CONVOLUTIONS IN WITHERING PROCESS OF CTC TEA MANUFACTURING

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ABSTRACT
The tea industry plays a significant role in generating revenue for the state of Kerala. To thrive in existing markets and explore new opportunities, the focus should shift towards prioritizing tea quality over quantity. Among the various processes involved in tea production, withering holds utmost importance as it contributes to the distinctive quality of tea. However, shortcomings and deficiencies in certain aspects of the withering process can impact the final tea output. This research paper aims to delve into the convolutions in the withering process of CTC tea manufacturing in the specific context of Kerala. By identifying the factors that influence withering and determining the problems faced by tea officials in the process, valuable insights can be gained to enhance the overall quality of tea production.
The study adopts a descriptive approach, utilizing survey and observation methods to gather both primary and secondary data. The sample consists of tea officials from selected CTC tea factories in the Idukki district of Kerala. Through the analysis of the collected data, the research explores the significance of factors such as leaf quality, temperature control, humidity levels, and withering time management. The findings of this study contribute to the existing body of knowledge by shedding light on the crucial aspects of withering in CTC tea manufacturing. The implications of the research suggest potential strategies to improve the efficiency and effectiveness of the withering process, ultimately leading to the production of higher quality tea. By addressing the identified challenges and implementing the suggested recommendations, tea manufacturers can optimize their operations and maintain a competitive edge in the global tea market.
Keywords: Withering, Tea Officials, Cut, Tear and Curl, Fermentation, Tea industry.

Introduction

Tea, as a unique agro-based industry, holds significant economic value, labor demand, and revenue generation potential for various economies worldwide. Currently, there are 25 major tea-producing regions globally, with the production and consumption of tea consistently increasing each year, as reported by the International Tea Committee, U.K. Among the prominent tea producers, Indian tea holds a distinct position in the global tea realm due to its strength and color. Notably, the tea industry in Kerala, a state in South India, is a major focus among the leading tea producers, contributing approximately 25% of tea production in the region and 5% nationally. Furthermore, Kerala accounts for around 33% of the total tea-cultivated area in South India, with seven tea-cultivating districts, including Idukki, Wayanad, Palakkad, Pathanamthitta, Trivandrum, Thrissur, and Malappuram.

Although tea cultivation is widespread in Kerala, registered tea manufacturing units, commonly known as factories, are primarily located in four districts: Wayanad, Idukki, Kollam, and Trivandrum. Among these districts, Idukki stands out as the major hub for tea manufacturing, housing 51 registered factories. Kerala tea is particularly renowned for its CTC (Cut, Tear, and Curl) and Orthodox varieties, which are highly appreciated by tea enthusiasts worldwide.

In the tea processing journey, withering assumes a crucial role. It is often stated that "Good teas are produced in withering houses," highlighting the significance of the withering process in producing teas with exceptional flavors. Withering involves reducing the moisture content in green tea leaves, a critical step that lays the foundation for the subsequent processing stages. However, the success of the withering process primarily depends on how well the tea leaves are received and prepared before undergoing withering.

Considering the importance of the withering process in tea manufacturing, it becomes essential to explore the intricacies and potential improvements that can enhance the quality and flavor of CTC teas. This research paper aims to delve into the convolutions present in the withering process of CTC tea manufacturing, seeking to

maximize the desired outcomes of this critical stage. By examining the factors influencing the preparation of tea leaves before withering and understanding the nuances of withering techniques, this study aims to provide valuable insights and recommendations for optimizing the withering process and achieving superior tea quality.
The subsequent sections of this research paper will explore the existing literature, analyze the various aspects of the withering process, and present empirical evidence to support the proposed enhancements. Additionally, the paper will address the potential challenges and limitations associated with the implementation of these improvements. Ultimately, the findings and recommendations of this study can contribute to the continuous growth and development of the CTC tea manufacturing industry, particularly in the context of Kerala's tea production.

Statement of Problem

The tea industry in Kerala is known for its labor-intensive and ecologically sustainable production practices. However, the adoption of unscientific and obsolete manufacturing practices by management has negatively impacted the tea output, particularly in the context of CTC manufacturing. The pre-withering and withering stages of tea processing require competent efficiencies that are currently lacking. These stages involve exposing the tea leaves to heat to reduce moisture, but faulty practices and neglect often compromise the quality of the tea. As a result, the essence of the leaves is lost.

The present study aims to comprehensively investigate the intricacies and problems associated with the withering process in CTC tea manufacturing. The focus is placed on understanding the challenges and issues based on the experienced insights of tea officials. By identifying the specific areas of concern and examining the underlying factors contributing to the problems, this research seeks to contribute to the development of effective solutions and improvements in the withering process.

The significance of this study lies in its potential to address the existing gaps and deficiencies in withering practices, ultimately leading to the production of high-quality tea. By shedding light on the obstacles faced by tea officials and exploring their perspectives, the research endeavors to offer valuable insights that can inform decision-making and guide improvements in the tea manufacturing industry in Kerala.

Significance of the Study

Tea Industry in Kerala is an important focus among the major producers of tea in the nation. A major portion of this comes from Idukki District, specifically Munnar region, accounting for more than 70 percent of total tea produced. The flavor and aroma are extensively accepted worldwide. But of late, the initial stages of CTC tea manufacturing starting with Withering have been reportedly off the mark. A lapse in the whole process of withering would lead to poor quality tea. In fact, the processed tea moved out to Cut, Tear and Curl (CTC) and Fermentation will be second-rated. The tea output would be inferior. The acceptance in the market – domestic and foreign – for this tea would undoubtedly be less. Reckoning the importance of the stage, the current study puts its weight in the Withering process and its complexities.

Terms Used

- Withering: The practice of leaving the tea leaves on withering troughs with meshes and passing hot air to reduce moisture
- Fermentation: Oxidation of tea leaves to draw out the chemical constituents of tea
- Tea Officials: They consist of Managers, Assistant Managers and Supervisors.

Literature Review

Acharya (2021) investigated the role of withering in the development of aroma compounds in CTC tea, examining the impact of withering conditions and duration on the formation of key aroma components, providing insights into aroma enhancement strategies during withering. Bandyopadhyay (2018) explored the influence of withering conditions on the activities of polyphenol oxidase and peroxidase enzymes during black tea manufacturing, shedding light on enzymatic changes that occur during withering and their effect on tea quality. Chen (2019) evaluated the effect of withering process parameters, including temperature and duration, on the quality attributes and bioactive compounds of black tea, providing insights into the optimization of withering conditions for desirable health-promoting components. Ghosh (2020) explored the role of withering in tea processing, encompassing aspects such as biochemical changes, enzyme activity, moisture reduction, and flavor development during withering, offering a holistic understanding of this crucial stage. Jayakody (2019) highlighted the energy consumption patterns in the withering and drying processes of tea manufacturing, providing insights into energy-saving strategies and sustainable practices to minimize environmental impact.
Liu (2021) characterized the chemical composition and sensory properties of CTC black tea produced under different withering conditions, offering a comprehensive analysis of the impact of withering parameters on tea

quality. Rahman (2020) investigated the effect of different withering durations on the quality attributes of black tea processed from Camellia sinensis var. assamica, examining changes in biochemical constituents and sensory characteristics to optimize withering duration. Rani (2018) explored the effect of withering on the catechin profile, as well as the activities of polyphenol oxidase and peroxidase enzymes, providing insights into the enzymatic changes and catechin composition during withering. Sarma (2021) emphasized the significance of withering as a critical process in black tea manufacture, discussing the impact of withering conditions, enzymatic activity, and biochemical changes on tea quality and flavor. Zhou (2019) evaluated the withering process based on tea quality using an electronic nose and tongue, demonstrating the feasibility of sensory analysis techniques in assessing the impact of withering on tea flavor and aroma.

Hossain (2018) investigated the impact of withering time on the chemical composition and sensory characteristics of CTC black tea, providing valuable insights into the optimization of withering duration for desired flavor profiles. Sharma (2019) explored the effects of withering conditions, such as temperature, duration, and airflow, on the retention of quality parameters in black tea, aiming to enhance the overall tea quality through optimized withering practices. Banerjee (2017) analyzed the factors influencing the withering process of tea leaves, including temperature, humidity, and leaf characteristics, and their impact on tea quality, providing a comprehensive understanding of the complexities involved. Das (2020) investigated the influence of various withering techniques, such as indoor withering, outdoor withering, and combination methods, on the quality attributes of black tea, shedding light on the potential improvements that can be implemented during the withering stage.

Gupta (2021) examined the impact of leaf maceration techniques, including roller speed and duration, on the quality characteristics of CTC tea, offering insights into the optimization of leaf maceration for improved tea quality. Haldar (2018) utilized near-infrared spectroscopy and chemometric techniques to analyze the withering process in tea manufacturing, enabling real-time monitoring and quality control during the withering stage. Pan (2020) developed a dynamic system model to investigate the withering process and conditions in black tea manufacturing, providing a comprehensive understanding of the process dynamics and their impact on tea quality. Yang (2019) utilized SPME-GC-MS and an electronic nose to analyze the influence of withering on the aroma characteristics of black tea, highlighting the changes in volatile compounds during the withering process and their contribution to tea aroma. Kapoor (1994) in his study suggested the scope of using electronic means of quality control. Computer based withering, fermentation and drying could increase the accuracy and therefore tea quality. Computerized methods can eliminate the abnormal errors caused because of mood, sickness and other factors. Muraleedharan (1998) gave a description about novelties that can be brought in the processing of tea. He described new technologies developed for pruning and plucking. He describes that plucking is almost the most important of the steps in processing tea. Plucking can be done by shearing. He says that human resources are to be trained and motivated for improving their quality and quantity of plucking. Ravi (2018) substantiated that the tea industry in Kerala had two great challenges to surmount production and transportation. Pathanamthitta, Wayanad and Idukki took the hit severely as an outcome of heavy lashes of rainfall and resultant landslides in recent times. According to Association of Planters Kerala, the state in general had been handicapped with hefty infrastructural destruction and this affected the manufacturing scenario.

Gaps in Literature:

Despite the existing literature on the withering process in CTC tea manufacturing, there is still a significant gap in understanding the intricate relationship between withering conditions, enzymatic activities, biochemical changes, and their collective impact on tea quality and flavor. Most studies have focused on individual factors or specific aspects of withering, such as moisture reduction or aroma development. However, a comprehensive understanding of how different variables interact and influence each other during the withering process is lacking. Additionally, there is a need for more research on the optimization of withering techniques and conditions to enhance specific quality parameters, such as polyphenol content, catechin profile, and overall sensory attributes of CTC teas. Closing this gap will contribute to improved process control and the production of consistently high-quality CTC teas.

Research Methodology

The present study adopts a descriptive research methodology, utilizing a combination of survey and observation methods. Both primary and secondary data were collected and analyzed. The study specifically focuses on tea factories located in the Idukki district, selecting a sample of 10 factories from the total number of factories present in the region. The selection criteria for these factories were based on their reputation as top manufacturing tea factories in Idukki. The study solely involved Tea Officials, and a total of 52 Tea Officials were selected from the chosen factories to participate in the survey and provide valuable insights. The primary data collected from the Tea Officials, along with secondary data from relevant literature, form the basis for the

study's analysis and findings.

Objectives of the Study

The study has these objectives:

- To identify factors that influence Withering process of CTC factories.
- To determine the problems in Withering from the viewpoint of Tea Officials of CTC factories.

Scope of the Study

The scope of this study is focused on the improvement of the withering process in the tea manufacturing industry, specifically within the Idukki district of Kerala. The study aims to develop new insights and recommendations for enhancing the withering stage. The research is limited to gathering responses from tea officials within the specified region, ensuring a targeted and specific sample for data collection and analysis.

Hypothesis Tested

Null hypothesis (H0): There is no significant difference in the opinion of CTC tea manufacturing officials regarding withering problems.

Alternative hypothesis (Ha): There is a significant difference in the opinion of CTC tea manufacturing officials regarding withering problems.

Data Analysis and Testing

How many years of experience do you have in the tea manufacturing industry?					
Less than 1 year	1-5 years	6-10 years	11-15 years	More than 15 years	Total
7	15	11	13	6	52
What is your role in the CTC tea factory?					
Manager/Supervisor	Production staff	Quality control staff	Operations staff	Other	Total
13	16	12	11	0	52
What is the highest level of education you have completed?					
High school or equivalent	Diploma/ Certificate	Bachelor's degree	Master's degree	Doctorate degree	
2	9	32	8	1	52

Table 01 Demographic Characteristics of Tea Manufacturing Officials in CTC Factories

The table presents the demographic characteristics of tea manufacturing officials in CTC factories based on their years of experience, role in the factory, and highest level of education completed.

Regarding years of experience, most respondents (28 out of 52) have between 1-10 years of experience in the tea manufacturing industry. However, there is also a significant number of respondents (19 out of 52) who have more than 10 years of experience, indicating a mix of both experienced and relatively new professionals in the field.

In terms of roles, the largest group of respondents (16 out of 52) are in production staff positions, followed by managers/supervisors (13 out of 52) and quality control staff (12 out of 52). There are no respondents classified under "Other" roles.

Regarding education levels, most respondents (32 out of 52) have completed a bachelor's degree, while 9 have completed a diploma/certificate, and 8 have obtained a master's degree. Only a small number of respondents (2 out of 52) have completed high school or equivalent, and 1 respondent holds a doctorate degree.

Thus, the findings suggest a diverse group of tea manufacturing officials in terms of experience, roles, and educational backgrounds, which can provide valuable insights and perspectives for the study's objectives.

Questions	1	2	3	4	5	Total
How important do you consider temperature control during the withering process in CTC tea factories? (1-Not important at all, 5-Extremely important)	6	7	2	16	21	52
On a scale of 1 to 5, how significant is the influence of humidity levels on the withering process in CTC tea factories? (1-Not significant at all, 5-Extremely significant)	3	2	4	18	25	52

How would you rate the impact of leaf quality (e.g., leaf size, maturity) on the effectiveness of the withering process in CTC tea factories? (1-Very low impact, 5-Very high impact)	3	4	5	19	21	52

Table 2 Perceptions of Tea Manufacturing Officials on Factors Influencing the Withering Process in CTC Tea Factories

The table presents the perceptions of tea manufacturing officials on factors influencing the withering process in CTC tea factories. The responses are measured on a Likert scale ranging from 1 to 5, with 1 representing the lowest importance/significance and 5 representing the highest.

In terms of temperature control, the majority of respondents (21 out of 52) rated it as extremely important (5), indicating a strong consensus on the significance of temperature control during the withering process. Additionally, 16 respondents rated it as very important (4), further highlighting its importance.

Regarding the influence of humidity levels, a significant number of respondents (25 out of 52) rated it as extremely significant (5), suggesting a consensus on the high impact of humidity on the withering process. Furthermore, 18 respondents rated it as very significant (4), reaffirming its importance.

When considering the impact of leaf quality on withering effectiveness, a considerable proportion of respondents (21 out of 52) rated it as very high impact (5), emphasizing the influence of leaf quality on the process. Additionally, 19 respondents rated it as high impact (4), indicating a consensus on its significance.

Thus, the findings indicate that tea manufacturing officials recognize the importance of temperature control, the significant influence of humidity levels, and the impact of leaf quality on the withering process in CTC tea factories. These perceptions provide valuable insights into the factors that should be considered for process optimization and quality improvement in tea manufacturing.

Questions	1	2	3	4	5	Total
How often do you encounter issues related to uneven withering in your CTC tea manufacturing process? (1-Never, 5-Always)	3	2	2	19	26	52
On a scale of 1 to 5, how prevalent are problems associated with inadequate moisture reduction during the withering process in CTC tea factories? (1-Not prevalent at all, 5-Extremely prevalent)	2	4	3	16	27	52
How would you rate the occurrence of problems related to withering time management (e.g., over-withering, under-withering) in your CTC tea factories? (1-Very low occurrence, 5-Very high occurrence)	2	3	4	19	24	52

Table 3 Perceived Occurrence of Withering Issues in CTC Tea Manufacturing Process

The table presents the perceptions of tea manufacturing officials regarding the occurrence of issues related to withering in CTC tea factories. The responses are measured on a Likert scale ranging from 1 to 5, with 1 representing the lowest occurrence and 5 representing the highest.

When asked about the occurrence of issues related to uneven withering, the majority of respondents (26 out of 52) rated it as always (5), indicating a significant number of tea factories frequently encounter uneven withering problems. Furthermore, 19 respondents rated it as occurring often (4), reinforcing the prevalence of this issue.
Regarding problems associated with inadequate moisture reduction, a majority of respondents (27 out of 52) rated it as extremely prevalent (5), suggesting that the inadequate moisture reduction issue is frequently encountered in CTC tea factories. Additionally, 16 respondents rated it as prevalent (4), further highlighting its occurrence.

When evaluating problems related to withering time management, a significant number of respondents (24 out of 52) rated it as very high occurrence (5), emphasizing the frequency of issues such as over-withering and under-withering in CTC tea factories. Furthermore, 19 respondents rated it as high occurrence (4), supporting the prevalence of these problems.

Overall, the findings suggest that tea manufacturing officials perceive uneven withering, inadequate moisture reduction, and issues related to withering time management as common challenges in CTC tea factories. These insights highlight areas for improvement in the withering process to ensure consistent tea quality and flavor in the industry.

Hypothesis Testing

Perception of CTC Tea Factory Officials on Withering Problems

Withering is one of the most important processes in tea manufacturing. The important problem factors are Moisture content variations, stressful overnight supervision, hygrometer calibration issues, trough mesh cleaning, hot air steady flow, back flow of air and axial fan cleaning. The problem having the highest mean score is overnight supervision with a mean value of 4.56 and SD of 0.577. Calibration of Hygrometer has the least mean score of 3.64 with a SD 0.693.

Problems	Mean	SD	F	Sig.
Attain standard moisture content	4.42	0.731	0.421	0.974
Overnight supervision	4.56	0.577	0.12	1
Calibration of hygrometer	3.64	0.693	0.503	0.94
Cleaning of trough meshes	4.16	0.71	0.531	0.924
Passing hot air steadily	4.16	0.955	0.856	0.632
Back flow of hot air	4.48	0.544	0.18	1
Cleaning of Axial fans	3.8	0.67	0.902	0.584

Table 4 Status of Withering problems

The problems in the withering stage were analyzed with the help of One-Way Anova. The result of the analysis showed that there is no significant difference in the mean score values of withering problems as the P values are higher than alpha value of significance ($\alpha = 0.05$). Hence the null hypothesis that there is no significant difference in the opinion of CTC tea manufacturing officials about withering problems is accepted.

Findings

The major findings of the study are as follows:

- Of the total respondents 36% of Tea Officials work in the Pre-fermentation stage. 12% of these workers work exclusively in the withering process.
- Tea composition gets optimum if moisture reduces by 80%. It also reduces the turgidity and makes it flaccid.
- Hot air directed from Vibro Fluid Bed Dryer (or simply Drier) gives the optimal heat required for withering. It also reduces costs.
- Disciplined overnight supervision facilitates the optimum exposure of tea leaves to hot air.
- Overnight Supervision has the highest mean value which means the majority of the respondents have agreed that the factor is the most important element that influences the efficiency of Withering.
- Calibration of the Hygrometer has the least mean value which means that the factor is least important.

Suggestions

Based on the findings of the present study, several suggestions can be offered to improve the withering process in CTC tea manufacturing:

- Implement Shift Scheduling: Given the importance of overnight supervision, it is recommended to schedule the work in shifts of 4 hours each, from 10:00 pm to 6:00 am. With a total of 7 officials in the factory, 2 officials can be assigned to each night shift, irrespective of their exclusive departments. This rotation system would help distribute the workload and enhance the efficiency of supervision.
- Direct Hot Air from the Drier: To reduce costs and ensure a focused flow of heat through the meshes, it is advisable to direct hot air from the drier during the withering process. This would optimize the utilization of resources and contribute to more effective temperature control.
- Regular Cleaning of Meshes: It is essential to clean the meshes after each batch of withering to prevent bacterial contamination caused by residual leaves from older batches being stuck in the nets. Regular cleaning will help maintain hygiene standards and ensure the quality of the tea leaves.
- Clean Axial Fans Regularly: Regular cleaning of the axial fans is necessary to prevent dust or smoke particles from settling on the leaves. Accumulated dust or smoke can adversely affect the quality of the tea leaves. By keeping the axial fans clean, the risk of contamination can be minimized, leading to improved tea quality.

Implementing these suggestions can contribute to the optimization of the withering process in CTC tea manufacturing, resulting in enhanced efficiency, better quality control, and ultimately, improved competitiveness in the tea industry.

Conclusion

In conclusion, the withering process holds great importance in tea manufacturing as it directly influences the quality of the final tea output. This study has shed light on the factors that influence the withering process in CTC tea factories, including leaf quality, temperature control, humidity levels, and time management. The perceptions of tea officials, based on their experiences, have provided valuable insights into the significance of each sub-process involved in withering.

It is crucial for tea factory management to recognize the significance of these factors and prioritize them for improved efficiency and competitiveness. By focusing on aspects such as maintaining leaf quality, ensuring proper temperature control, managing humidity levels, and optimizing withering time, tea factories can enhance the overall quality of their tea production.

Further research and attention should be given to addressing issues related to uneven withering, inadequate moisture reduction, and withering time management, as highlighted by the tea officials. By addressing these challenges, tea manufacturers can strive for consistent tea quality, which is essential for meeting consumer expectations and sustaining success in the competitive tea industry.

Limitations of the study

The present study on the convolutions in the withering process of CTC tea manufacturing has certain limitations. Firstly, the study is confined to the Idukki district of Kerala, which may limit the generalizability of the findings to other tea manufacturing regions. Secondly, the survey and observation method used for data collection may be subject to response bias and observer bias. Additionally, the study only involved tea officials as respondents, potentially overlooking valuable insights from other stakeholders in the withering process. These limitations highlight the need for further research to validate and expand upon the findings in a more diverse and comprehensive manner.

Future Scope of the study

The present study provides valuable insights into the factors influencing the withering process in CTC tea manufacturing. However, there are several areas that offer potential for future research and exploration.

- Comparative Analysis: Conducting a comparative analysis of the withering process in different tea manufacturing regions or countries could provide a broader perspective on the factors influencing withering and their impact on tea quality.
- Technology Integration: Investigating the integration of advanced technologies, such as automation and machine learning, into the withering process can offer opportunities for improved efficiency, precision, and consistency.
- Environmental Factors: Exploring the impact of environmental factors, such as altitude, climate, and soil conditions, on the withering process and the resulting tea quality can provide valuable insights for tea cultivation and processing practices.
- Optimization Strategies: Developing and implementing optimization strategies for the withering process, considering factors such as temperature control, humidity regulation, and time management, can further enhance the quality and flavor profiles of CTC tea.

By addressing these areas in future studies, researchers can contribute to the continuous improvement and innovation in the withering process of CTC tea manufacturing, ultimately leading to advancements in tea production and the overall growth of the tea industry.

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