

Quality and Process Control Initiatives for Achieving Manufacturing Excellence in Cooperative Tea Factories

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Abstract— Tea is the largest consumed beverage after water worldwide. In Nilgiris alone there are 63,000 small tea growers and 15 tea factories run by the cooperative society for tea growers. There are few tea factories run by private companies as well. It is reported that the tea growers are not availing a good price for their tea leaves from the factories they supply. The factories report that they are not able to pay the desired value for tea leaves because the sales price in the tea auction is not great. The prices in the tea auction are reported to be not favorable as buyers are not willing to pay more for the given quality. It is thus concluded that, if quality of tea leaf and the process of manufacturing tea is good, then the quality of 'Made Tea' would obviously be good, and if the quality of 'Made Tea' is good, then its sale price will be good in the tea auctions. Thus, a good price could be given to the tea growers. This research study involves an analysis of tea leaves supplied by tea growers, the manufacturing process, quality control practices adopted by the tea factories and provides suggestion to achieve excellence in product quality.

Index Terms—Made Tea, quality management, process control, made tea, Nilgiris tea, cooperative tea factory

I. INTRODUCTION

There are around 63,000 small tea growers in the Nilgiris District cultivating tea in an area of more than 30,000 hectares. Initially, the small tea growers were supplying green leaf to bought leaf factories at low price. In order to uplift the tea growers, the Government of Tamil Nadu decided to promote Cooperative movement among small tea growers. With the establishment of the first Industrial Cooperative Tea Factory (ICTF) at Kundah in 1962, these small tea growers were able to realize a better price for their green leaf. Now, 15 ICTFs with 25,393 members are working in this district. They are producing 210.00 lakh kilograms of made tea every year, contributing 19% of the total production of made tea in this district. Apart from ICTFs, there are many tea factories established as private and public limited companies as well.

The Central organization of the 15 Industrial Cooperative Tea Factories is called 'Indcoserve' (The Tamilnadu Small Tea Growers Industrial Cooperative Tea Factories Federation Ltd.). The office of Indcoserve is located in Coonoor, in the Nilgiris District of Tamil Nadu. Today, the Indcoserve has become the

largest tea business organization in the country. The Indcoserve also provides various services to the ICTFs such as warehouse facilities at Coonoor, Coimbatore and Cochin, supply of fertilizers, supply of jute bags for packaging of tea, machinery spares, and other inputs to small tea grower through the ICTFs besides helping them to market the teas of the factories to their best advantage. The Indcoserve also provides financial support to the member ICTFs. It sells the brand 'Ooty Tea' through the Public Distribution System (PDS) as well. The Indcoserve has achieved the highest sale of 'Ooty Tea' to the extent of 5,084 MTs through the PDS. This could be made possible because of measures taken by the State Government.

II. NEED FOR THE STUDY

This study is very important because, the performance of ICTFs impacts the wellbeing of its members, the tea growers. The area of tea plantation is significantly large, and so is the number of dependents in this sector. The performance of ICTFs during the past few years is furnished in table 1.

Table 1: Performance of the ICTFs in the Nilgiris District

Year	No of Tea Factories	Total Production (Rs.in lakh)	Total Sales (Rs in lakh)	No of Profit Making Tea Factories	No of Loss Incurring Tea Factories
2012-13	15	14,009	14,055	15	0
2013-14	15	14,211	13,346	9	6
2014-15	15	10,317	9,822	1	14
2015-16	15	10,237	10,183	9	6
2016-17	15	12,919	12,501	10	5
2017-18	15	12,057	6,628	1	14

Source: indcom@tn.gov.in

Note: Performance data for 2018-19-20 is not been published by the Indcoserve as on date

This study has been initiated to understand the performance of ICTFs, especially to understand the reasons for losses in ICTFs, and to provide solutions for improving the performance of the ICTFs and to safeguard the wellbeing of

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the small tea growers, for whose benefit the ICTFs have been setup for. Tea factories and plantations are labour intensive and therefore, the impact is felt by the growers and the workers. Further, the price paid to the tea grower has not been favorable in the recent past whereas, the price for made tea have been increasing from time to time. It has been also observed that private tea factories are more profitable and sustaining than the ICTFs. The products of such private factories are reported to be superior to those of ICTFs. Ultimately, in the tea auction, the produce of private tea factories fetches more earnings than that of ICTFs.

During preliminary discussions with the employees of select ICTFs, they commented that:

“If the quality of tea leaf is good, the quality of made tea would be good. If the quality of made tea is good, then its sales price will be good. If the sales price is good, then we can give a good price for the tea grower...”

The comments of the employees of ICTFs were shared with few tea growers in the region. The tea growers denied the comments and shared their views as follows:

“We have been supplying tea leaves from the same plantation for years; there is no problem with the quality of tea leaf. The tea factories are not upgraded by technology, not maintained well so the quality of made tea may not be good, not because of tea leaf quality. There is no proper guidance or training offered to improve tea cultivation, plantation maintenance, harvesting and other aspects by the ICTFs or Indcoserve, so the cultivation, maintenance and harvestings is all done with our past experience...”

Therefore, the contradicting views are also a strong base to justify the need for this research study.

III. RESEARCH METHOD

The study involved an extensive empirical study pertaining to various aspects of tea, its history, manufacturing process, quality and process control aspects in manufacturing Made Tea, performance of the Indian tea industry, trade directions and recent research outcomes.

Objective: The primary objective of this research is to know the causes for losses incurred by ICTFs and to provide suggestive measures so as to operate with profits, keeping in view the small tea growers interest as a priority.

Research Approach: The study is ‘Exploratory’ in nature, involving field observations, investigations and discussions at shop floor aiming at exploring opportunities for improvising practices, processes and tasks. Objective and subjective observations were made and results recorded. At the end of the experimental season, qualitative and technical suggestions were made to the ICTFs. The study was conducted from April to August 2020.

Sources of Data/ Information: Both primary and secondary data/ information have been used for the conduct of this study. Primary data/ information were gathered through observations and interviews with employees of the ICTFs and tea growers, and secondary data from official publications of the government, Indcoserve and other authorized agencies.

Analysis and Interpretation: Qualitative analysis was made based on observations of specific activities and tasks crucial to the scope of study. The observations were compared with

defined operational guidelines set by Indcoserve and scientific bodies engaged in the study or processing of tea. Conceptual inferences were drawn so as to suggest improvements in all possible means so as to achieve quality ‘Made Tea’ through manufacturing excellence.

IV. COOPERATIVE TEA FACTORIES

Tea is one of the industries, which by an Act of Parliament comes under the control of the Union Govt. The initiation of the Tea Board India dates back to 1903 when the Indian Tea Cess Bill was passed. The Bill provided for levying a Cess on tea exports - the proceeds of which were to be used for the promotion of Indian tea both within and outside India.

The present Tea Board set up under section 4 of the Tea Act 1953 was constituted on 1st April 1954. The Tea Board of India is functioning as a statutory body of the Central Government under the Ministry of Commerce. The Board is constituted of 31 members including a Chairman (drawn from Members of the Parliament), tea producers, tea traders, tea brokers, consumers, and representatives of government, principal tea producing estates, and trade unions. The Board is reconstituted every three years.

Tea is included in the commodities list of India as a ‘Soft Commodity’. Being a commodity, tea is sold through auctions scheduled and monitored by the Indcoserve. ‘Teaserve’, a separate wing under the governance of Indcoserve conducts tea auctions and facilitates buyers to participate, bid and purchase the ‘Made Tea’. In the auction system of ‘Teaserve’, there is complete transparency with regard to prices set, information about buyers, quantity bid, and bid price. On a given day, all buyers pay the same price through bidding for the same ‘Made Tea’, whether small traders or large multinational companies. Auctions are an effective way of moving large volumes of tea from producers to buyers, which guarantees freshness of the ‘Made Tea’ and payment is realized within the fixed contractual time, usually ten days, ensuring fast cash flow for the producers. Smaller producers can also participate, which gives them access to local, regional and international markets, the standard unit being the pallet of 20 sacks for buying. There is a cost for operating within such a fully organized platform, which is, however, considered to be a win-win investment for all the stake holders.

Several factors influence the demand for tea, including the traditional price and income variables, demographics such as age, education, occupation, income, cultural background, consumption pattern of people. In addition, human health is influenced by tea consumption because of its health benefits.

Finally, apart from consumption, other main drivers of international tea prices are trends and changes in per capita consumption, market access, trade policies, potential effects of pests and diseases on plantations, and changing dynamics between retailers, wholesalers and multinationals.

V. MANUFACTURING PROCESS OF TEA

Tea manufacturing is normally carried out in two ways namely, the CTC process and the Orthodox process. CTC refers to the Crush, Tear & Curl process where the withered green leaves are passed in-between two rollers rotating in

opposite directions. There is complete maceration of the leaves and the resulting powdery material is referred to as “cut dhool”. Enzymatic action is higher in the CTC method of processing. In orthodox processing, the withered leaves are rolled on specially designed orthodox rollers which twist and crush the leaves thereby rupturing the cells. The maceration is less as against CTC processing. But this process results in teas with good flavor and aroma. Today, all the ICTFs in Nilgiris are manufacturing tea through the CTC processing method. Few factories do manufacture tea through Orthodox processing method.

The raw material for tea is only one component that is, green tea leaves. The green tea leaves are supplied by tea growers proximate to the tea factory in their area. For every cluster of tea plantations, a tea leaf collection centre is established by the respective tea factory in that area. It is the responsibility of the tea grower to bring the tea leaves from their plantation farms to the allotted collection centre.

Tea growers bring their tea leaves in bags to the tea leaf collection centre. In the collection centre, the tea leaves brought by the growers are spread in an open area and inspected by the weighing authorities. After inspection, the tea leaves are filled into standard coir bags provided by the tea factory and then weighed. Each coir bag shall hold a maximum of 50 to 55 kilograms of green tea leaves. From the gross weight, 2 kilograms is deducted as weight of the coir bag. Immediately after weighing the tea leaves, a receipt is issued to the grower for the quantity supplied. After which, the tea leaves collected are transported to the tea factory. Transportation of tea leaves from the collection centre to the tea factory is the responsibility of the tea factory.

Upon the tea leaves reaching the tea factory premises, the tea leaves are again weighed on first come first weighed basis and then sent into the processing unit. Fig.1 illustrates the processing of tea – from leaves to made tea (black tea).

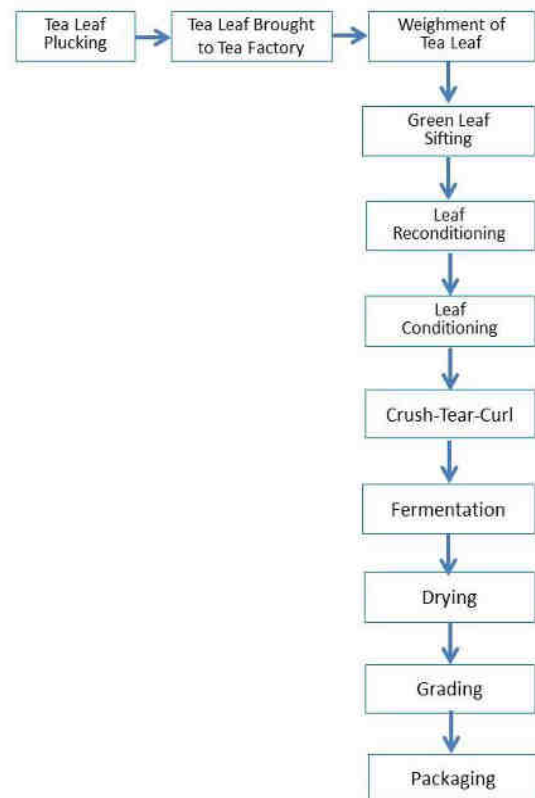


Fig. 1: Tea Processing (CTC Method)

The tea leaf processing unit is a multi-storied building where, the green tea leaves are received in the first floor and spread on the troughs for withering. After withering, the tea leaves are moved through ‘sifters’ and fed through the channel for further processing in the ground floor. Apart from withering, sifting and loading the tea leaves in to the feeder channels, all other processes are carried out in the ground floor.

The CTC method of processing as shown in fig.1 includes various steps and tasks elucidated as follows:

a) Withering: In this step the tea leaves are spread over a trough and hot air is blown into the trough to remove moisture from tea leaves. The moisture content goes down from 70-80% to 60-70%. 14-18 hours is considered as the optimum time period for withering. Withering makes leaf look limp and soft enough for rolling. The commonly adopted trough withering system is of two types:

i) Open trough: In an open trough, air is blown by fan below the leaves, the fan is moved in both forward and reverse direction so that both the top and bottom layer of leaves are equally dried. Often the leaves are moved by hands to ensure equal drying of leaves.

ii) Enclosed trough: Similar to open trough, with a cover on top so that the air is circulated to all the leaves and no need for operating the fan in reverse direction, damage to the tea leaves is minimum in this method.

b) Leaf Sifting: The green leaf sifter is a device for introducing continuous and even flow of withered leaves into CTC processing. Perforated tray with strong magnets is used to remove any metal particle comes along with the tea leaves which causes damage to the product, process and the machinery.

c) **Reconditioning:** The process of recycling secondary grades of withered tea leaves and residues in the trough or in the sifter obtained while moving the withered tea leaves and subsequent cleaning.

d) **Leaf Conditioning:** It is the process of pre-conditioning tea leaves for CTC processing. This process involves two components namely, the shredder and the rotor vanes. Shredding of withered leaf into fine particles increases the rotor vanes capacity and helps efficient mixing of the leaf with reconditioned dust in rotor vane.

e) **CTC processing:** It is a mechanical processor with two co-axial drums moving in opposite directions. CTC stands for ‘Crush, Tear, and Curl’ operation on pre-conditioned leaves.

f) **Fermentation:** In this step the processed leaves are left to oxidize, for 60-90 minutes with conditioned air in rotating drums. Rotation facilitates granulation of the tea particles and increases bulk density of the tea. A new method for fermentation is UV radiation fermentation.

g) **Drying:** This step brings down the moisture content of the tea leaves to 2.5-3% (which is ideally preferred). The objective of drying is to arrest the fermentation process and to remove moisture to produce tea with long shelf life. Two common methods adopted for drying are:

i) **Conventional Drying:** The principle involved in the conventional driers is that fermented leaf is subjected to a blast of hot air in such a manner that the hottest air first comes in contact with the tea having the least moisture content. In these driers, the fermented leaf falls on a series of moving perforated trays on which it is passed and re-passed through a moving stream of hot air.

ii) **Fluidized Bed Drying:** Tea industry presently enjoys a variety of fluidized bed drying equipment like ‘vibrobed’, built with five zones and three zones cross flow fluid bed driers. All of them strive to get increased fuel economy without affecting quality. Fluidized systems have high rates of heat and mass transfer while maintaining uniform temperature characteristics on the bed. This method of drying results in achieving more blacker teas with better appearance, flavor and bloom.

h) **Grading:** In this operation tea particles of the bulk are separated into various grades of different sizes and forms conforming to trade requirements. PVC rollers are used for this purpose. The common grades of CTC tea are as shown in table 2. Anyhow, at a given point of time all the grades are not produced by every tea factory. The grades intended to be produced depends on the quality of green tea leaf procured from tea growers of the designated area and the processing method adopted in that particular tea factory.

Table 2: Common Grades of CTC Tea

PEK	Pekoe
BP	Broken Pekoe
BOP	Broken Orange Pekoe
BPS	Broken Pekoe Souchong
BP1	Broken Pekoe One
FP1	Flowery Pekoe One
OF	Orange Fannings
PF	Pekoe Fannings

PF1	Pekoe Fannings One
BOPF	Broken Orange Pekoe Fannings
PD	Pekoe Dust
D	Dust
PD	Churamani Dust
PD1	Pekoe Dust One
D1	Dust One
RD	Red Dust
FD	Fine Dust
SFD	Super Fine Dust
RD1	Red Dust One
GD	Golden Dust
SRD	Super Red Dust

Source: Indcoserve

i) **Packaging:** Teas are packed in airtight containers in order to prevent absorption of moisture, which is one of the main causes for loss of flavor during storage. Packing chests are usually constructed of plywood, lined with aluminium foil and paper, and sealed with the same material. Corrugated cardboard boxes lined with aluminum foil and paper sacks lined with plastic are also employed. Jute bags lined with BOPP liners are extensively used for packing tea. Multi-wall paper sack is also found to be suitable alternative for packaging bull tea and is widely used by tea factories.

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VII. DISCUSSIONS

As the primary objective of ICTFs and the Indcoserve is aimed at supporting small tea growers in the region, it is observed that there is flexibility in meeting operational guidelines right from procurement of green tea leaves. The following are critical observations made by the researchers during their field visit:

ICTFs have incurred loss due to the poor price fetched in the auctions and, the price is low because of the quality of Made Tea it has produced. Another factor for incurring loss is because of the increasing overheads met by the tea factories.

The tea plantations are grown in varied types of soil in the district resulting in varied yields of green tea leaves.

The climatic condition is also varying at various localities in the district resulting in variance in the moisture level in the green tea leaves.

The ICTFs are scattered in the entire district of Nilgiris. Therefore, tea leaves procured are from different parts of the district, impacted by the soil type and moisture level of the green tea leaves.

Green tea leaves are to be plucked by hand as per specification that is, to pluck a stem with two tender leaves with a bud. Owing to shortage of labor and to harvest more sickles are used for plucking tea leaves. In the process the specification with regard to two tender leaves and a bud is hardly met. Even thick stems are found in the supplies.

There is variance in the use of yield enhancers and crop protection methods adopted by the tea growers, even within a small locality.

Breeding of tea saplings are through two methods, one is through using the seed (convention practice) and the other is through 'cloning'. Thus, the green tea leaves supplied by a grower may be from any of the two types of tea plants or sometimes a combination of both. Thus, quality variance exists among the tea leaves supplied by growers.

Use of crop protectors such as pesticides and insecticides by tea growers are also different by nature, brand and method of administration. This also leads to green tea leaves supplies with varied degrees of infections.

Firewood is used for fuelling the furnace for roasting the tea. As there is no specific fire wood is constantly used, there may be variations in the roasting level of tea. In some kinds of wood, the odor of the wood also impacts the tea being roasted.

For a long time, recruitment has not happened in these ICTFs in spite of many employees having retired from service. This has led to shortage of manpower which in turn impacts effectiveness and efficiency in the workforce. This has also impacted the operation of tea factories.

Initiatives are yet to be taken with respect to technology up-gradation in manufacturing process, quality control and innovations.

VIII. SUGGESTIONS

Based on the observation recorded during field visit, the researchers have suggest the following actions-

- So as to achieve product quality, the ICTS shall encourage tea grower to adopt the recommended practice

of tea leaf plucking.

- A schedule be fixed for growers to supply their green tea leaves based on the nature of soil of their plantation and the climatic condition largely prevailing in that locality.
- Standardized yield enhancer and crop protection mechanism be recommended for the locality from where a particular tea factory procures the green tea leaves.
- Recruitment shall be considered so as to effectively manage the green leaf collection centres and in the plant so as to ensure quality standards.
- Modern technologies shall be identified for roasting the tea so as to avoid the use of firewood as fuel.

The ICTFs may revisit the recommendations of researchers aimed at achieving product quality and manufacturing excellence in tea factories. Few such recommendations in brief are as follows-

- The optimum fermentation may be tried at a temperature of 35°C, time duration of 75 min, and pH 5.1
- Appropriate dosage of ultra-violet B (UV-B) could stimulate the expression of β -primeverosidase and β -glucosidase genes, resulting in the release of volatiles in tea leaf. The effects of UV-B on release of volatiles depended on UV-B dosage and tea cultivar. The number and total concentration of released volatiles increased when the fresh tea leaves were irradiated by UV-B with fluence 3.0 $\mu\text{mol m}^{-2}\text{s}^{-1}$ for 2 h and then decreased as the UV-B irradiation extended to 6 h.
- The low-cost colorimetric sensor array-based artificial olfactory technique has great potential for application in intelligent evaluation of the quality of green tea. A novel and economical colorimetric sensor array-based artificial olfactory system could enable intelligent evaluation of green tea's quality. In addition, the entire analysis process is quick and easy; both pre-treatment of the sample and the personnel professional qualifications are not required.
- Visible and NIR hyperspectral imaging combined with Lib-SVM has the capability of rapidly and non-destructively classify tea categories. The highest CCR obtained from the Lib-SVM model based on data fusion achieved 98.39%, which were superior to the models based on single features.
- A machine vision-based NDT (Non-Destructive Testing) method could be established to detect the moisture content of withered leaves.

Few Process Control Techniques recommended by researcher in the recent past are as follows-

- Use of microwave technology – in withering and drying
- Using an electronic nose to find the optimum level of fermentation
- Implementation of Computer Integrated Manufacturing (CIM) at tea factories

IX. CONCLUSION

The ICTFs and Indcoserve have been striving to support the small tea growers since their inception. Support in the form of providing with tea saplings, fertilizers and farm equipment at subsidized prices were extended by the agricultural ministry

from time to time to motivate the small tea growers. The ICTFs have been kind enough in accepting the supplies of tea growers even when their supplies were not meeting quality expectations.

These researchers have identified ample scope for improvement especially with regard to enhancing the quality standard of green tea leaves supplied by tea growers and quality in the process of manufacturing tea. The discussions and suggestions are hoped to contribute for achieving product quality through process quality which help the ICTFs and the Indcoserve to obtain a favorable price for Made Tea in the auctions. Thus, a better price could be paid to the tea grower.

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