manufacturing methods by transferring tea seeds from China and India.

2.1 Trials of Tea Seeds and Plants

Ferguson's directory cites Bertolecei's account and James Cordiner's depiction of Ceylon to illustrate that the tea was found near Trincomalee (Ferguson, 1891, p.38). Further, Ukers highlights the records of Bennett on "Ceylon and its Capabilities" and Bertolucci's "View of Agriculture and Financial and Commercial Interest of Ceylon", where the observation of wild tea trees was noted before British arrival (Ukers, 1935, pp.173-174). Remarkably, Evans (1992, p.27) argues that Buddhist monk's exchanges through the Maritime Silk Route trade became the reason for the arrival of tea on the island. However, Ferguson (1891) highlights that Mr Maurice Worms and Mr Gabriel B. Worms bought tea plants from China and conducted experiments at the Rothschild estate in Pussellawa. The Diffusion of Innovation Theory highlights how tea seeds and plants were transferred from China and India to Sri Lanka. It explains the process of new ideas and practices that spread from one civilisation to another. The transfer of tea seeds is a determining factor in the establishment of the tea industry in Ceylon.

Even though historical records indicate that tea trees were native to Sri Lanka, it is clear from the historical archives that Chinese and Indian tea seeds, along with the plants, were used to build the Ceylon commercial tea cultivation in the 19th century (Peebles, 2006, p.72). British researchers brought the tea plants from China for testing in 1824 and planted them at the Royal Botanical Gardens at Peradeniya for testing (Wijayasiri, 2018, p. 111). When the tea seeds grew well, the British transferred the tea manufacturing knowledge from China and tea technologies from India to establish the island's tea cultivation (Mills, 1934, p. 249). Ferguson's records mention that the Ceylon Crown claims that Governor Stewan Mackenzie sent tea plants for trials from Assam to Peradeniya Royal Botanical Garden in 1839 to progress tea cultivation (Ferguson, 1891, p. 67). Thus, the British administrators, Indian tea planters and Sri Lankan tea cultivators played a vital role in facilitating the diffusion process as well as introducing new technologies and practices to the island.

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2.2 Formation of the Tea Association and Expansion of Tea Cultivation

After a decade of trials of tea cultivation in major British gardens and associated plantation regions, the British established the Planters Association of Ceylon (PAC) on February 17, 1854. The Dependency Theory applies here in understanding the cooperation between the British administrators and Indian and Sri Lankan tea planters. Significantly, estate owner's meetings were organised (Ukers, 1935, p.180). It mirrored the methods of electing the representative of the planters committee from the United Tea Planters Association of South India (UPASI). Captain John Keith Jolly became its first Chairman of PAC, and the association's initial membership is provided based on its laws formed in 1862. (Wickramasinghe, 2005). However, in 1865, Messer Worms trialled commercial cultivation by establishing tea cultivation at Pussellawa by bringing Chinese farmers and producing tea worth £5 per lb using the traditional methods of tea manufacturing. By recognising it, the British government expanded the tea plantation and acquired the land. Further, it purchased the tea plantation trial gardens at Kotmale, Puudaluoya and Ramboda Pass (Ferguson, 1891, p.39). Hence, the establishment of the tea industry in Sri Lanka was dependent on the transfer of tea seeds, plants, as well as manufacturing methods from China and India. It influenced the development of the industry and the dependence of the local farmers on foreign technology and labour.

2.3 Transfer of Assam Jats from India and Expansion of Ceylon Tea Industry

James Taylor travelled to India in 1866 to study tea cultivation. He brought Assam Jats tea seedlings from the Royal Botanical Garden in Calcutta to cultivate in the highlands in Ceylon. The Technology Determination Theory aims to understand the impact of the transfer of Assam Jats seedlings on the growth and success of the Ceylon tea industry. With the assistance of Mr. Harrison, James Taylor then experimented with Assam Jats tea cultivation along the roadways at Peradeniya in Ceylon to test (Wijayasiri, 2018, p.111). The Tropical Agriculturist report highlights the Tea Association conference that discussed the creative attempt of James Taylor that grabbed the attention of Tea Plantation Association secretary Mr. W. M. Leake and proved the effectiveness of the Assam Jats (Ukers, 1935, p. 184).

Mr Leake then recommended that Sir Hercules Robinson's administration send his plantation team to inspect the tea plants in the Assam district of British India. Ferguson mentions that the planters' team from Ceylon produced the report to the Ceylon Crown by visiting the Indian Tea Plantation in 1867. Mr Leake initially attempted to order the hybrid Assam tea seeds named Assam Jats by understanding the importance and bringing them to Ceylon (Ferguson, 1891, pp. 39-68). Ukers mentions that the Assam Jats were then tested alongside the Chinese varieties and other Ceylon's earlier survived plants, where the Assam Jats produced the darker leaves and were chosen (Ukers, 1935, pp. 424-425). With the success of the trial cultivation and approval of the administrators, James Taylor gained the authorisation to expand his tea cultivation to 19 acres for the first time at the Loolecondera Tea Estate near Kandy in late 1867 (Public Record Office, 1873). His efforts in raising the Hybrid Assam tea seeds resulted in a high yield gained at the No.17 Field (Peebles, 2006). Hence, it resulted in the marking of Ceylon's first tea industry for commercial production for export (Hall, 2000, p.16). Mr Leake further conducted the experiments in a broader spectrum to help the association expand the economic contribution of the 75 properties owned by the Planters Association of Ceylon. (Planters Association of Ceylon, 1867). To overcome the shortage of cultivation on the island, the Dutch brought the farmers from South India (De Silva,1973, p.40). These estates ranged from spare initial patches to a few acres in the island's plantation districts. In their attempts to become the first owners of these tea regions, the pioneers on a sizable scale achieved the best reputation for administering the tea industry. Ferguson (1891, p.41) highlights how tea cultivation expanded due to the spread of tea plants and the imported Assam hybrid tea seeds from Calcutta. The growth of the tea industry boomed after three decades with the emergence of numerous tea garden pioneers on the island. By building the tea industry gradually, Ceylon sent its first shipment to London. Notably, the transformation of coffee-producing countries has led to the importation of tea from southern India. The adoption of Assam Jats tea seedlings led to increased production of the tea and improved quality. It managed to expand the markets, driving the economic development of the country. On the other side, the Dependence Theory shows how the tea industry relied on the technology transfer from India and highlights the dependence of the industry on foreign technology and labour.

3 DEVELOPMENT OF THE CEYLON TEA INDUSTRY

From 1878 to 1883, the Coffee Blights in Ceylon devastated the coffee industry. It occurred between the introduction of tea seeds and the expansion of industry on the island, allowing space for the development of tea cultivation. Coffee growers viewed the tea sector as an alternative for reconciling economic pressures (Peebles, 2006, p.72). Due to the popularity of Ceylon tea, the Ceylon Chamber of Commerce held the first public Colombo Auction on July 30, 1883, at the headquarters of Somerville & Co (Wilson, 1897). According to

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Money (1883), the tea sector was analysed for having a solid chance of becoming one of the best in the world, and the grades of tea produced in Ceylon are on par with those in India (Agarwal, 1989). The significant advantages include the island's industry being in a favourable location and the tea-growing region being extensive and ideal. From 1882 to 1883, James Taylor worked with the farming techniques of China and India. He attained advanced cultivation with the support of Campbell, who was a retired tea planter from British India. As a result, he enhanced the tea plucking and pruning techniques, which increased the crop returns. However, during this development, the inspection of Robertson of the Madras presidency recommended the parallel growing of the same breed of tea plants rather than mixed cultivation. Diffusion of Innovation Theory determines the emergence of Ceylon's farming techniques, that is adopted through the transfer from China and India.

Table 1. Pioneers of Tea Companies of Ceylon **Source: Ukers, 1935**

Year	**Company**
1880	Lanka Plantations Co., Ltd
1884	Ceylon Land & Produce Co., Ltd, Hunasgeria Tea Co., Ltd
1885	Ceylon Estates Investment Association, Ltd
1886	Anglo-Ceylon & General Estates Co, Ltd, Ceylon Tea Plantations Co., Ltd.
1887	Talgaswela Tea Company of Ceylon, Ltd.
1888	Eastern Produce and Estates Co., Ltd.
1889	Battalgala Estate Co., Ltd, Scottish Ceylon Tea Co., Ltd.
1891	United Planters' Co. of Ceylon, Ltd.
1892	Carolina Tea Co. of Ceylon, Ltd.
1893	Great Western Tea Co. of Ceylon, Ltd.
1895	Alliance Tea Company of Ceylon, Ltd, East India and Ceylon Tea Co., Ltd, Nuwara Eliya Tea Estates Co., Ltd, Vogan Tea Co. of Ceylon, Ltd.
1897	Ceylon & Indian Planters' Association, Ltd. Ceylon Proprietary Tea Estates Co., Ltd. Tea Corporation, Ltd.
1898	Rajawella Produce Co., Ltd

According to a report by renowned tea farmer Morice, Ceylon tea became well-known for its distinctive flavour and scent around 1867 (Hall, 2000, p.17). Mr Gepp, who had previously documented the experiments in Sir Anthony's Garden, later became a tea specialist from Colombo in England in 1869. Meanwhile, his assistance expanded the reach of the Ceylon tea business through his efforts and reached it globally (Ferguson, 1891, p.40).

The Technological Determinism Theory distinguishes the impact of the technology on the society and shows how the flavour and scent of the tea contributed to the popularity of the tea. The exports then promoted the expansion of the tea estate at Hope, Rookwood and Mooloya in Sri Lanka. It had produced about 400 hectares by 1875 (Tea Board of India, 1980, p. 179). Further, with the thriving success of the Sri Lankan Tea industry, Indian Ocean Colonies such as Java began learning the tea plantation from South India, Assam and Sri Lanka. With the immense tea trade in the 19th century, tea in Britain became a national beverage. Britain was the second-largest consumer of tea in the world after importing around 23 million pounds of Chinese tea in 1800 (Tang, 2008, pp.31-33). James Taylor's tea plant was completely operational in Loolecondera by 1872 (Wijayasiri, 2018). Significantly, Ceylon distributed China Variety and Assam Hybrid tea from its garden between 1873 and 1874; most of the plants for these collections came from the Peradeniya and Hakgala gardens (Ferguson, 1891, p.40). Under the management of Ceylon Co. Ltd., tea cultivation was expanded to Yakdessa, Kelani Valley, Kalutara region, Ambagamuwa, Messes, Galboda and Leechman (Roberts, 1966). Their garden labels typically identify the famed Ceylon teas and tea quality. The progressive improvement of tea grading standards and sales quality was prioritised for the continued export of tea to other parts of the world. The Ceylon Traders Association was established in 1894, and the Colombo Brokers Association was established in 1896 (Thasfiha, 2020). Secondly, the lack of skilled labour in the homeland grew due to rising labour needs in the British colonies of Malaysia and Ceylon. By controlling the emigration policies, the British Crown of Ceylon made a plea to the British government of India. Beyond being a significant supplier and promoter of the growth of Ceylon tea, British Planters of Assam teamed up with Ceylon to compete with the Western world's international tea markets (Andrew, 2020, p.190).

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Notably, in 1900, Ceylon Island had 2000 gardens (Ukers, 1935, p. 224). Thomas Amarasuriya became the first Chairman of the Planters' Association in 1916, and his reforms and contributions to the tea business helped the sector grow (Thasfiha, 2020). He identified that the mixed production of several types of bread in the same colony caused the Nilgiris tea sector to experience leaf-type separation. He believed that by replacing the combination plantation and continuously reviving the tea plantation, the drawbacks of such a plantation could be remedied over time (Ferguson, 1891, p.42). These actions increased the production of tea leaves on the island, and the branding was based on different tea types. Tea cultivation was extended inland to the Pidurutalagala, which is even 6500 feet above sea level, and to the western beaches at all altitudes.
However, six of the nine significant provinces of the island were under British Ceylon administration (De Silva,1973, p.303). The tea estates were in Ceylon's Sabaragamuwa, UVA, Southern, Western, Central, and North-Western areas (Wenzlhuemer, 2008). Ukers (1935) adds that the tea plantations were thriving in 51 districts on the island of Ceylon. He also emphasises that most of the tea was produced in Ceylon's central region at an elevation of roughly 7000 feet above sea level.

3.1 Improvement of Tea Industry Connectivity

Initially, Ceylon relied on horses, mules and donkeys for the transportation of tea from the estate to tea processing factories and then to the port for export. However, to improve transportation, the Ceylon tea industry has adopted steam-powered tramways and upgraded to electric tramways in its tea estates (Tayler 1900, pp.292-293). Notably, the establishment of steamship connections from Southern Indian ports to Colombo in the 1880s increased the number of immigrants arriving in Colombo in 1877. The principal ports in South India where Tamil labourers from Tuticorin, Pamben, Tondi, and Ammapatinam moved (Wesumperuma, 1986, pp.41–61). Ceylon's transportation network was extensively developed and connected by roads and railways, from the ports to the tea gardens (Ukers, 1935, p. 417). Roadways and railways link the country's ports and tea gardens together. Colombo was the most prominent shipping port, receiving tons of merchandise daily via communication from the garden. In order to export the produced tea to the port, the British administration considerably improved the connectivity of these tea areas with the contemporary transportation network, with railways extending to 740 km between the tea estates. The Tea Planters Association of Ceylon steadily increased their estate count from 75 in 1867 to 2394 in 1921. As a result, the ancient Chinese tea expertise in the Assam region has been modernised by the South Indian Tea Technology created during the British Raj in India. It has been successfully transferred to other places in India, Sri Lanka, and beyond.

3.2 Transfer of Labourers and Tea Plantation Knowledge from South India

The British hired Tamil tea planters from South India based on the contract, generally termed "Malabar Collies". (Jayaraman, 1967, pp.319-359), legally considered for labour recruitment under the Kangani system (Peebles, 2006, p.36). When the need for employees in the tea plantation industry arises, "Coast Advances" are given to Kanganies. These Kanganies fill the market by bringing Tamil plantation workers from South India to Ceylon (Jayaraman, p.327). This system acted as a regulator to provide Tamil farmers with linguistic compatibility and the transfer of modern cultivation techniques using the CTC method of tea manufacturing (Heidemann, 1992, p.5). Peebles (2006) highlights that Tamil immigrants of about 62,305 immigrants from Tamil Nadu, South India, were brought in by 2000 Kanganies (Public Relations Office, 1873). According to Jayaraman, the number of Tamil labourers hired by Ceylon's plantations expanded significantly after 1870. He refers to the Ceylon Census data and demonstrates how the Tamil population increased by 67 per cent during the 1871 and 1881 censuses, from 123,654 to 206,495 (Jayaraman, p.325). However, Jayaraman argues that most Tamil plantation workers were recruited since these Kanganies were Tamil recruiters. The South Indian tea sector expanded, providing more chances for educated Tamil tea growers (Satyanarayanan, 2001, p.13). The population of Tamil planters in Ceylon gradually grew, with an average growth of one lakh every ten years. According to the 1901 census, there were 441,601 Tamil people, a 68.4% increase over the previous year (Jayaraman, p.325). According to Andrew (2020, p.258), Lu Ying's trip to Ceylon and Darjeeling significantly demonstrated to the world the value of hiring labour for the tea plant. This led to the development of the tea industry, which developed the context of industrial activities. Jayaraman (1967, p.326). Further, explains the initial migration of Tamilians into the plantation sectors in the 1820s and, once again, the need for cultivation in Ceylon, which was a primary demand and responsibility for the intercensal percentage increase during 1891 and 1901.

Tinker (1974, p.55) highlights that these skilled farmers played a vital role in the expansion of the Ceylon tea industry. Thus, the success of the tea industry's establishment and the creation of the Ceylon tea industry are credited to these efforts in establishing the management and innovation of James Taylor. Therefore, James Taylor became the founding father of the Ceylon tea industry. The superior tea made in Ceylon has even put

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competition between that country's output and that of China and India. South Indian labour was more in demand in Ceylon for the tea plantation business. As a result, the number of skilled workers from South India working in the tea sector has grown yearly. Meanwhile, the tagline "Direct from the Tea Garden to the Tea Pot" captured the Western world's attention at a later stage when companies like Lipton Teas owned these tea plantations, which superintendents often ran (Hall, 2000, pp.16-17). Most of the labour force in Sri Lanka's tea plantations originated in South India. The tea farmers faced economic challenges due to the unequal distribution of revenues, yet Ceylon's tea industry was thriving. Notably, tea, rubber, and coconut exports have become the island's primary sources of income (Dawood, 1980, p.43).

3.3 Tea Research Institutes of Ceylon

Coombe submitted the Ceylon Tea Research plan for incorporating the chemist and entomology station technicians to the Planters Association of Ceylon in 1924. Thus, the London-based Ceylon Tea Association then approved the implementation of the Tea Research Institution of Ceylon. Notably, it received Rs. 90,000 in funding per year for its research and experimentation in the tea sector. In 1925, a referendum was conducted by the delegates from London and Ceylon to evaluate the expenditure procedures. 378572 acres of representatives voted in favour of the management, while 8668 acres voted against it. Notably, in 1925, the Tea Research Institute (TRI) was established and backed by the connected landowners (Barua, 1989).

The preliminary goal of TRI is focused on research, scientific understanding, and offering technological know-how to Sri Lanka's Tea Sector. For undertaking the research, Mr Petch, who was a famous botanist and mycologist, was chosen as the institute's first director in March 1926. He administered the well-known assistants and strengthened the institute. It is to be noted that the TRI of Ceylon was initially operated at Nuwara Eliya before moving permanently to the St. Coombs tea plantation in the Dimbula area (Baruah, 2008, p. 45). Thus, TRI trained tea producers, growers and other industry participants by researching several related fields, including plant pathology, agronomy, soil science, tea chemistry, biochemistry and technology. The research progress contributed to the development by growing and making tea to boost Ceylon's tea industry output. The institute's research centred on enhancing the manufacturing processes to increase tea yield (Thasfiha, 2020). To conduct research and offer extension services to tea growers, TRI operates a network of research stations spread throughout Sri Lanka's several tea-growing districts.

The institute also worked with universities and other international research institutions to advance study and research in the world tea market. Thus, tea production has increased gradually on the island. Sri Lanka exported more than 100,000 metric tons of tea in 1927. Meanwhile, the membership of the association in 1932 increased to 406,727 acres. Thus, the gradual increase in cultivation led to the founding of the first Sri Lanka tea brokerage business in 1941 by Pieris & Abeywardena (Wijayasiri, 2018). Further, the discovery of novel tea cultivars, the introduction of new technology for tea production, and the identification of best practices for tea cultivation and processing are just a few of the significant achievements the TRI recognises for making in the tea industry.

4 TEA MANUFACTURING METHODS AND MACHINES OF CEYLON

In the beginning, tea plants were produced on modest farms nationwide, and the tea leaves were manually harvested. Ceylon implemented systematic farming practices and paid close attention to its movement. Early manoeuvring experimentation uses the scientific methodology from the Tea Research Institute. Traditional techniques were used to make the tea, including hand-rolling and sun-drying the leaves. The leaves were withered, rolled, and dried using simple processing techniques before being packaged and delivered to the Colombo auction houses for sale. However, when Ceylon's tea business grew in the late 1800s, new technology was added to advance the country's tea processing techniques (Mel, 1972). To develop its tea industry, Ceylon combined Chinese and Indian tea manufacturing techniques. Remarkably, it primarily adopted the traditional tea-making method of China. Later, the advancements brought the upgraded Cut, Tear and Curl (CTC) method of tea making from India. It leads to the innovation of the Lawrie Tea Processors (LTP) method on the island to produce tea (Wijayasiri, 2018). This process is a traditional five-step method for manufacturing tea: withering, rolling, fermenting, drying, and sorting (Thasfiha, 2020).

Ukers (1935, p. 427) also sheds light on the manoeuvring strategies of the Ceylon tea sector. Due to the early trials and adoption methods, it didn't employ green manoeuvring. Rather, the "enveloping forking" method was adopted. This method allowed for the improvement of cultivation in Ceylon's mountainous region, which has tough soil for irrigation. Therefore, the pruning methods were tuned to meet the needs of the plantation output. Liu states that Ceylon also used equipment throughout all stages of tea production by employing Indian tea-making methods to reduce contamination and maintain the natural quality of tea (Liu, 2020, p.115). However, early in the 20th century, Sri Lanka's tea industry experienced technological progress,

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which included the rotor vane, which processed tea much more quickly than earlier tea-making methods. With the innovative approach, the tea leaves were dried out by the rotor van using centrifugal force. This method increased the tea processing method and increased the tea yield. The ancient manual processes were replaced with withering mechanical troughs, rolling machines, fermentation boxes, and drying machines, which improved the quality and consistency of the tea produced. These tools contributed to the automation and efficiency improvement of the tea-producing process.

4.1 Pruning and Plucking Tea

The first-generation plucking methods were seen as a hand clipper that was upgraded by the shearers, and gradually, with the mechanical selective pluckers, and recently, it has been adopted with the computer-aided selective pluckers (Abhiram, 2024).

The pruning process is used to increase the tea leaves' lifespan. The Ceylon tea calendar was thus marked. Money advises that the pruning should be undertaken in cold weather when the plants are hibernating (Money, 1883, p.85). Due to frequent pruning techniques, the tea trees on the island produced more leaves throughout the year. It was then followed by cultivating the land and further approaches using periodic observation and factors, including elevation. The tea leaves were also subjected to periodical plucking according to the type of tea (Jat) that was cultivated (Henry, 1902, pp.121-124). Pruning considers the local climate, and on the island, pruning is most frequently done between February and March and, on occasion, from June to September, depending on the production ratio. Many pruning techniques are used on the island, including collar, extreme down, limb, and heavy pruning. These techniques use a sharpened pruning knife, which is preferred depending on the bush's thickness. A pruning strategy is chosen based on the soil, climate, and frequency of tea leaf harvesting.

When tea was first produced in Ceylon, the island nation used Indian tea plucking techniques, essentially Chinese tea plucking techniques improved upon. Later, the research also developed the harvesting and transferring of tea from the plant. The Kanganies supervised the tea industries in Ceylon, which adopted the plucking procedure for seven to fourteen days. Due to the frequent use of tea seeds imported from China and India, monitoring and supervision became a part of the Ceylon tea industry practice to care for the variety of breeds it cultivated (Ukers, 1935, p. 429). Skilled Kanganies gathered the tea leaves as a customary procedure by adopting frequent plucking methods periodically to meet the demands, such as extreme down trimming. It enhanced the second flash and the production of succulent young shoots. In the early phases, workers carried bamboo backpacks filled with tea, collecting them according to Chinese and Indian customs (Neil, 2010). However, the weight of these bamboo bags was eventually decreased with the use of contemporary materials. The labourers used the tramways built in the tea plantation area to transport the tea leaves from the tea plantation to the factory. Notably, eco-friendly procedures were adopted to enhance the welfare of its employees. To improve transportation and cut labour costs, tramways were built to connect the plantation areas to the export zones. These inventions improved the harvesting of tea leaves, which boosted the output by lowering labour expenses.

4.2 Withering

The harvested tea leaves arrive at the station in the morning to wither and spread out for the leaf's breathing space. The spread-out leaves were treated in the morning, which is thought to be for the natural moisture evaporation process while kept in the open air. According to the island's custom, rotating the tea leaves early will significantly impact most of them (Neil, 2010, pp.12-13). Ukers (1935, pp.281-282) points out that Ceylon's climate is humid. Thus, the withering is carried out in enclosed lofts by maintaining the temperature at or below 90^{o}F. For this process, the bamboos were used to make the withering racks to spread the tea leaves evenly.

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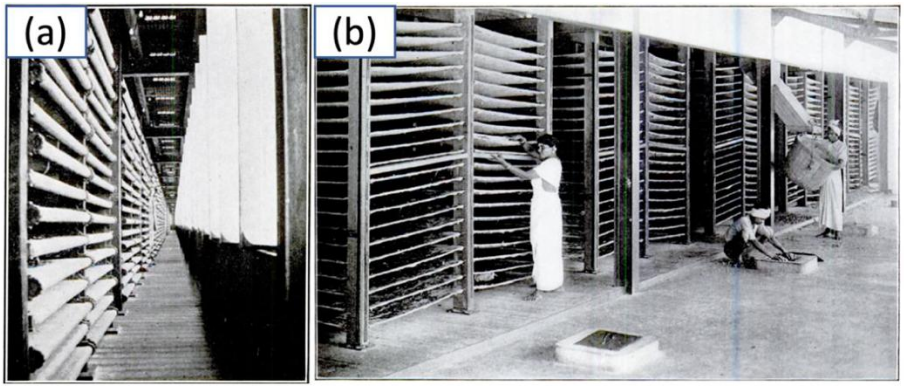

Fig. 1. (a) & (b) Withering Lofts and Hessian Withering Tats. **Source:** Ukers, 1935

According to Neil (2010, p.10), the usual practice was to spread the tea leaves out overnight so they may initially dry naturally. With the development of the methods, the leaves were stretched out for one or two hours beneath the fans to produce the same outcome. Bamber (1893) asserts that the oxidation process needs to be maintained for the tea to have a better flavour. The companies provide these places for rake building, and the rack size per pound ranges from 10 to 12 square feet. As a result, the infrastructure has adequate windows to allow air circulation and withering. The task was completed more quickly with the installation of a fan than with the preceding techniques.

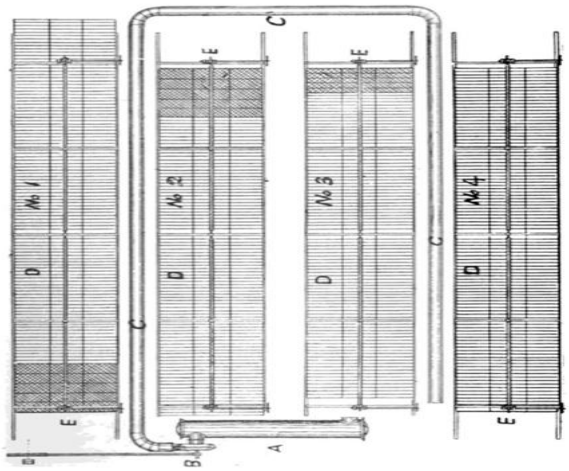

Fig. 2. Limping Apparatus at Meddecombra Tea Estate in Ceylon. **Source:** Tayler, 1990

Tayler (1900, pp.65-67) observes that the dry, warm air withering system has been in place for eight months at the Meddecombra tea estate in Ceylon for research purposes. The machine's operation was continuously scrutinised by the managers and engineers for developing the tools and equipment to wither the leaf. Further, Mr Edward Robinson from London gained the patent for the "Limping Apparatus". The heat produced in the furnace through the fan and circulated over the leaf for withering was provided by the apparatus's dry, warm air circulation system. Ingeniously, it was even tried to distribute the circulation in Limping machines by using the heat from other equipment at the companies (Ukers, 1935, pp.62-63).

4.3 Rolling and Fermentation

Hand rolling was customary in the early phases of the tea industry. In contrast to James Nelson's bag roller invention in Cachar, India. Ceylon inventors or planters tried to speed up the procedure. Ukers (1935) notes that the timelines for developing the tea industries in Ceylon and India are similar. The British encouraged trade and cross-employment of the tea machinery experts from and to the island to India because the revolutionaries of both sectors worked together under the same banner. Due to its numerous small adjustments in creating tea processing automation, the Ceylon Tea Industry accomplished a breakthrough in developing tea technology. The mechanical design for the rolling process was created in 1872 by the founder of the Ceylon tea industry, who also built a rolling table (Hall, p.7). Later, rolling adopted the mechanical pressure initially used to break up the tea leaves. The leaves produced by the withering process will have a good twist rather than

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being crushed or damaged (Pett, 2009). According to the records maintained by the Ceylon-manufacturing of tea, it is determined that hard-rolled tea provides a great scent of tea with bitter essence, which is considered a better flavour, whereas light-rolled tea produces mild strength. Additionally, it is noted that to achieve the preferred outcome, it is preferred to roll more slowly.

Slow rollers correspond to the complete wither. The cell debris is extracted during the rolling process. It has been noted that the leaves from bushes that have not been freshly clipped would require a more difficult rolling operation. Because of this, the rolling method was prescribed based on the frequency of pruning in the planting area (Pett, 2009). The leaves were divided into groups according to how wet they were and then dried for 30 minutes. The spread-out, dried leaves were sent to fermentation, and the coarse leaves were given another round of high-pressure treatment for 30 minutes (Sicapalan, 1986). Ceylon made a breakthrough in 1893 when it changed its cross-cutting technique for making tea breakers to longitudinal cutting. William Cameron, a planter in Ythanside, Ceylon, and James Brown, a partner at Brown & Co. in Hatton, Ceylon, created this unique longitudinal cutting tea breaker (De Silva, 1973, pp.230-234). Tea rolling techniques were first developed in Ceylon. Colombo Commercial Corporation invented the single-action tea roll in 1931 to replace the traditional rolling method. Ukers (1935) draws attention to Mr H. J. Moppett, a tea planter in Ceylon, who made some noteworthy comments about rolling. He offers many rolling options, including no pressure, light pressure, half pressure, and strong pressure rolling, depending on the sort of leaves needed. He emphasises that most of Ceylon's rolling was done with Jackson's roller machines. The Sirocco tea roller, ball breaker, infinite chain pressure, and sorters were developed and introduced to the Ceylon tea sector as part of the government's modernisation imports.

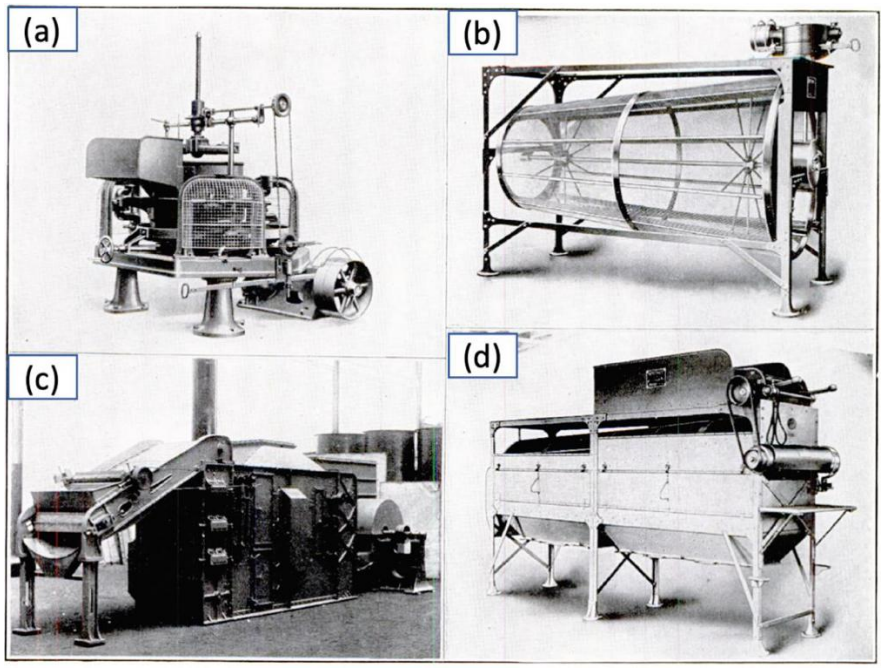

Fig. 3. (a) Sirocco-Roller; (b) Sirocco-Ball Breaker; (c) Sirocco-Endless Chain Pressure Drier; (d) Sirocco-Sorter. **Source:** Ukers, 1935

The withering method in this device was a shallow, standard-perforated jacket that was then changed with double rollers. Notably, the Colombo Commercial Corporation revolutionised Brown's triple-action roller, fundamentally designed to tolerate harsh rolling and three actions. Ukers (1935, pp. 435-481) mentions that John Walker & Co. began Ceylon's tea-rolling machine business in 1880. With the periodic exports of machines, the Colombo Commercial Corporation was founded at Mahatenne in 1932. Accordingly, the cell chap exists and reacts with oxygen for the fermentation process, short-term and long-term rolling affects the quality of the leaves. During the process, it generates essential oils, the main component of which it produces the aroma of the tea leaves (Thasfiha, 2020). Thus, to maintain the freshness of the tea leaves, the cropped tea leaves undergo the medium withering process to produce the tea. It is then processed through methods such as light rolling and rapid-fire, based on the demand for the specific type of tea production.

Notably, in most Ceylon tea factories, the clipped tea bushes undergo ordinary rolling at the processing centre as a general procedure. The tea industry was introduced by an estate in Elkaduwa, Ceylon, using multiple

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roll breakers and green leaf shifters (Ukers, 1935, p.489). The tea leaves are then rolled three times for half an hour while the roll breaker is positioned to follow the shift (Neil, 2010, p.16). Therefore, the process of rolling further becomes one of the basic customs of the island that is employed to improve the earlier Indian and Chinese rolling techniques. For this process, manufacturers adopted Jackson Rolling machines, which could roll up to 8000 pounds of tea leaves per day (John, p. 39). The Jackson rolling machine is sold to companies in Ceylon for $300,000. In this procedure, the green leaves are permitted to be stretched out in layers to give them the copper colour that indicates the end of the fermentation. Layers were 8 to 10 cm high, providing the procedure with the necessary wet and chilly environment for one to three hours (Thasfiha, 2020). The fermentation process of tea leaves begins when the rolling starts, and it requires maintaining temperature and humidity. Thus, to provide the environment in the room and to facilitate the processing, the infrastructure is maintained. Ceylon adopted the Indian practices, but it differed in maintaining the fermentation temperature, which is 82° F in India, whereas it is 65°F in the Ceylon tea industry.

4.4 Frying and Drying

The Updraft machine of William and John Jackson was used in 1883 to automate the tea-drying plant in Ceylon. Tayler (1900, p.175) notes that compared to Indian drying machines, the capacity of a 42-inch Drying or Firing Automated Machine in Ceylon has reached 80-90 pounds per hour. It operates by automating the rotating web or bands that perform the rotation when the warm air dries the tea leaves. The moisture is released from the leaves during this process, leaving delicate, dry tea leaves behind. Money explains that the machine's moving bands can repeatedly alter the feeding web and rotate continuously to heat the leaves. It was famously called Victoria (Money, 1883, p.248). When the tea leaves arrive at the drying station, they are handled at 850–880°C to prevent disrupting the oxidation process. Copper-coloured dried leaves are produced using this technique after removing the last moisture from the leaves. As a result, the leaves develop a dark brown colour to ensure the process is complete.

Mr Robinson improved the machine's dry-warm air system in 1892 and tested it in the Ceylon Tea Estates. According to reports from Ceylon Tea farms, its steam-heated automatic Robinson tea-drying Machine outperformed (Ukers, 1935, p. 481). The Ceylon tea business adopted the inlet air temperature to preserve the quality of tea leaves after withering (Mills, 1934, p54). Edward Money claims Che mentions the Ceylon Observers and queries about the drying procedure. He draws attention to how the Siroccos steam the leaves using a boiler, maintaining a temperature of 275 degrees (Money, 1883). To further modernise the production of tea, J. M. Boustead of Colombo obtained the patent for electrifying the heated drying system in 1896. The action performs the porcelain-coated iron coils to generate heat on the surface (Mills, 1934).

Thus, the device became one of the island creations that invented the hearting frame that transported the tea leaves inside the continuous belt to carry out the drying and frying process. Later, a Sirocco endless chain pressure dryer using this technique was created and released in 1907–1908 (Ukers, 1935, p482). Notably, Mr J. S. Stevenson from Hatton in Ceylon continued the innovation of the electric dryer by creating another electric dryer and receiving a British Patent (Joseph, 1969, p.108). Additionally, Shand's Dryer was invented in Ceylon, which uses the same method of streaming tea for drying as its forerunners but differs from them where it is not treated in heat to be burned (Money, 1883). Notably, while designing the machine's heating point, the tea leaf's acceptable temperature is considered. Thus, Mr C Shand of Colombo created the process and was awarded a patent for the tea drier.

4.5 Sorting and Shifting

After firing and drying, the tea leaves were subjected to a sorting procedure to separate them based on their size. After the procedure of separation, the leaf's size was determined. All tea grades are made using the traditional broken, fanning, and dust process (Thasfiha, 2020). However, the grade selection criterion of the plant, which establishes the grade requirement, determines the size of the leaves. According to Ukers (1935), the Broken Orange Pekoe grade in Ceylon is 50%, while the Broken Pekoe and Orange Pekoe grades are worth 20%. Finally, while sorting, the 10% comprises Pekoe Souchong, Fannin and Dust, which is then separated. For separating these Pekoes, the machinery designed for shifting consists of sieves comprising varying mesh sizes that are levelled on each other. On the other side, the finest teas were collected at the base of the sieve where the primary sorting and shifting machines were built to separate coarse mesh at the top. The divided leaves are then collected in the collection box. In the latter half of the 19th century, this system of categorising the Ceylon tea business arose, and the technicians pioneered the production in the Colombo industries (Gow, 1897).

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4.6 Green Tea Machinery

Green tea production was mechanised in the Ceylon tea industry. Earlier, the traditional tea-making methods of China were shortened by India and then followed in Ceylon, where the tea manufacturing duration was decreased. For producing green and black tea, Horace Drummond Deane created the first device. It marked the beginning of Ceylon's invention of green tea machinery. It is noted that the concept of the machine was developed by uniting Ceylon's tea industry planter's feedback and ideas. Ukers (1935, p. 483) points out that the green tea machine has made the tea leaf flexible for further production. Then, the tea leaves were rolled and twisted. Further, the hexagonal hardwood drum was created to meet the manual and mechanical solutions. Meanwhile, Dean & Rae Green Tea Machine received a patent when he joined the innovation and took over production from Colombo's Brown & Co., Ltd.

Notably, H. M. Alleyn of Maskeliya created the green tea maker in 1902 and received the British patent. The machine processes the grading, breaking and cutting, as well as shifting of the tea leaves. This machine joined the list of island tea machine creations. Secondly, the Mitrailleuse pan frying machine was developed in 1902 by Whittall & Co. of the Colombo tea industry. Thirdly, William Butler's patent-winning mechanism on pan-firing functioned similarly to that of the Mitrailleuse (Money, 1874). These machines revolutionised the concept of tea machine inventions in Ceylon to speed up tea making. Further, the development of finishing and glazing devices was produced by William Butler and Colonial Indian Inventor Charles G.L. Judge in 1902.

Due to their collaboration, Ukers (1935, pp. 484-485) notes that Dean Judge introduced Deane's equipment into India. In this equipment, by centrifugally tossing off 3000 lbs of stream water in two to three minutes, Judge and Deane made a significant contribution notable enough to receive a patent. The heater for steaming, drying, and steam roasting was created in 1903 by F. E. Mackwood, G. Sterrting, and H. Traver for the Ceylon tea business. It completed the burning and finishing of tea. The Dean Judge procedure was enhanced in the same year by famous chemist and scientific officer Kelway Balmer of the Ceylon Tea Association for disinfecting tea leaves containing the free carbonic acid gas. Especially, for performing the action, the cup's quality was enhanced and over-fried in the hot pots. It is noted that the procedure was expensive, yet the improvement was seen through the subsequent process that led to the approval. Therefore, these inventions of tea machines and the collective adaptation of these machines through its tea administration made the TRI and Tea Planters Association of Ceylon contribute to the tea business of Ceylon.

4.7 Types of Tea Manufacturing in Ceylon

Ceylon and Indian tea gardens initially adopted the tea-making technique brought by Chinese tea workers. Thus, India and Ceylon's tea industries followed the traditional tea manufacturing methods at the beginning of the cultivation stage. However, the processing methods were gradually improved to produce the green tea leaves using improved methods of tea making, and then the processed tea was dried and box-packed firmly using the hand-processing method. For drying charcoal fires are used, which is operated by the method of pumping using one's feet.

The British view this labour-intensive practice as being uncivilised and unhygienic. It consequently results in the introduction of new equipment. The first rolling machine was created in 1872 by British scientist William Jackson. This was put into practice in Ceylon's tea industry. After this process, additional tools were also employed for brewing tea, and the Britishers developed the "CTC method" of tea production in India. This incorporates cutting, tearing and curling methods using the machines to replace the older tea-making methods. This technique further improved the tea-making procedure and modernised the tea-making methodology.

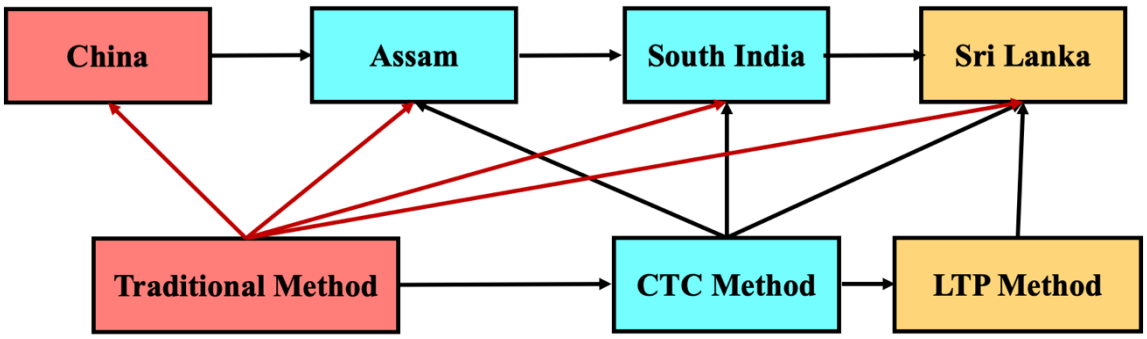

Fig. 4. Evolution of Tea Manufacturing Methods from China, India to Sri Lanka **Source:** Author's Research

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4.7.1 CTC Method of Tea Making

The CTC processing method was implemented in India and Sri Lanka's tea industry to increase tea production. It is noted that the CTC (Cut, Tear and Curl) processed tea differed from the traditional tea aroma and flavour. During the CTC method, the tea leaves were ground by rolling them into little pieces, so that they looked as if it was ground tea powder. This method was first used and followed in Sri Lanka in the 1920s. This led to the development of the unusual type of tea known as "Ceylon tea,". The CTC-processed tea was especially well-suited to the robust teas grown in Sri Lanka. The introduction of the CTC method, which included breaking up the tea leaves into tiny bits, led to a richer flavour and quicker brewing times. The Ceylon tea industry then widely used the CTC method as the primary tea-making method for tea production. The island further innovated the packaging of tea with teabags to improve the quality of tea. It utilised the Assam tea technology apparatus and packing methods to modernise its tea packing methods (Money, 1883). Notably, the teas produced using this method produce a uniform size that doesn't further need sorting because it is a unique size. However, this method also involves sorting to fine-tune the packing of tea. Tea leaves that have withered are crushed in metal rollers to collect the cell sap, which is then put back into the leaves. After being CTC-processed, these leaves were sent for fermentation, drying, and sorting to finish the tea-making process.

4.7.2 LTP Method of Tea Making

While developing the tea industry, Sri Lanka continued its innovation for producing the Lawrie Tea Processors (LTP). It was the innovative tea processor that created enterprises to use advanced methods for processing tea. This included the customary steps of withering, rolling, fermenting, and burning the tea leaves. Using the LTP method, high-quality teas with distinctive flavours and smells were produced. The LTP method innovates the tea leaves slicing to maximise the production before entering it into the Liquid Dispensing Beverage (LDB) machines. With effective motors to finish the process in the later phases of island tea production, this approach speeds up tea production even more (Thasfiha, 2020). Hall noted that it replaced 60 to 70 skilled manual labourers. The Assam and Ceylon tea industries were revolutionised because Jackson created the tea machine between 1849 and 1915. LTP created new tea blends that helped diversify the Ceylon tea business. By employing the LTP, the Dimbula tea mix was created, which gained popularity for its robust taste and flavour, and it further promoted the reach of Sri Lanka's tea industry (Jackson, 1881). This method has incorporated the earlier development of machinery for tea-rolling, drying, sorting and other relevant devices that improved the tea manufacturing mechanisms. Notably, the drying machine's processing technique was brought to Ceylon in 1880, replacing the charcoal-burning furnaces to improve the drying process. It reduced the labour of thirty-five workers to complete the drying process effectively. Hall claims to have demonstrated the distinction by presenting how tea leaves spread over time because warm air circulated inside the chamber (Nick, p.17). The tea industry of South India and Ceylon exchanged ideas and worked together, which led to extensive research and development in both countries.

Mr. Kelway Bamber, who lived in India and Ceylon, published the book "The Chemistry and Agriculture of Tea", which illustrated the changes both tea industries have undergone (Bamber, 1893). He also contributed the report titled "Ceylon Tea Soils," this contribution on the chemistry of tea led both nations to agree with the Ceylon Tea Planter's Association and Indian Tea Association in 1891-1892 to study the soil and pursue investigation to understand the soil, chemistry and agricultural practices in both countries (Bamber, 1900).
Ukers (1935, p.169) notes that in British India and Ceylon, the pioneers of the tea industry were highly honoured. In 1898, Mr G. G. Anderson, a planter in the Ceylon tea sector, was elected chairman of the Indian Tea Association by Williamson Magor & Co. For his significant work with the Indian Tea Association in London, Mr W. H. Verner, Chairman of Ceylon Tea Co., Ltd, was appointed Chairman of Dooars Tea Co., Ltd in India for a brief period (Ukers, 1935, p.160). Until 1902, his participation helped both countries' tea industries grow in trade and commerce. As a result, throughout the late 19th and early 20th centuries, the South Indian and Ceylonese tea industries experienced parallel expansion due to the interaction, development, and exchange of traditional and cutting-edge tea knowledge.

5 CONCLUSION

The Ceylon tea industry excelled in machinery innovation and contributed to the world with its advanced tea machinery through manufacturing. Initially, Ceylon learnt the tea manufacturing methods from China and India. Ceylon adopted the traditional tea-making method of China in the trial stages. Ceylon tea cultivation progressed by importing tea cultivators from Southern India and implementing the production of Assam Jats from India. It also brought the tea cultivators from Southern India for the expansion of the tea industry in the island. Ceylon tea production also adopted India's CTC method of tea making. Ceylon has improved the

manufacturing methods of tea, developed based on the feedback arising from the Tea Planters Association of Ceylon. Innovative tea manufacturing methods were implemented in the tea machinery production headquartered in Colombo. Ceylon tea machineries were experimented with in the island and even adopted in India. Thus, the tea machinery innovation of Ceylon is interlinked with the integration of the farmers and the machine builders of the island.

The tea production of Ceylon focused on producing Green and Black tea with major methods of tea making such as Withering, Rolling, fermenting, drying and sorting. By adopting the Cut, tear, and curl method, black tea manufacturing enriched the packaging methods. The Ceylon innovation in tea manufacturing has excelled in some notable tea machines and methods. At first, the usage of the Limping Apparatus for Withering. In the process of drying the Mitrailleuse pan frying machine, Robinson and Stevenson's innovation of the tea-drying Machine that electrified the dryers has improved the drying techniques. Notable production of rolling machines, such as John Walker & Co. Ceylon's tea-rolling machine, and Jackson Rolling machines, has mastered tea manufacturing. H. M. Alleyn of Maskeliya created the green tea maker that kick-started the themed tea-making machines. Finally, the Lawrie Tea Processors were some of the key innovations of the island that contributed to upgrading tea production. Therefore, the paper explains how the transfer of tea cultivation and manufacturing methods from China and India has progressed the tea industry. Secondly, it describes how the key innovation of the island has mastered the tea production that led to making Ceylon the leading tea industry in South Asia.

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