FACTORS AFFECTING DAILY PRODUCTION WASTAGE OF TEA BAGGING MANUFACTURING

MASTER OF BUSINESS ADMINISTRATION

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SUPPLY CHAIN MANAGEMENT

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ABSTRACT

This research identifies and analyses of factors affecting production wastage of teabagging manufacturing. Minimizing production wastage is a very important operation consideration of any production oriented organization. The aim of this study is to identify the variables and their relationship in relation to Packing Materials (PM) wastage of tea bags. In other words, the purpose of this study is to answer the questions what are the factors affecting tea bag production wastage, which factor is significantly contributing to generating wastages and what is the nature of the relationship of these factors. The industrial norms for tea bags PM wastage in a production run is 2% or below that however in this study, wastage of above PM's constitute nearly 2% and above 2% hence there is a gap between expected level and the outcome. Therefore, the issue has been identified and analyzed empirically. Nevertheless, much literature and related research knowledge on wastage of tea bag manufacturing were not found thus related knowledge is limited. In addition, there were many limitations such as the inability to access of some information, sudden changes of management decisions on production lines, even though there were variable but not significant to achieve the objective of this research trying to achieve. A descriptive approach using primary data gathered from questionnaire-based interview survey design was adopted. A statistical modelling approach using secondary data from teabagging production records from January 2017 to December 2017 was also used. According to the analysis of primary data, gathered from the structured questionnaire the employees of the organization have been able to capture many problematic areas of the packing function that was not paid enough attention by the management which causes tea bag wastage. The most statistically significant and correlated problems discovered from the primary data are as follows: Flavored Black tea/ Green tea tends to generate less wastage while Black tea/ Green tea with herbs tend to generate more wastage, Envelope tea bags generate lower wastage and other variable does not have an impact on wastage.However, according to the analysis of secondary data, the total of wastage is less impacted by wastage of Flavored Black tea/ Green tea bags than of Black tea/ Green tea with herbs while total production significantly influences the total wastage. It is concluded that on average 2% of the total production of tea bags are wasted under the existing production process. However, this study can be further extended to find out the impact on the cost of production regarding PM wastage, production vs. wastage by machines, impact on inventory management of PM by wastage, and impact on tea export supply chain by wastage.

Key Words: Production Wastage, Machine Change Over, Constanta Machine, Compacta Machine, IMA Machine, String & Tag Tea Bag, Envelope Tea bag, Pacing Materials

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M. A. Danushka Perera.

DECLARATION OF ORIGINALITY

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the Supervisor: .... Date: ....

Dr Sudath Manjula Amarasena

Signature of the Supervisor: .... Date: ....

Dr Yapa Mahinda Bandara

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PM – PACKING MATERIALS

CBSL-CENTRAL BANK SRI LANKA

TB- TEA BAG

CON: CONSTANTA

COM: COMPACTA

MAI: MAISA

FUS: FUSO

IMA: IMA

1. FACTORS AFFECTING DAILY PRODUCTION WASTAGE OF TEA BAGGING MANUFACTURING

1.1. Background

Wastage can be identified as a Loss, decrease, or destruction of something (as by use, decay, erosion, or leakage or production output); (Merriam-Webster Dictionary, referred 2017), wastage especially a wasteful or avoidable loss of something valuable. Wastage is also can be an output due to consumption of scarce resources. Therefore, wastage turns out to become an important material of the environment as it directly connects to scarce resources. What should be thoroughly considered is that if we keep Wastage as unusable material, we intend to create a bigger impact for the future, as the consumption of today will hinder the future consumption due to the scarcity of resources. Many developed countries such as USA, Australia, Germany, Canada, France, Italy, Japan, South Korea, Spain, and the UK produce more waste per capita because they have higher levels of consumption. There are higher proportions of plastic, metal, and paper in the municipal solid waste stream and there are higher labour costs involved. As countries continue to develop, there is a reduction in biological solid waste and ash. Per capita waste generation in OECD countries has increased by 14% since 1990, and 35% since 1980. Waste generation generally grows at a rate slightly lower than GDP in these countries. Developed countries consume more than 60% of the world industrial raw materials and only comprise 22% of the world's population. As a nation, Americans generate more waste than any other nation in the world with 4.5 pounds (2.04 kg) of municipal solid waste (MSW) per person per day, fifty-five percent of which is contributed as residential garbage. However, with the introduction of the sustainable system many developed countries today recycle wastages into energy which reproduces back resources for their existence. For example, waste materials turn into recycling and reuse materials, treatment is done for wastewater and rainwater and reuse, waste food, tea, the commodity will be used for biomass production as fertilizer.

On consideration of a developing country like Sri Lanka, a permanent wastage management system is yet to be found. Although the per capita wastage is considerably high, there is no proper management system. When it comes to national or industrial level, Sri Lanka has formulated some companies such as GEO CYCLE. But the attitude of people does not fall in line with such type of company’s wastages whether it is material or any other. This directly impacts the ultimate bottom line of our own organizational profits margin. Therefore, it is paramount important to identify the variables of the wastage generators and find proper wastage management systems.

The Tea industry is an important agricultural industry that plays an important role in many developing countries around the world (Gesimba et al.2005; CBSL 2009; FAOSTAT 2010) around 15 % of the direct employment opportunities are created from the tea industry in Sri Lanka (Herath &Weersink 2006; CBSL 2009) at present tea exporting industry facing a massive competition which has been affected even the company going to modeled in this research

Presently I am working at a leading tea exporting company which has a turnover of 2.5 billion during last financial year (annual report) and which holds the 33rd position in tea exporters overall ranking 2016 (Data one book Sri Lanka Custom, 2016), waste management is a great challenge to tea processing and export industry in Sri Lanka as well as many other countries in the world. The packaging materials, Tea, machinery, labour are the major inputs in tea export organizations. When it comes to Tea bag production in the world it faces a great challenge in high cost of production due to the higher cost of raw materials and other inputs.

1.2. Problem Statement

It has been observed that for the last three years Regency Teas (Pvt) Ltd organization's daily production wastage of raw materials is averagely between 2 % to 5% and sometimes even more than that. However, the organization policy of benchmark companies' production wastage of raw materials percentage should be below 2%. There is a considerable gap between the existing average wastage percentage of raw materials and the expected level. Thus, this is the case study approach of looking into a problem in operations, the manufacturing process wastage is inevitable but the proper planning, controlling, and monitoring can reduce it. These statistics show the average wastage of raw materials in the teabagging production process from the year 2014 to 2017 and it shows the behavioural pattern of the wastage.

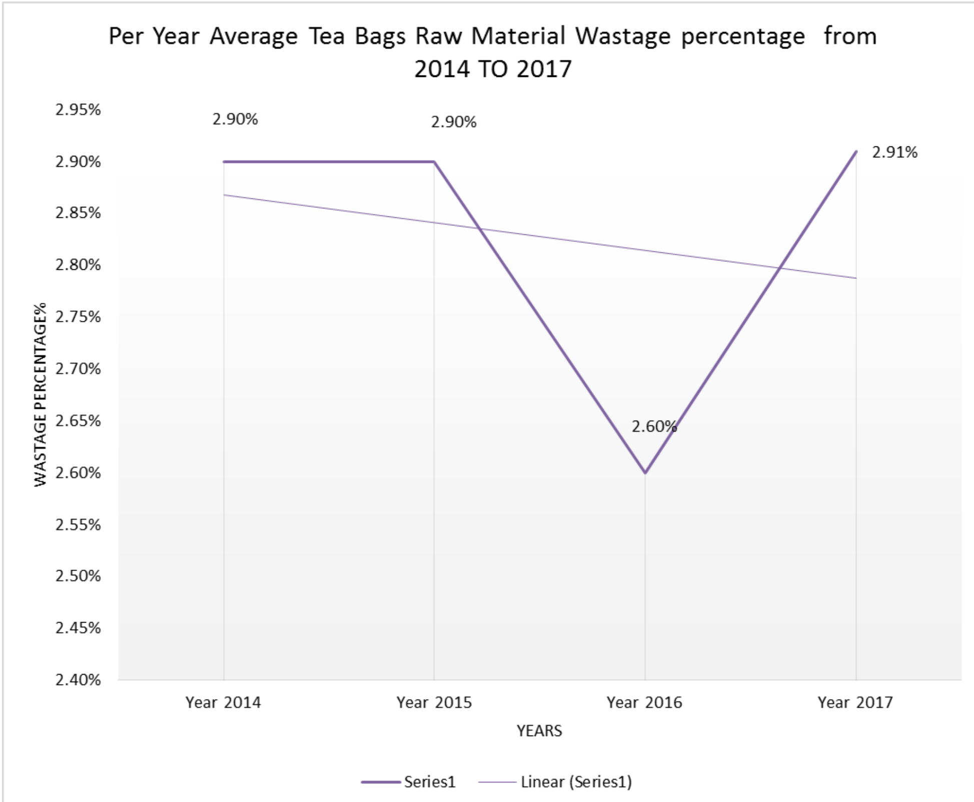

Figure: 1.1: Average Annual Wastage Percentages from 2014 to 2016

Source: Daily production records of Regency Teas (2014-2017)

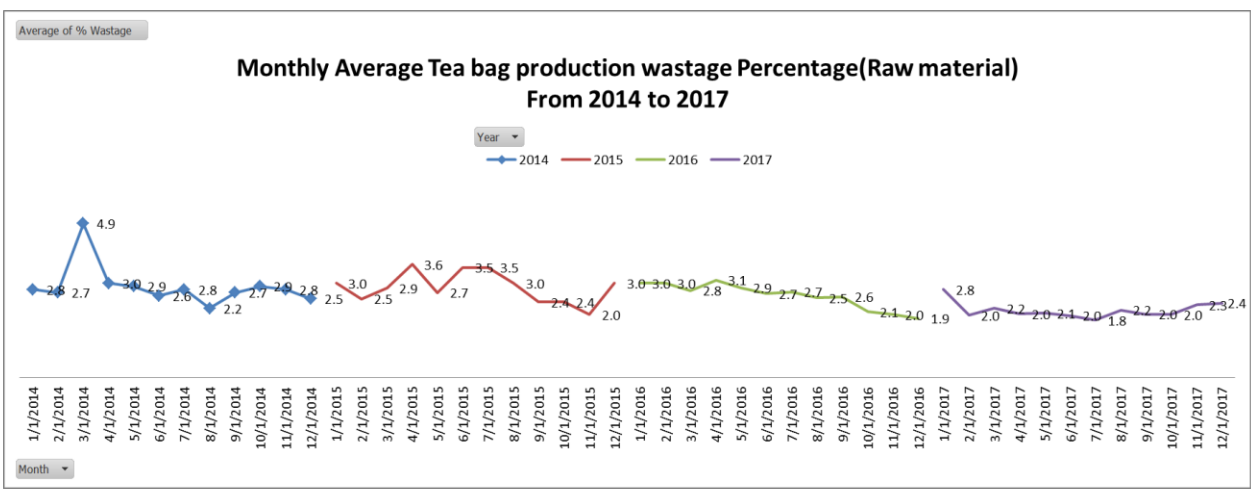

Figure: 1.2 Monthly Ave. Tea Bags Production wastage 2014 to 2017 (Source: 2014 to 2017 source Daily production records)

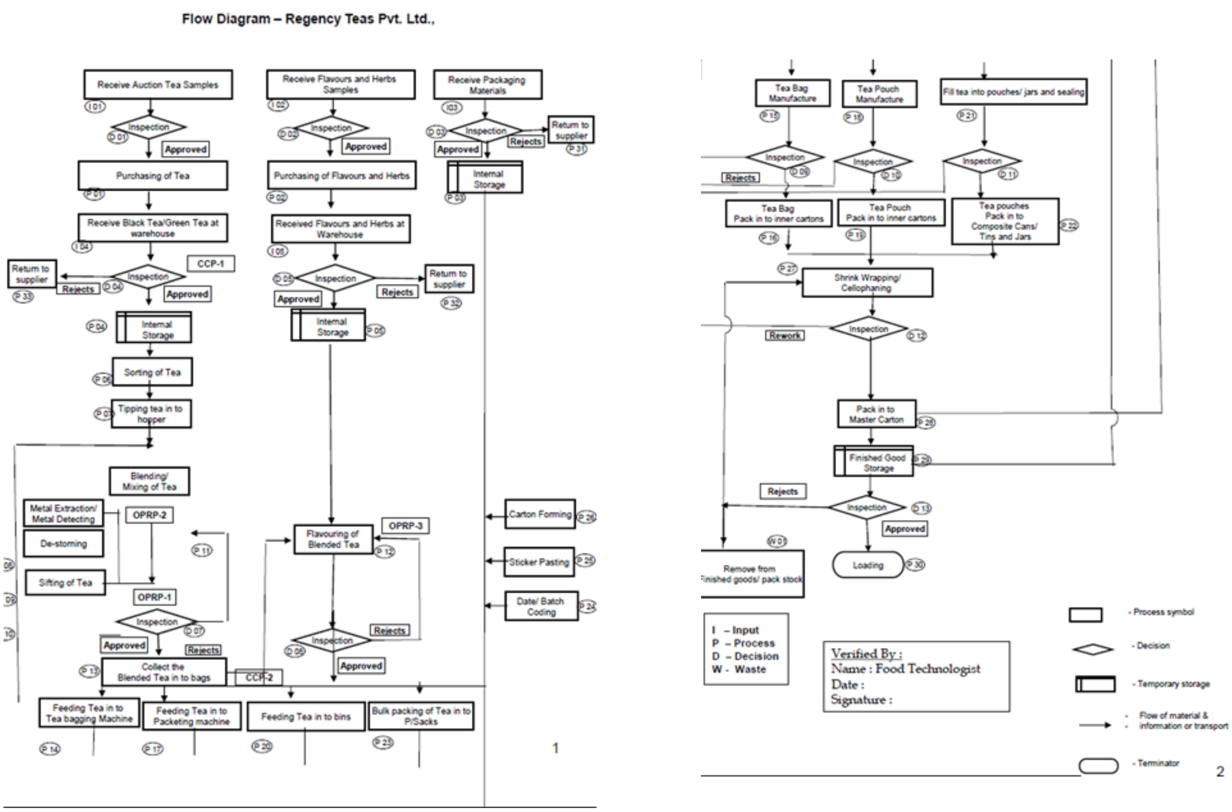

Figure:1.3 Flow Diagram of total production process

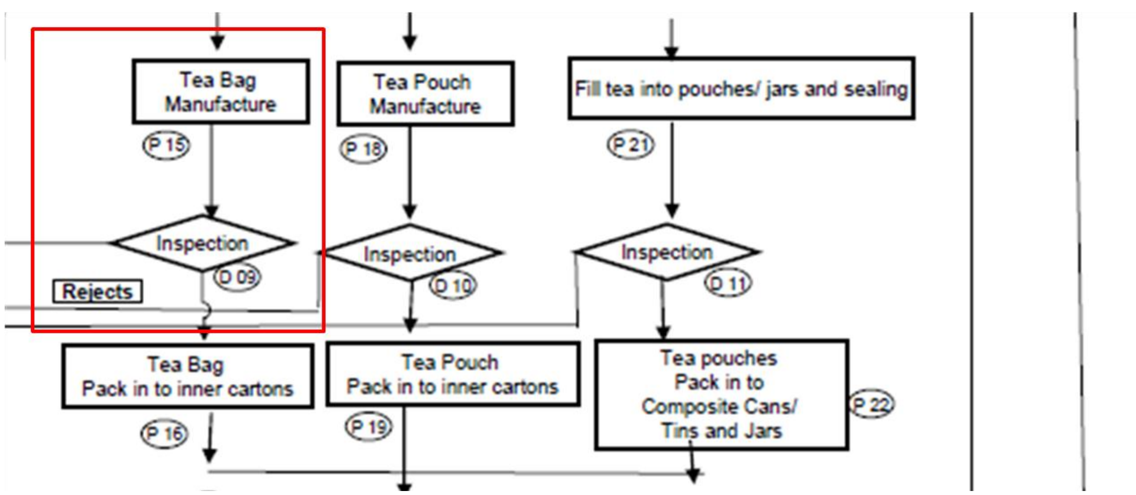

Figure: 1.4 Problematic area of the total process

Comparing the illustrations of past three years and the current year there are persistent ups and down trend of monthly average tea bag production wastage of raw materials existing in the production process. This brings a negative impact on followings , cost per unit, inventory value of materials, space of the materials storage , production disruptions , machine performance, market share, profit margin and customer satisfaction.

1.3. Research Objectives

a) To identify the factors that are affecting to generate packing materials wastage such as total production, type of tea, type of tea bag, type of filter paper, number of change overs and work shift.

- The following hypotheses testing for each parameter are carried out.

i) H_0 ; There is no impact of Total production on Total Tea bag wastage.
   H_{a1} : There is impact of Total production on Total Tea bag wastage.

ii) H_0 ; There is no impact of Tea type on Total tea bag wastage.
   H_{a2} : There is impact of Tea type on Total tea bag wastage.

iii) H_0 ; There is no impact of Tea bag type on Total tea bag wastage.
   H_{a3} : There is impact of Tea bag type on Total tea bag wastage.

iv) H_0 ; There is no impact of filter paper type on Total tea bag wastage.
   H_{a4} : There is impact of filter paper on Total tea bag wastage.

v) H_0 ; There is no impact of number of machine changeover on Total tea bag wastage.
   H_{a5} : There is impact of number of machine changeover on Total tea bag wastage.

vi) H_0 ; There is not impact by work shift on Total tea bag wastage.
   H_{a6} : There is impact by work shift on Total tea bag wastage.

b) To determine the significance of the factors affecting to generate packing materials wastage

c) To develop statistical models that explain the relationship between tea bag wastage and the affecting variables

1.4. Research Questions

The following research questions address the above-defined research objectives.

i. Do "total daily production, type of tea, type of tea bag, type of filter paper, number of change overs and work shift" cause to significantly increase tea bag wastage?
ii. Does 'liquid flavoured black tea/ green tea' generate more wastage than 'black tea/ green tea with herbs w?
iii. Do 'string and tag tea bags' generate more wastage than 'envelope tea bags'?
iv. Does 'Ahlstrom' filter paper generate more wastage than 'Glatfelter' the?

The above-introduced research questions are related to research objectives as displayed below the table.

Table: 1.1: Relationship between research objectives and research question

Research Objective	Research Questions
a	i
b	ii, iii, iv
c	i

1.5. Unit of Analysis

In general, wastage can be defined as a loss, decrease, or destruction of something (as by use, decay, erosion, or leakage); especially: wasteful or avoidable loss of something valuable. In this study, the unit of analysis is "Wastage" which is measured by the "number of defective tea bags identified before packing into the inner cartons as the final product".

It is a count which aids to estimate the extra material handling cost, extra labour cost and wastage of packing materials during tea bag production.

1.6. Research Scope

The production process of a tea exporting companies has more concerns on their production input usage of utilization; therefore, this study focuses on the operational aspect to identify factors affecting the generation of production wastage of tea bag packing materials. Further, the selected company is a leading and competitive value-added tea exporter to the major tea consuming parts of the world; therefore, minimizing production wastage is an important function for the company. Therefore, thorough productions records of teabagging wastage analysis have been carried out in the organization.

The case study describes the daily production wastage of packing materials from January 2017 to December 2017.

The following Table1.1shows the combinations of types of machines and their units operated during the studied period.

Table: 1.2: Number of Machines operated during 2017

The YEAR 2017	Machine Type				
Month	Constanta	Compacta	MAISA	FUSO	IMA
January	5	4	0	0	7
February	6	4	1	1	7
March	6	4	1	1	7
April	6	4	0	0	7
May	6	4	1	0	7
June	6	4	0	0	7
July	5	4	0	0	7
August	6	4	1	0	7
September	6	4	1	1	7
October	6	4	1	1	7
November	6	4	1	0	7
December	5	4	1	1	7

According to the Table 1.1, the company has employed 5 types of teabagging machines namely CONSTANTA, COMPACTA, MAISA, FUSO and IMA. The different number of machine units operated is subject to the client demand for different types of tea bags during the study period for the e.g.in month of January. There had been a demand for tea bag types and used CONSTANTA / COMPACTA and IMA machines production also there was no demand for MAISA and FUSO machines production.

The below Table 1.3 further describes machine types and their respective production types (Tea bag Type).

Table 1.3 Machine type Vs Production type

Machine Type	Tea Type	Tea Bag Type					
		String & Tag		Envelope		Nylon mesh	
		Filter Paper - Ahlstrom	Filter Paper - Glat Filter	Filter Paper - Ahlstrom	Filter Paper - Glat Filter		
Constanta	Herbs	√	√	√	√		
Compacta		√	√				
MAISA		√	√				
FUSO						√	√
IMA				√	√		
Constanta	Black Tea	√	√	√	√		
Compacta		√	√				
MAISA		√	√				
FUSO				√		√	√
IMA				√	√		

The target population of this study in terms of qualitative approach is 200 employees in the company, out of that 23 employees of a sample were selected i.e. (10 %+) comprising all subset in the target population. In this case study, the term manufacturing is limited to the manufacturing processes within the teabagging machinery where the tea bag production operations necessary to produce a product to perform.

The conceptual framework is developed by taking the related variables into account.

1.7. Research Limitation

Regarding this study, the main Limitation was lack of availability of literature and previous empirical studies and similar case studies. In addition, some data are limited and hard to access due to the company policy. There are data that are difficult to quantify due to practical issues such as cost and time e.g.; wastage by machine type/wastage by materials like-wise some data are available but not useable to the current study. e.g. night shift has been cancelled due to company sudden management decision in the year 2017 changes, inability to access the information of machine specification, performance, life cycle and fitness for the production. Due to the volatile market situation, product movement of an item has also varied hence change over frequency may get high. Therefore, all of the above are identified as limitations when conducting this study.

1.8. The significance of the study

Analyzing production wastage of a tea exporting company has much significance. From the point of industry perspectives, it gives immense benefits and reduce the production cost thereby increase profits and also from the point of capital equipment produces (machinery) also benefits with machine efficiency, productivity, controlling wear and tear, increases of capacity are some of the significances, apart from the individual company can get benefits from following aspects;

Following are the benefits of study:

I. Improvements in labour productivity

Productivity is the ratio between output and input. It is a quantitative relationship between what we produce and what we have spent to produce. Productivity is nothing but a reduction in wastage of resources like men, material, machine, time, space, capital etc. It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be the maximum distribution of benefits among a maximum number of people. Productivity denotes the relationship between output and one or all associated inputs. European Productivity Council referred (2017states “Productivity is an attitude of mind. It is a mentality of the progress of the constant improvement of that which exists. It is certainty of being able to do better than yesterday and continuously. It is the constant adoption of economic and social life to changing conditions. It is continual effort to apply new techniques and methods. It is faith in human progress”. In the words of Peter Drucker (2011 productivity means a balance between all factors of production that will give the maximum output with the smallest effort. On the other hand, according to International Labor Organization productivity is the ratio between the volume of output as measured by production indicates and the corresponding volume of labour input' as measured by production indices and the corresponding volume of labour input as measured by employment Indices. This definition applies to an enterprise, industry or an economy as a whole

$$\text{Labour productivity} = \frac{\text{Total output}}{\text{Labour input}}$$

$$\text{Material productivity} = \frac{\text{Total output}}{\text{Material input}}$$

Figure: 1.5: Equations for Labor productivity and Material productivity

II. Quality control Better field material control

Quality of a product can be defined as desire expectation of consumers minimizing the wastages of raw materials will leads to produce a quality product. On the other hand, improving the overall quality of a company's manufacturing process will reduce waste overall as it will increase the quantity of finished goods that pass quality inspection.

With regard to this study assumed the quality of the raw materials that are fed to the teabagging machinery has a significant contribution. If the required quality parameters are implemented subsequent to the study, it could be one of the significant areas of this.

III. Better relations with suppliers

Customer, supplier relationship is very vital aspect when long-term business is concerned. As a customer always anticipate reliable and trustworthy service from the suppliers if the supplier is not performing well in terms of on-time delivery, quality of raw materials, after sales services. It is a disturbance to the production floor this study helps to identify such scenarios and could be able to implement some controls.

IV. Better handling of the material

The raw materials that are used for teabagging production should have sound quality consistency, in that case, it could be handled properly limiting the wastages. On the other hand, it is necessary to have a skilled labour force in terms of proper handling of materials. This study helps to find such requirement in the longer run.

V. Reduction in duplicated orders

Increasing wastages is basically Kwon as duplication of the work, minimizing wastage leads to run smooth floor of production. Therefore, it is of paramount importance to minimize wastage and avoid duplication of production as much as possible, that helps overall reduction of production cost and achieve the ultimate objective of profit.

VI. The uninterrupted flow of Material is available when needed and in the quantities required?

VII. As mentioned in the previous paragraph maintaining an uninterrupted flow of material to the production is a vital aspect. Wastage increase of raw materials interrupts the production floor at this stage stocks replenishment in which quantity at what time the decision is very important, therefore this study will help to fulfil such information. Reducing the overall production costs

Managing M5 is a critical task when overall production cost is concerned basically reducing wastage component helps to reduce the cost of materials, cost of labour, cost of machinery and other production-related areas, this study could help to implement controlling systems to mitigate such cost generated areas.

VIII. Reduction in technical problems

Wear and tear of machinery are very important when their life cycle is concerned, impure quality materials increase the technical issues in machine spares and whole plant. Periodic proper maintenance and good quality materials also help to eliminate technical problems this study enables to identify which machine types generate more wastage and technical issues.

IX. Avoids sudden demand fluctuation problems arising with materials

More wastage means more consumption of materials; in that case, it is very difficult to face sudden demand fluctuation and scarcity situation of materials unless the organization holds adequate buffer stock. This could be identified as another benefit of a study.

X. Reduces overall production cost Avoids delay in work, etc.

As mentioned in the previous paragraph If the wastage is managed and controlled properly, as a result, the organization could get an economy of scale when the production volume is concerned. Further, it reduces the overall production cost and also avoids delay in work which is considered as another benefit of this study.

XI. Proper maintenance of machinery

In order to increase the lifetime of machinery, it is advisable to maintain them properly and timely. Machine efficiency is depended on proper maintains, this study helps to identify as to which machine to be maintained properly and in a timely manner.

1.9. Chapter breakdown

Chapter 1; the first chapter, Introduction, includes a general description and a background to the research followed by the research questions addressed. The objectives of the research, the purpose and the significance of the research and the organization of dissertation are also included in this chapter.

Chapter 2; the chapter discusses previous studies different industries done related to this research are discussed in the second chapter of the literature review. Research papers published in various journals are selected and filtered based on the requirement of this study.

Chapter 3; provides the rationale for the development and implementation Methodology is the third chapter in this dissertation including methods of data gathering, interviews done, the population and sample designs required. Development of questionnaire, selection of respondents, analysis of data and other requirements for the survey administration are further discussed in this chapter.

Chapter 4, discusses the findings of the Research Findings, comprises with the interpretation of the data and the analysis of data using the logarithmic regression method suggested by research supervisor and also using the average method for qualitative data that are gathered, Tables, graphs and sums are used here for the interpretation based on the comprehensive procedure described under the analysis of data under the fourth chapter.

Chapter 5 and the final chapter, Chapter 6 discusses conclusions arrived through the study and the recommendation based on them. Limitations of the research and the suggestions for the future development are also discussed under this chapter.

2. LITERATURE REVIEW

2.1. Introduction

The review of the literature provides the necessary justification to carry out the research and the specific methodologies or theories adopted through a thorough explanation of the literature sources consulted by a researcher to understand and investigate the research problem (Nova South Eastern University, 2011). The focus of this chapter is to review the existing literature to identify the variable of wastage generates indifferent as well as similar industries and also study the relationship of them suggested by different researchers. In the process of literature review, extensive and structured literature studies were conducted based on a keyword search in “wastage generation”. The literature selection method was based on abstract review and further full-text reading. This chapter provides a summary of previous research and the theoretical findings of this thesis. It begins by reviewing. Material efficiency management in manufacturing material, Factors Affecting Material Management on Construction Site” Handling of production disturbances in the manufacturing industry, measuring waste to reduce waste in CTP, Waste Management: A Systems Perspective Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies are discussed, followed by an introduction to material efficiency strategies. The main results of the literature study are presented in the Theoretical background and later used in the Analysis.

2.1. Material efficiency management in manufacturing material

This is a review of an article on “. Material efficiency management in manufacturing material” written by (Shahbazi, 2015).The article comprises of 87 pages .basically (Shahbazi, 2015) has identified as to improving material efficiency will have an impact on global manufacturing and helping achieve a reduction in the volume of generated industrial wastages the extraction and consumption of resources, energy demand and carbon emissions. However, this research has done with the limited knowledge since the study on material efficiency in manufacturing has been under research. Moreover Factors such as the value of process and residual materials in material efficiency, with a particular Concentration on enhancing the homogeneity of generated waste by increasing segregation rates, decreasing the generation of waste material and reducing total virgin raw material consumption without influencing the function or quality of a product or process barriers , further improvements in material efficiency were identify in this study .The methodology was adopted in this study represent in two stages. (Saunders et al., 2009). *credibility . In sum, the mixed methods research design produces complete knowledge (Saunders et al., 2009).* For data collection in this study was questionnaire survey. Observations, interviews, environmental report reviews and company walk through to investigate material efficiency and industrial waste management systems. Data analysis method of this study were waste flow mapping, expert opinion and discussions through workshops, data matrix, pie chart, cross-case analysis waste stream mapping, and waste sorting analyses, in addition to Cross-case analysis, categorization and clustering, data matrix were conducted According to the findings of the study Multiple barriers that hinder material efficiency were identified while identifying The most influential barriers to improved material efficiency concern the areas of Budgetary, Information, Management and Employees considered as critical factors of this study. Finally, factors affecting materials efficiency in the manufacturing in this study majority of identified material efficiency barriers are internal, originate within the company itself and are dependent upon the manufacturing company’s characteristics.

2.2. Industrial waste management within manufacturing: a comparative study of tools, policies, vision, and concepts

This is a review of article on “Industrial waste management within manufacturing: a comparative study of tools, policies, visions and concepts” by (Radiology & Society, 2000) this article comprises of 6 pages and (Radiology & Society, 2000) has identify categorized such as visions, concepts, tools, and policies as variable of this study further these factors are used to improve the environment effect of manufacturing, and materials efficiency this study has also been identifying majority of these approaches have a direct bearing on industrial wastage . The objective of this study is to see how waste management approaches can be integrated to reach the vision of zero waste in manufacturing. The literature was conducted gathering secondary data from 80 papers and the selecting method was based on both keywords a qualitative up-stream and down-stream search for relevant references. The empirical data reliability was based Upon discussion with an expert in the industry.in addition (Radiology & Society, 2000) has identified 18 papers of waste management approaches and presented in this paper Similarly additional 19 were identified but omitted.

Moreover, the identify approaches have been categorized, as zero waste, waste prevention, cleaner production and zero emission. Most of the time waste management approaches have similar goals and approaches which lead to a confusion and puzzlement for companies targeting to produce their management system to fit their waste management strategy.

Zero waste

Zero waste emphasis waste prevention, limitation and reusing. This approach was considered while carrying out the main research especially the teabagging production the waste tea can be re-used, This approach aims to utilize materials efficiently and uses all material inputs in the final product or changes it into other inputs for another process (Tang, 2008). Zero WIN, (2010) and Atlas(2001) have identified matching input and output of different industries is one of the key challenges that need to be solved, possibly by industrial ecology through eco-industrial parks, industrial symbiosis, and new technologies The zero waste vision and closed-loop are both directed towards preventing waste rather than managing generated waste, however zero waste can be integrated with other approaches including industrial ecology, cleaner production, pollution prevention, zero emissions and natural capitalism. (Curran and Williams, 2012). Furthermore, tools including Green performance map, eco-mapping and waste diversion planning system can be commonly used to pursue zero waste vision as all are based on eliminating wasteful use of energy, material, emissions and resources

Waste prevention

As for Waste Prevention approach, it has identified that this is not the approach of recycling or product design for remanufacturing (Lilja, 2009). The discarded material is in this vision considered as waste, even if they are recycled regardless of if money is paid for the material. In addition to that author was able to highlight Material efficiency and waste prevention both are crucial approaches towards zero waste (ZeroWIN, 2010). However, material efficiency is a preferred life cycle approach rather than waste prevention since the majority of the environmental benefits from waste prevention stem from the decreased requirement to produce materials (Lilja, 2009).

Cleaner production

Cleaner production is basically focused on environment efficiency that has environment advantage, the author has also identified the next step of cleaner production is zero emission.

Zero emission

Under this approach author was able to emphasise that zero emission is very expensive than cleaner production, this approach is closely related to carbon footprint in additionally this particular waste as the output of zero-emission is used in another industry

This study further identifies increasing global manufacturing activities, industrialization, globalization has been led to an increasing product demand and increased manufacturing activity we have seen a 35% increase of global manufacturing activities over 2001-2010 while the global GDP increased by 26% (Wiktorsson, 2012), which also lead to larger volumes of industrial (material) waste (Tojo, 2004).

In terms of methodology used for this study was structured extensive, literature search done as a complement previous review on wastage management approaches that are applicable in the manufacturing industry however, papers addressing waste management outside of this scope were also included in the study and also this study was based on both keywords a qualitative up-stream and down-stream search for relevant reference. The empirical base for the paper relies upon discussions with experts in industrial workshops, in order to verify the results. Apart from the eighteen waste management approaches also presented in this paper.

Table 2.1: most cited tools, concepts, visions and policies categorized

	Type	Visions				Concepts								Policies			Tools		
	Waste management approach	1. Zero emission	2. Cleaner production	3. Waste prevention	4. Waste Minimization or Zero Waste	5. Eco-efficiency	6. Eco-design	7. Best practice	8. Environmentally Concious Design & Manufacturing (EDCM)	9. Closed-loop	10. Industrial ecology	11. Reverse logistics	12. Material efficiency	13. Product stewardship	14. Environmental management system (EMS)	15. Eco-mapping	16. Green performance map (GPM)	17. Waste hierarchy	18. Waste diversion (planning system)
Organisation level	Management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
	Operational		✓					✓			✓	✓	✓			✓	✓	✓	✓
Measument	Quality	✓	✓	✓	✓		✓	✓	✓					✓	✓	✓			
	Quantity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Improvement actions	Technological		✓	✓	✓				✓		✓								
	Managerial	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
	Operational	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓
	Raw material substitution				✓		✓		✓		✓		✓	✓					
	Mindset			✓	✓			✓					✓					✓	
Citations	"Waste management approach" AND "waste"	40	140	50	434	54	12	70	1	98	76	55	23	12	44	0	0	21	26

As stated in Table 2.1, most of the approaches are favourable for management whereas one vision and two concepts are in line with the operational level. This had lead to a disparity between practical operational processes not having sufficient background or purpose. Further, the lack of vision or purpose may fail to succeed hands-on environmental efforts, tools and policies introduced at the shop-floor as they may end up with distrust. The outcome can lead to inefficient waste management and non-sustainable production.

The best way to improve waste management at the operational level is to transparent the vision and concept associated with each tool for easy use. Furthermore to focus on reduction of waste both quantitatively and qualitatively is important whereas it is only practised by half of the given approaches. This includes reduced toxicity through treatment and hazardous waste and toxicity and disposal. 77% of all approaches suggest that better management and decision making can make improvements on the environment. Whereas 88% recommend on the operational improvement of the waste generating process. Apart from that 30% approved that operational improvement and managerial decision together work significantly in environmental improvement.

Table 2.2: Integrated table of waste hierarchy and product lifecycle, with numbers from Figure 1

Product Life Cycle	Landfill	Energy Recovery	Recycling	Reusing	Reduction	Prevention
End of Life	1	1 10	8, 9, 1 10, 11 13	8, 9, 10, 11 12, 13	5, 6, 1 9, 10 12	1 5, 8
Consumption	1	1 8, 9, 11	1, 4 8, 9, 11	4 8, 9, 11 12	1, 4 5, 8, 9 12	1, 4 5, 8
Manufacturing	1 16	1 10 16	8, 9, 1, 4 10, 11 16, 18	8, 9, 2, 4 10, 11 18 12	1, 2, 3, 5, 7, 8, 4 9, 10 16 12, 14	1, 2, 4 5, 7, 8 16
Raw material Processing	1 16	1 10 16	8, 9, 1, 4 10, 11 16	8, 9, 2, 4 10, 11 12	1, 2, 3, 5, 7, 8, 4 9, 10 16 12, 14	1, 2, 4 5, 7, 8 16
Design	1	1	1, 4 6, 8	4 6, 8 12	1, 4 5, 6, 8 12	1, 4 5, 6, 8
	17 - Waste Hierarchy					

The above matrix (Table 2.2) indicates that waste management approaches that cover the most areas are zero. The most popular waste management approaches refer to reduction, followed by reuse, recycling and prevention of waste. Since waste reduction has a direct effect on manufacturing activities at the factory, volume reduction cost and complexity are outcomes of waste reduction. The approaches that are linked to landfill and energy recovery are a direct outcome of this study's focus on manufacturing. In addition, it also shows that these end of pipe solutions have a limited connection to a product's life phases and waste management activities in manufacturing. About 70% of the waste management approaches have an impact on the manufacturing phase of the product. Apart from that 77% of approaches influence raw material processing phase while half of this is affected by the end of life phase. In addition, 44% of the approaches are influenced by design and consumption. In conclusion, as the outcome of this study, the author has identified the most frequent barriers towards waste management and sustainable production. According to this study, factors like a technical limitation, cultural shifts, lack of EU-Level goals on waste prevention and material efficiency, a hindrance for waste prevention due to low waste disposal costs and absence of standards for reusable products considered as barriers. Therefore sustainable production can be achieved through the best use of existing tools and concepts included in the environmental policies. If not, development of new policies in order to prevent waste is applicable. Further, the enhancement of waste minimization on the approaches of facility-level along with the integrated methods should be used within shop-floor in order to motivate companies to influence them in waste minimization actions.

2.3. Factors Leading to Losses and Wastage in the Supply Chain of Fruits and Vegetables Sector in India

This is an article review of factors leading to Losses and Wastage in the Supply Chain of Fruits and Vegetables Sector in India by (Negi & Anand, 2016). This article starts with describing the amount worth of post-harvest and food wastage basically around 30 %-40 % total production gets waste at various levels the author has also identified apart from the losses these wastages leads to an additional cost in the supply chain. Further, Negi & Anand (2016) has identified fruits and vegetables are the major factors leading to losses and wastages in logistics and supply chain of Fruits and Vegetables sector. The main objective of this study is to avoid losses and wastage in the Fruits and Vegetables supply chain in India, through identifying the factors leading to losses and wastage while suggesting measures to improve its supply Chain and its effectiveness with context to Fruits and Vegetable sector.

The methodology is based on descriptive research in finding losses and wastages of post-harvest of fresh food have been investigated in order to identify the underlying factors. This is further explained through basic and contemporary literature available.

The study identifies six main categories of losses and waste of the fruits and vegetables supply chain. They are Infrastructure, Transport, Intermediaries, Harvesting, Farmer’s knowledge and storage and handling. Further, each of this section is divided into subsections and analyzed individually in order to identify ways of waste critically under each category. The other main result is based on recommendations for improving supply chain of fruits and vegetables and its effectiveness. The measures of improving are restructuring the parties involved in the entire process at different levels, providing of infrastructure facilities such as ICT, training, collection centers and packaging, proper demand forecasting, proper demand of farmers with cooperatives, effective information system between all stake holders for better coordination from farmer to end consumer, private sector involvement in implementing services to add value services to the fruits and vegetables supply chain ex: precooling, washing, packing on farm storage in order to avoid wastage of highly perishable fresh fruits, adopting safety methods of loading and uploading goods, establishing packing stations at nodal points and finally converting physically damaged goods into value added products by processing.

This study addresses the areas and causes of losses and wastage within the supply chain of fruits and vegetables. Poor infrastructure, a large number of intermediaries, poor harvesting and transportation, lack of knowledge and awareness of farmers along with poor storage and handling are some of the major contributions for losses and wastage in the supply chain of fruits and vegetables. Thus, this study will be helpful to various stakeholders involved in the supply chain of fruits and vegetables to map the factors leading to wastage and adopt the provided recommendations to minimize the risk of losses and wastage.

2.5. Modelling the causes of food wastage in Indian perishable food supply Chain

This is the review of article by (Balaji & Arshinder, 2016)according to National Horticulture Database 2014, India is the second largest producer of fruits and vegetables next to China.India produced 88.97 million metric tons of fruits and 162.98 million metric tons of vegetables during 2014, which constitutes around 12.6% and 14% of the total world production of fruits and vegetables respectively (Handbook on Horticulture Statistics,2014). Despite this enormous volume of production, the amounts of exports are only 1–2%. As high as 18% of the total amount of fruits and vegetables produced are wasted beginning from the postharvest stage until they reach consumers (FASAR, 2014). Both the lack of an integrated approach and poor management of the supply chain are attributed to this wastage.

To identify and rank the causes of food wastage in fruits and vegetables supply chain in the Indian context • to establish the interrelationship among these identified causes using TISM and Fuzzy MICMAC and• to provide the key insights to the practitioners.

This study intended to identify and priorities the causes of food wastage in the fruits and vegetables supply chain and to analyze the interactions among the causes which facilitate in understanding and controlling food wastage in the Indian context. A combination of TISM, an upgraded version of ISM methodology and fuzzy MICMAC is used to achieve these objectives

Due to the short shelf life and product perishability, inventory management for agri-food supply chains is important (Beshara et al., 2012). Apaiah and Hendrix (2005) proposed a methodology for designing efficient food supply chains and identifying problems in supply chains. Supply chain design plays a crucial role, in dealing with the products which have a short shelf life and higher quality degradation.

Waste reduction is the principal factor in achieving sustainability of the food supply chains (Kaipia et al., 2013). Carter and Rogers (2008) proposed the triple bottom line for sustainability. They argued that a firm has to do well in the areas of economy, society and environment to achieve sustainability and that sustainability should be part of an integrated strategy for managing the firm. Van der Vorst et al. (2007) proposed the quality controlled logistics that integrate the quality dimensions with the logistics operations. Jedermann et al. (2014) proposed intelligent food logistics by better quality supervision and prediction models to address the food loss. Kaipia et al. (2013) demonstrated using pilot projects on the benefits of information sharing, including demand and shelf-life among producers, wholesalers, and retailers to accomplish enhanced fresh food supply chain performance. They argued that improved visibility along the supply chain would enhance the supply chain performance. Manzini and Accorsi (2013) presented a conceptual framework for the assessment of integrated food supply chain.

2.6. Factors Affecting Material Management on Construction Site

This is the review of an article on Factors Affecting Material Management on Construction Site by (Kulkarni, Sharma, & Hote, 2017.)The article comprises of 5 pages basically the author has identified factors affecting effective materials management in building construction project. The main objectives of this study are To gather the information about material management procedures of different firms, Construction site, Project cost, Material Management, To study the different material management procedures (From collected data), To find out factors affecting material management for small, medium & large construction firms to suggest remedial measures to overcome factors. Future the author has identified following as benefits of this study Improvements in labour productivity, Improvements in the project schedule, Quality control, Better field material control, Better relations with suppliers, Better handling of material, Reduction in duplicated orders, Material is on site when needed and in the quantities required? Reducing the overall costs of material, Reduction in technical problems, Avoids seasonal problems arising with materials, Reduces overall project cost Avoids delay in work, etc.

Several studies have been done by various researchers in related to this study, therefore, the author has reviewed several empirical studies and literature to gather information, on effective materials management. Dr Kevin Okorocha,(Okorocha, 2013) has identified a good management system for materials management will lead to benefits for construction. N.B. Kasim(Kasim, Anumba, & Dainty, 2005) states that it is clearly important to manage all materials from the design stage to the construction stage he also states The wastage of materials should also be minimized during construction in order to avoid loss of profit for construction companies while Ashwini Patil(Patil & Pataskar, 2013) explains that Construction material constitutes a major cost component in any construction project. The total cost of material may be 50% of total cost; so that it is important for the contractor to consider that timely availability of material is a potential cause of successful completion of the project. T. Phani Madhavi"("Factors Affecting Material Management on Construction Site by IRJET Journal - issue," 2013.), has identified in construction project operation, often there is a project cost variance in terms of the material, equipment 's, manpower, subcontractor, overhead cost, and general condition. The material is the main component in construction projects. Therefore, if the material management is not properly managed it will create a project cost variance. Project cost can be controlled by taking corrective actions towards the cost variance. It is often necessary to dedicate important resources like money, personnel, time, etc. to monitor and control the process. A.A. Gulghane ("A. A. Gulghane, Prof P. V. Khandve, Management for Construction Materials and Control of Construction Waste in Construction Industry: A Review, Int. Journal of Engineering Research and Applications, Vol. 5, Issue 4 (Part -1), April 2015, pp.59-64 - Google," n.d.)describes that Materials management processes require a transformation to improve the overall in the handling of materials for more efficiency and effectiveness on the construction site. This is because the poor handling of construction materials affects the overall performance of construction projects in terms of cost, time, quality, and productivity

.For this study nine firms (3 small, 3 medium, 3 large) construction firms were selected randomly in the Maharashtra region of India.The methodology adopted for data collection in this study was questionnaire survey. A structured questionnaire comprising nineteen nominal and ordinal scale question used for the data collection the data gathered from the questionnaire survey was arranged and studied properly. Based on the gathered data it was identified that there were little flaws in the material management systems of all three sizes of construction firms which affect the material management,

Finally (Kulkarni et al., 2017.) concluded with following findings with the further recommendation which has been incorporated in the current study.

- Found that large firms are good & capable enough in applying material management techniques on construction sites
- Medium firms have some technical as well as some seasonal problems as they don't use any software.
- Small firms lack behind in material management.

3. CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

The methodology is the most important part of the research, this chapter emphasis how the researcher plan to tackle the research problem with the objective of the previous chapters and identify the importance of the conducting an empirical study of wastage generating factors and evaluating them further. Hence, the purpose of this chapter is to explain the process of data gathering through internal teabagging production records and survey through interviews. The chapter continues by identifying the sample, selection of respondents and design of the questionnaire. The further chapter explains both quantitative and qualitative analysis techniques that were used in the current study, a qualitative approach for the areas which require in-depth answers and the quantitative approach for the analysis of internal data. The study is based on an inductive approach initiating from the observations which move towards more abstract generalizations and ideas (Neuman, 2003). In addition, this will describe all the activity necessary for the completion of this study, as mentioned since this study mainly is on operation and production related the source of information taken from the daily teabagging production records which are secondary data and which already available,

3.2. Conceptual framework

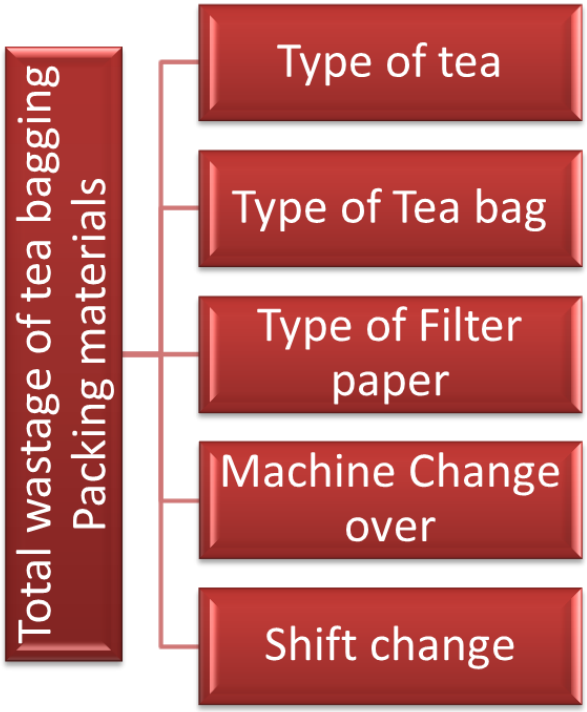

Figure: 3.1: Conceptual Framework

The dependent variable of this study is wastage tea bag packing materials such as filter paper, cotton thread, aluminium wire, tags, TB envelope foil/paper, labour, and re-work

Tea type is one of the independent variables in this study and it defines as black tea or Green tea or herbs which are used produce tea bags.

Type of tea bag is also an independent variable which describes whether it is a string and tag tea bag or envelope tea bag.

Similarly Type of filter paper also an independent variable as identify of this study. There are two types of filter papers one is called Ahlstrom and the other one is Glatfelter.

And then machine changeover is considered as another independent variable of the study last but not least the shift change is considered as an independent variable too.

3.3. Research Design

McCaston (2005) states that the research design is the step by step plan guiding the researcher through data collection and analysis Research design starts with the research problem to identify instances where the industrial norms of tea bags packing materials defective rate 2% exceeds.In the second stage The process initiated with the review of the literature. The literature review of the previous studies was conducted comprehensively to identify the wastage generation factors and material efficacy, quality control barriers, materials management techniques, industrial waste management techniques, in different industries, in the third the step first objective of quantitative and qualitative approach data collection was achieved , quantitative data were analysed by using data analyzing software such as SPSS, MINITAB the analytical tool that was used is logarithmic linear regression with assumptions of 0.05 a confident level. Similarly, for the qualitative data gathered from questioner survey, a descriptive analysis was done to identify the mean, mode values, and frequencies to further validate the study, as a fourth step based on the log regression analysis the expected results or findings were achieved thereby in the final step suggestion and the recommendation was given.

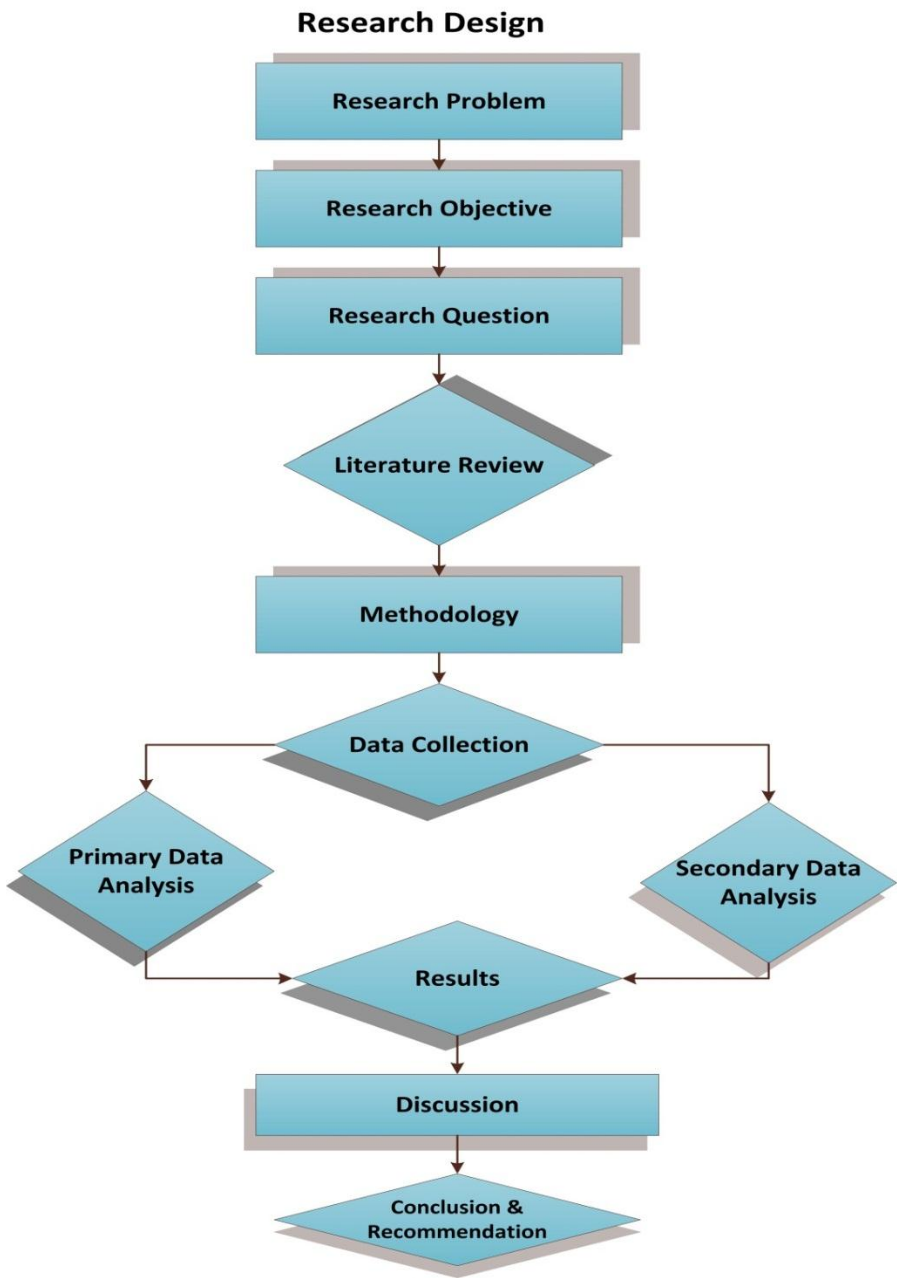

Figure: 3.2 Research Design

Table: 3.1: Analysis Methodology

CRITERIA	METHOD 01	METHOD 02
Population	Production output of tea bags during(2014 - 2017)	200 employees, of Regency Teas (Pvt) Ltd
Sample selection	Out of Total production output (2014-2017) and year 2017 production out put has been considered i.e Jan/Feb/March/April/May/June/July/Aug/Sep OCT/Nov/Dec 2017	Convenient stratified sampling method to cover up every sub set of the –population and Considering the variables are weighted with minimum difference sample size of 23 was selected(10%+)
Methodology (Data collection)	Regency teas daily tea bagging production records from Jan to Dec 2017shift changes records/ machine change overs records /materials (filter paper) tea type /tae bag type records	Primary Sources – one to one direct interviews with Managers/executives/production in charges/supervisors /quality executives/machine technicians/machine operators/packing assistant
Data Analysis method	Regression analysis in order to test the relationship with variable and the significant of them in terms of wastage.	In order to validate and justify the mathematical an opinions survey was conducted and will be analyses using Descriptive statistical analysis.

3.4. Selection of population and sample

The population refers to the entire group of people, event, or things of interest that the researcher wishes to investigate .this study basically following a mixed method i.e. quantitative and qualitative for the quantitative method population Is considered as past four years teabagging production record. The however the year 2017 has been taken as simple random sample method for this study in addition to for the qualitative method especially on questioner based interview survey population has been determined 200 employees of the organization and convenient stratified sampling method has been selected to cover up every subset of the population.

3.4.1. Population

In terms of quantitative method past four years production records tea bags in the organization has been considered as the population. With regard to qualitative method, 200 employees of the organization have been considered as the population.

3.4.2. Sample

According to the Uma Sekaran and Roger Bougie ((Research Methodology for Business fifth edition 2011) the minimum sample requirement has been achieved since this study carries out as mixed method for the 1st method a Year 2017 January to December production records such as production output, machine change over, string & Tag tea bags production, and envelope tea bag production are considered as simple random sampling method but for the second method convenient stratified sampling method was adopted in order to cover up sub set of population and those subset are Managers, Executives, Engineers, Technicians, Quality executives, Machine operators, Supervisors and packing assistant. The composition of the sample is given below Table 3.2.

Table: 3.2: Sample and Population of the interview

Tea bag Packing Section Employees			
Functional Area	**Designation**	**Total Allocated**	**Sample**
Overall Stores function	Stores Manager	1	1
Production / Quality Assuarance /Technicle and engeering	Tea Bag production in charge/ QA Engneer/Technicle Executive	5	4
Supervisoring	Supervisor	7	3
Technical	Technician	5	3
	Operator	15	3
Tea bag Packing	Packing assistant	80	9

3.5. Data Collection

It was essential to collect data from a variety of source to increase the validity and reliability of the research results. Since this study is mainly in operation and production related the information will be taken from the secondary source from data which is already available. Basically. it saves the time however some data were transformed in line with the research objective. Apart from that primary data for this study was mainly gathered from questions based interview.

3.5.1. Primary data sources

The researchers collect mostly primary data themselves following methods such as interview, observation, action research, case studies, life histories, questionnaires, ethnographic research, longitudinal studies etc. (University of Surrey, 2009). The objective of such method is to collect data to address achieve the requirements based on the research questions or the hypothesis. Curtis (2010) stated that the primary data is collected specifically to address the question, which is collected by interviewing through the survey. A questionnaire-based interview survey was carried out in this study to gather the primary data which is the ultimate respond from different categories of the organization

3.5.2. Questionnaire

Primary data collection was conducted through a questionnaire addressing the second, and third research objectives. The survey questionnaire was designed according to Questioners are an efficient data collection mechanism when the researcher knows exactly what is required and how to measure and justify the variables of interest, this structured questioner was basically designed with Likert scale and divided into five sections. Question No 01 to 08 described organization information and personal information of the responding question No 09 to 16 were describe based on the objective of the research.

3.6. Secondary Data

Sources already collected information in published or electronic form is considered as secondary data which helps to reduce the cost and time of the research (Curtis, 2010). Previous research, official statistics, mass media products, diaries, letters, government reports, web information, historical data and information etc. can be identified as such types of data (University of Surrey, 2009). Such information provides a thorough knowledge to construct the research questions and to create a baseline for the primary data collection. Novak (1996) states that the importance of initiating a research activity through review of the available secondary data.

The secondary data had been very useful with regard to this study, this data mainly gathered from the daily teabagging production record which was available in the stores. The data comprise daily production output, tea type, envelope type, number of change over likewise so on so forth

3.7. Data analysis

Collection of all the necessary data was followed by the systematic data analysis according to (Schroeder, 2010) the methodology of regression analysis, one of the classical techniques of mathematical statistics is an essential part of the modern econometrics. Further the statistical methods used in econometrics are oriented toward specific econometric problems and hence are highly specialized Hence econometric models, adapted to the economic reality, have to be built on appropriate hypotheses about distribution properties of the random variables. It also distinguishes between two characteristics of a structural relationship, the variables and the parameters.

According to Negi & Anand (2016) the author has identify the major factors leading to losses and wastages in the logistics and supply chain management of Fruits and Vegetables sector classified into categories namely Poor Infrastructure, Intermediaries, Harvesting, Transportation, Information, Knowledge of Farmer's, Storage and Handling the author further says Rehman et al. (2007) found that losses mainly occurred during picking of the crop. The author found harvesting at the improper stage and improper care at harvest, post-harvest problems as the primary factor responsible for post-harvest losses in tomato crop. Babalola et al. (2010) analyzed the determinants of post-harvest losses among tomato producers in Imeko -Afon local government area of Ogun state and revealed through regression analysis that the age of fruits at harvest and the number of baskets.

As per the (Authors, 2016) Life cycle cost (LCC) is one of the most crucial functions in decision making during the early phase of a project's life-cycle (Islam et al. 2015a). All decisions about the project and the implications for it requires a range of stakeholders including the owner, contractor, designer, and lending company. They include economic analysis of many alternative project components, clarifying the feasibility of a projector identifying an initial cost of a project (Sonmez 2004). To achieve objective 3, data were collected from the files of 138 construction building projects completed in the UK. The data were obtained from the Building Cost

Information Service (BCIS) database of The Royal Institution of Chartered Surveyors (RICS). This data covered all the main costs of the principal sub-components of the building projects. Information obtained in respect of each project included a number of stores, type of building, gross floor area, location, number of the elevator, type of structure, roof type, foundation type and project life and inflation rate. The data were used to clarify the relationship between capital costs and running costs and to clarify and identify the relationship between capital, running and LCC and non-cost factors by using the multiple regression methods.

As per the above literature, several studies had been used the linear regression as an analysis tool to check the relationship of a different variable, therefore, this study is also used the same tool to find out the relationship and significance of identified variable.

4. : DATA ANALYSIS

4.1. Primary Data Analysis

The primary data analysis has been carried out based on the responses gathered through the structured questionnaire which was offered as an interview for a sample of employees who were picked using stratified cluster sampling method.

In this process, more than 10% of the total employees (23 responses) from the organization were interviewed as the sample. The composition of the interviewed sample of employees in terms of managerial hierarchy, experience level, area of expertise and employed shift are summarized below, starting from Table 4.1 to Table 4.4 respectively.

Table 4.1: Composition of management levels of the respondents (employees) interviewed for the questionnaire

Management Level	Frequency	Percent	Valid Percent	Cumulative Percent
Executive	4	17.4	17.4	17.4
Machine Operator	3	13.0	13.0	30.4
Manager	1	4.3	4.3	34.8
Packing assistant	9	39.1	39.1	73.9
Supervisor	3	13.0	13.0	87.0
Technicians	3	13.0	13.0	100.0
Total	23	100.0	100.0	

In table 4.1 the respondent composition shows that packing assistant representation in the sample is higher than the other position.

Table 4.2: Composition of experience levels of the respondents (employees) interviewed for the questionnaire

Experience Level	Frequency	Percent	Valid Percent	Cumulative Percent
1 to 5 years	5	21.7	21.7	21.7
11 to 20 Years	8	34.8	34.8	56.5
6 to 10 Years	10	43.5	43.5	100.0
Total	23	100.0	100.0	

In table 4.2 the respond composition shows that the 6 to 10 years work experience employees representation in the sample is higher than other work experience category.

Table 4.3: Composition of the area of expertise of the respondents (employees) interviewed for the questionnaire

Specialized Area of Expertise	Frequency	Percent	Valid Percent	Cumulative Percent
Engineering	2	8.7	8.7	8.7
Overall Production in charge	2	8.7	8.7	17.4
Packing	9	39.1	39.1	56.5
Quality Assuarance	1	4.3	4.3	60.9
Supervisory	3	13.0	13.0	73.9
Technical	6	26.1	26.1	100.0
Total	23	100.0	100.0	

In table 4.3, the respond composition shows Packing expertise area is higher than other expertise areas.

Table 4.4: Composition of management levels of the respondents (employees) interviewed for the questionnaire

Work Shift	Frequency	Percent	Valid Percent	Cumulative Percent
Day	21	91.3	91.3	91.3
Night	2	8.7	8.7	100.0
Total	23	100.0	100.0	

In table 4.4, the respond composition shows production is done mostly in the daily work shift.

4.2. Identification of Factors Affecting Tea Bag Wastage According to Employee Perception

The following 10 claims were investigated by using a series of Likert scale questions in the structured questionnaire which was answered by the interviewed sample of employees from the organization.

The objective was to qualitatively identify factors that affect tea bag wastage by analyzing employees' perception.

4.2.1. Claim 1: Flavored Black tea/ Green tea generates low wastage in production.

Table 4.5: Descriptive Statistics of Claim 1

Claim 1: Flavored Black tea/ Green tea generates low wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fully disagree	2	8.7	8.7	8.7
	Disagree	12	52.2	52.2	60.9
	Neutral	1	4.3	4.3	65.2
	Agree	8	34.8	34.8	100.0
	Total	23	100.0	100.0	

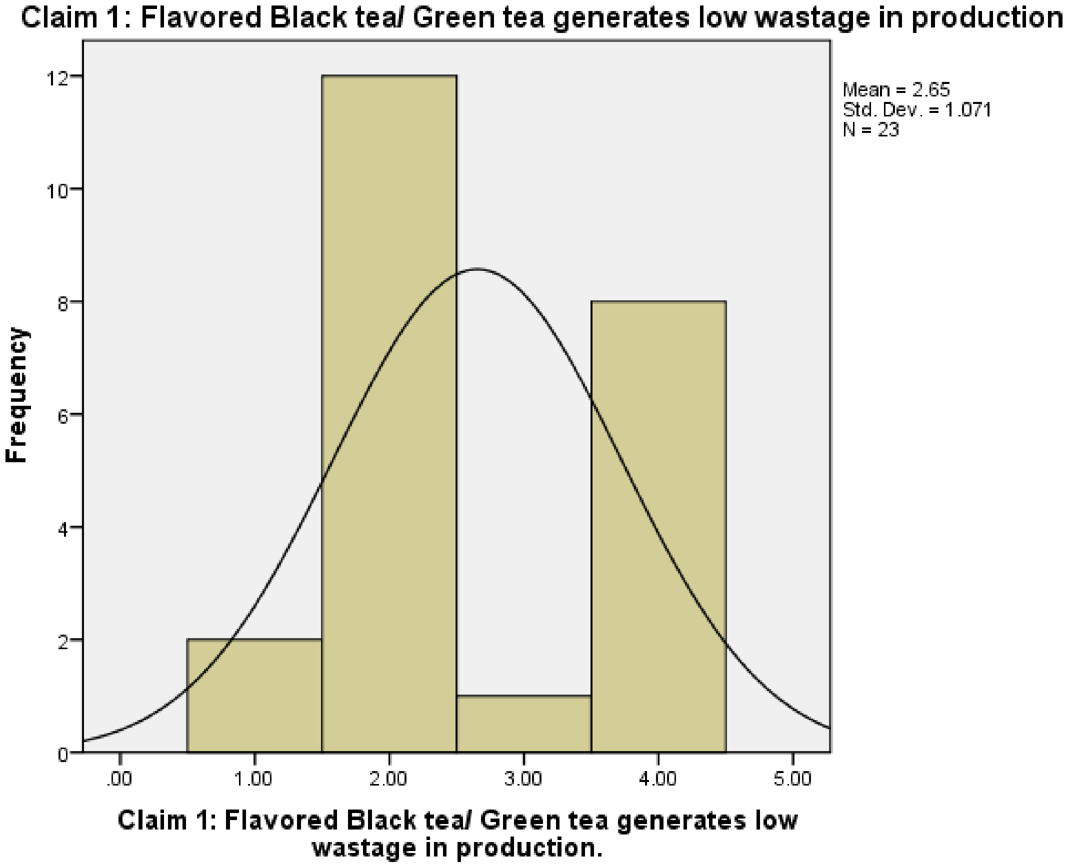

Figure 4.1: Frequency Distribution of Employees' Responses to Claim 1

4.2.2. Claim 2: Black tea /Green tea with herb generates low wastage in production.

Table 4.6: Descriptive Statistics of Claim 2

Claim 2: Black tea /Green tea with herb generates low wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	5	21.7	21.7	21.7
	Neutral	3	13.0	13.0	34.8
	Agree	14	60.9	60.9	95.7
	Fully agree	1	4.3	4.3	100.0
	Total	23	100.0	100.0	

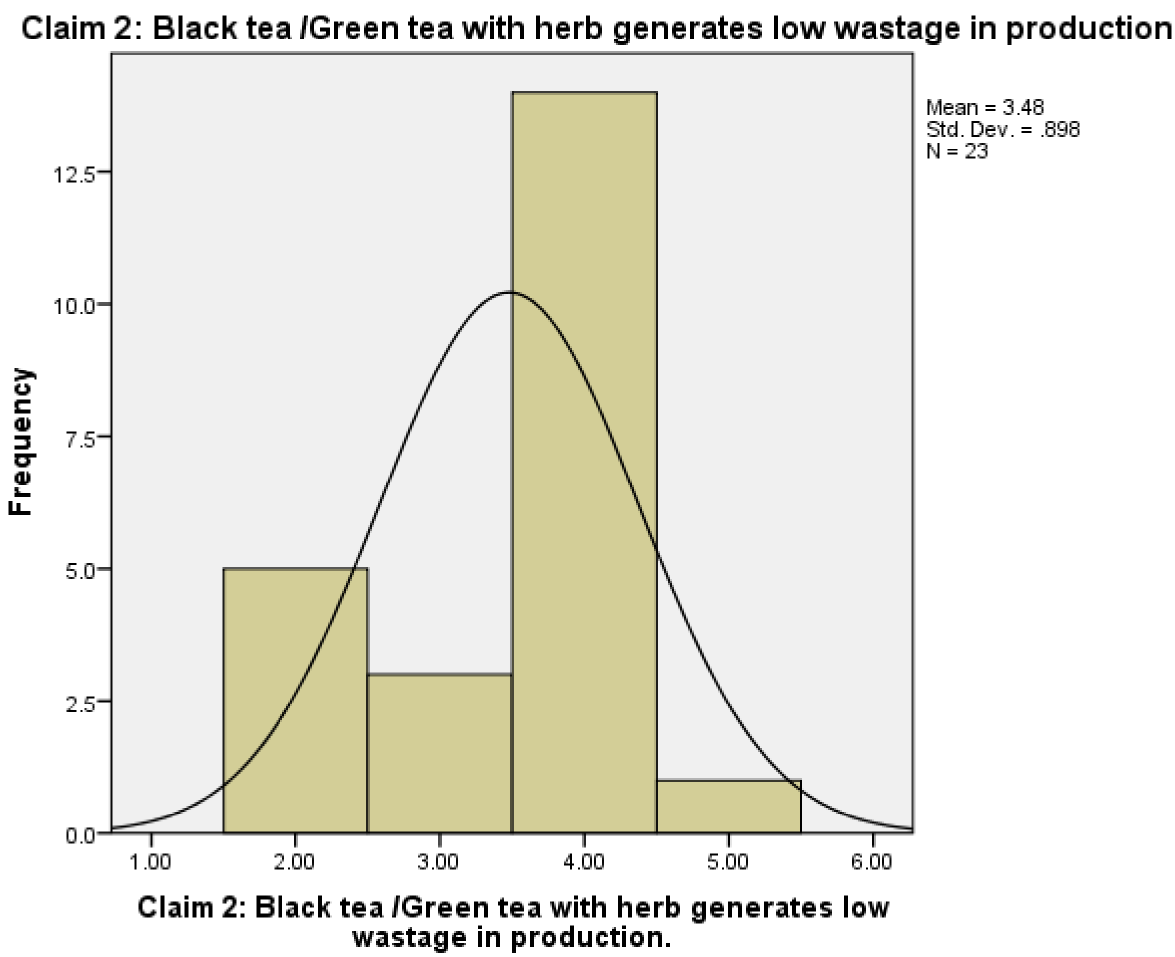

Figure 4.2: Frequency Distribution of Employees' Responses to Claim 2

4.2.3. Claim 3: 'Envelope' Tea bags generate high wastage in production.

Table 4.7: Descriptive Statistics of Claim 3

Claim 3: 'Envelope' Tea bags generate high wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fully disagree	3	13.0	13.0	13.0
	Disagree	17	73.9	73.9	87.0
	Neutral	3	13.0	13.0	100.0
	Total	23	100.0	100.0	

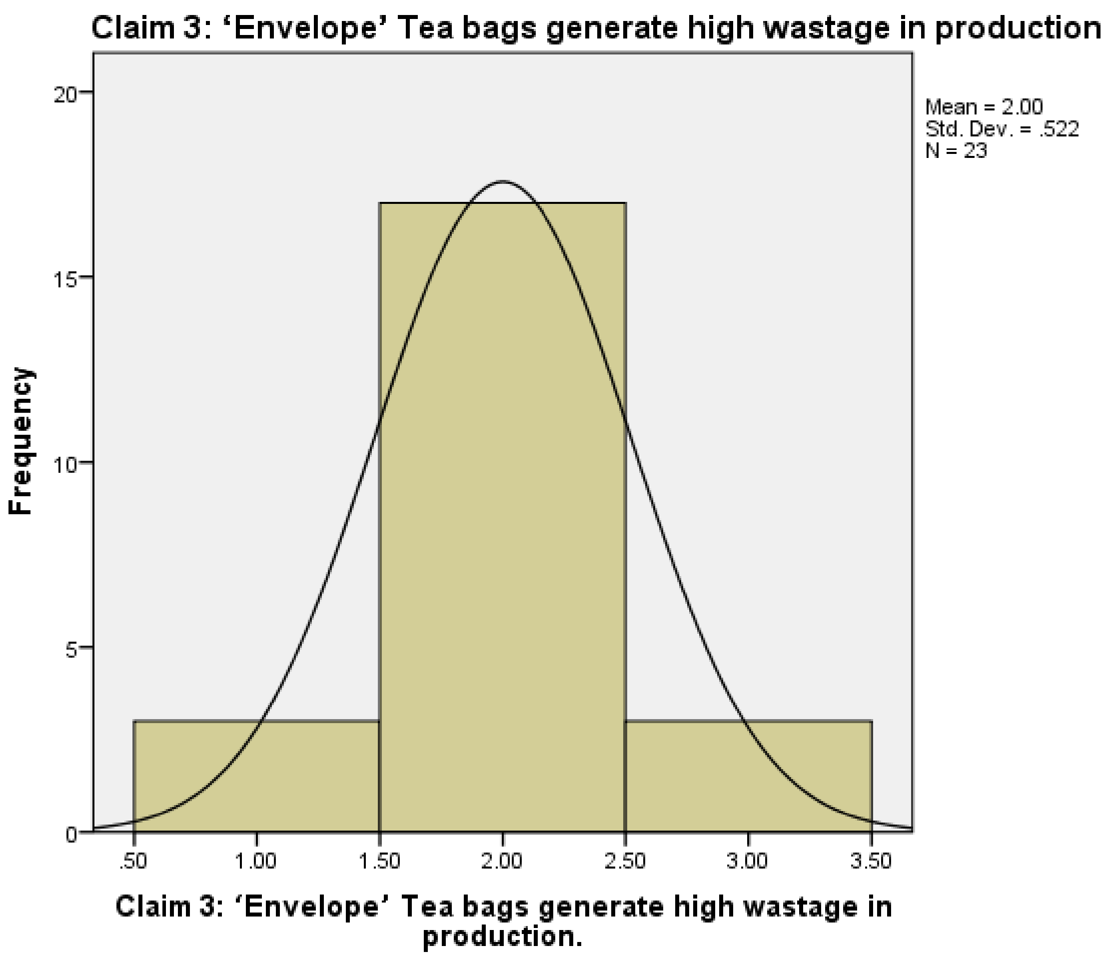

Figure 4.3: Frequency Distribution of Employees' Responses to Claim 3

4.2.4. Claim 4: ‘String and tag’ tea bags generate high wastage in production.

Table 4.8: Descriptive Statistics of Claim 4

Claim 4: ‘String and tag’ tea bags generate high wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	4	17.4	17.4	17.4
	Neutral	3	13.0	13.0	30.4
	Agree	15	65.2	65.2	95.7
	Fully agree	1	4.3	4.3	100.0
	Total	23	100.0	100.0	

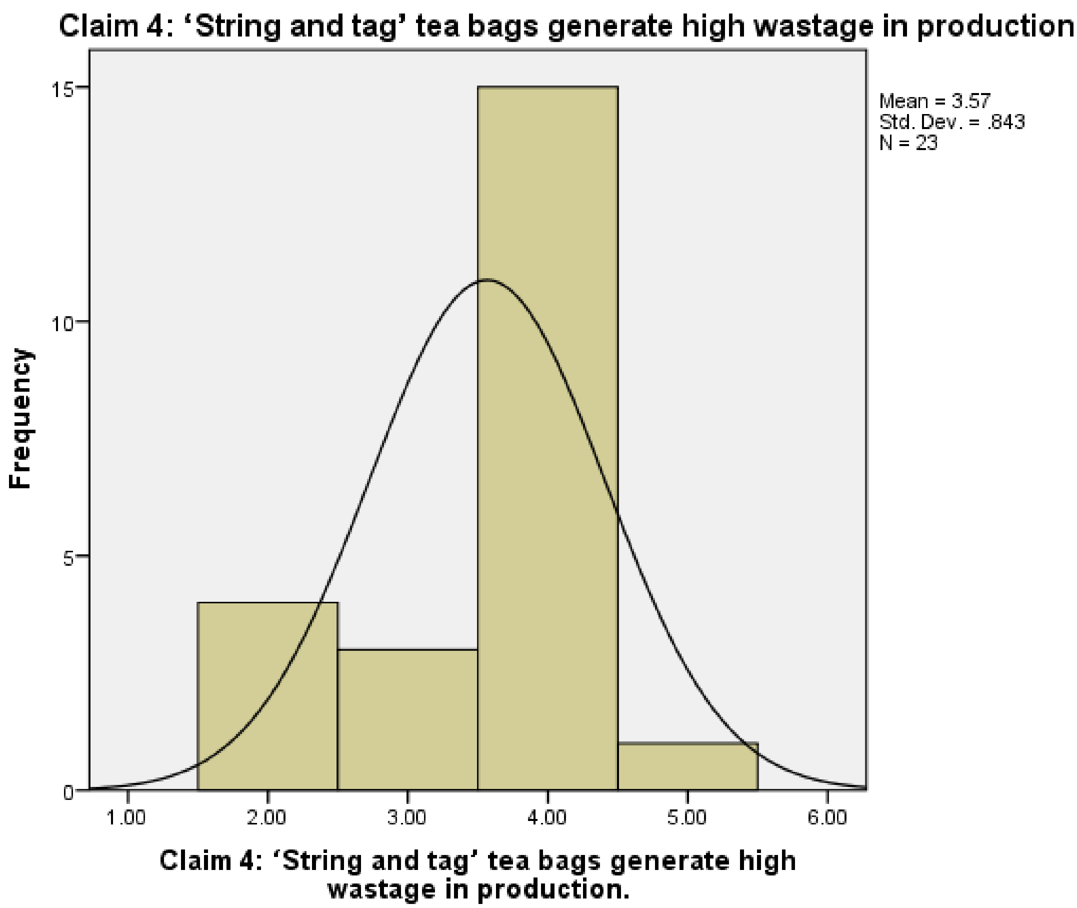

Figure 4.4: Frequency Distribution of Employees' Responses to Claim 4

4.2.5. Claim 5: Ahlstrom material generates low wastage in production.

Table: 4.9: Descriptive Statistics of Claim 5

Claim 5: Ahlstrom material generates low wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fully disagree	3	13.0	13.0	13.0
	Disagree	9	39.1	39.1	52.2
	Neutral	7	30.4	30.4	82.6
	Agree	4	17.4	17.4	100.0
	Total	23	100.0	100.0	

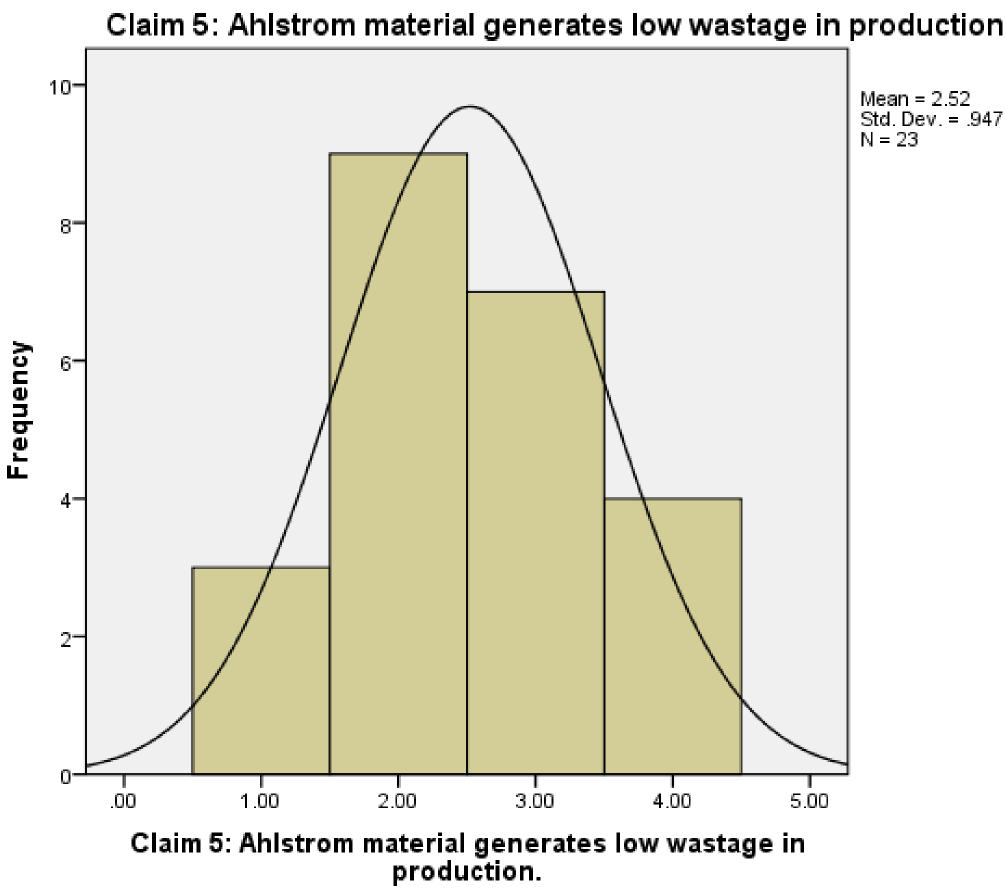

Figure: 4.5: Frequency Distribution of Employees' Responses to Claim 5

4.2.6. Claim 6: Glatfelter material generates low wastage in production.

Table: 4.10: Descriptive Statistics of Claim 6

Claim 6: Glatfelter material generates low wastage in production.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	7	30.4	30.4	30.4
	Neutral	12	52.2	52.2	82.6
	Agree	4	17.4	17.4	100.0
	Total	23	100.0	100.0	

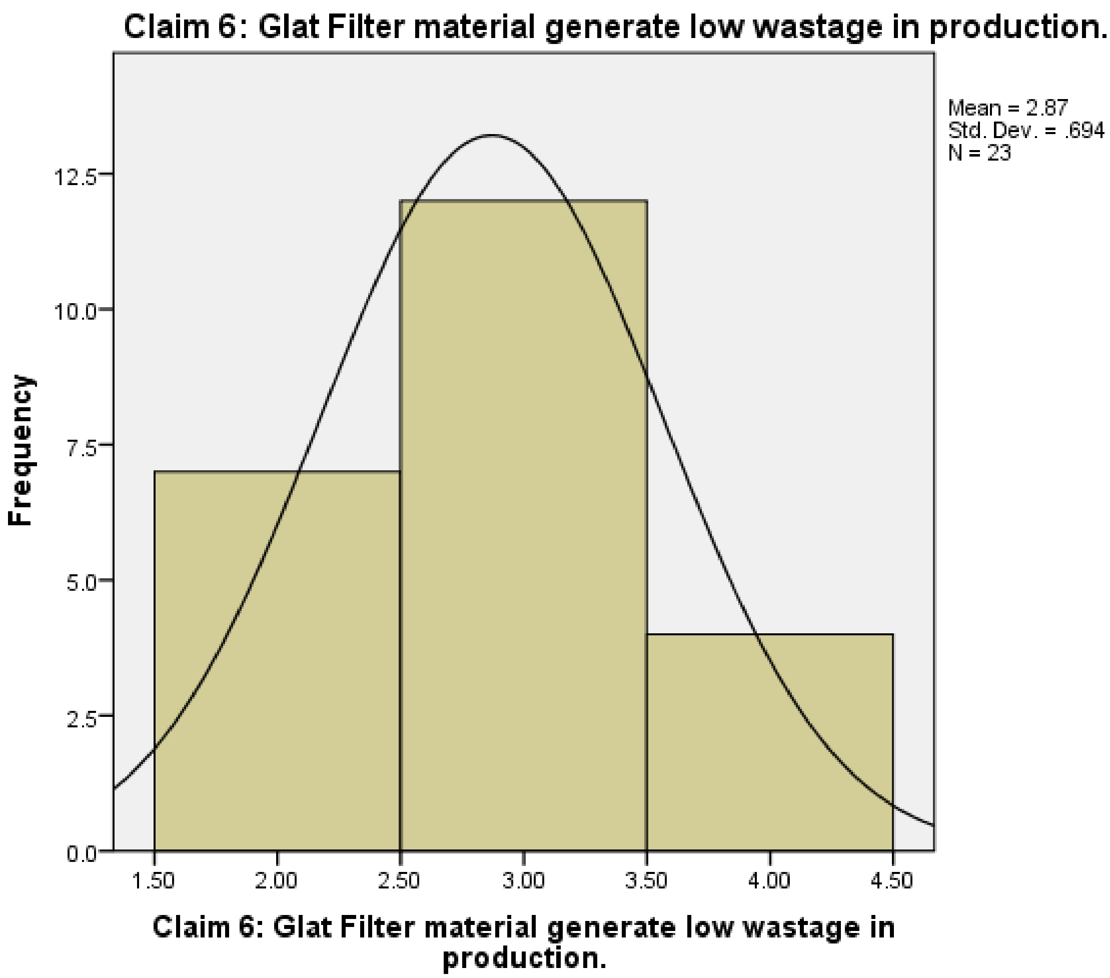

Figure: 4.6: Frequency Distribution of Employees' Responses to Claim 6

4.2.7. Claim 7: High frequency of machine changeover will generate high wastage amount in Tea bags /envelopes.

Table: 4.11: Descriptive Statistics of Claim 7

Claim 7: High frequency of machine changeover will generate high wastage amount in Tea bags /envelopes.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fully disagree	15	65.2	65.2	65.2
	Disagree	5	21.7	21.7	87.0
	Neutral	1	4.3	4.3	91.3
	Agree	2	8.7	8.7	100.0
	Total	23	100.0	100.0	

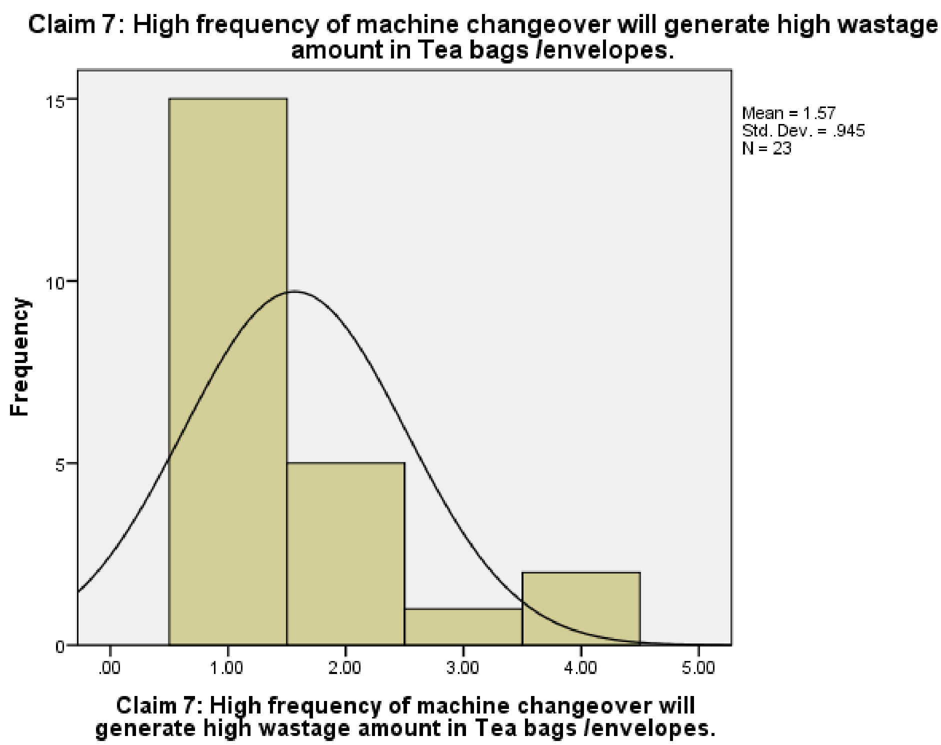

Figure: 4.7: Frequency Distribution of Employees' Responses to Claim 7

4.2.8. Claim 8: The work shift that generates highest wastage of tea bags is,

Table: 4.12: Descriptive Statistics of Claim 8

Claim 8: The work shift that generates highest wastage of tea bags is,

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Day	18	78.3	78.3	78.3
	Night	5	21.7	21.7	100.0
	Total	23	100.0	100.0	

According to Table 4.12, it can be concluded that 78.3% of the employees consider the "Day" shift, as the work shift that generates the highest wastage of tea bags.

4.2.9. Claim 9: Some of the old tea bagging machines should be replaced to reduce tea bag wastage.

Table: 4.13: Descriptive Statistics of Claim 9

Claim 9: Some of the old tea bagging machines should be replaced to reduce tea bag wastage.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maybe	2	8.7	8.7	8.7
	No	5	21.7	21.7	30.4
	Yes	16	69.6	69.6	100.0
	Total	23	100.0	100.0	

According to Table 4.13, it can be concluded that 69.6% of the employees agree with the Claim 9.

Therefore, according to employees' perception, some of the old tea bagging machines should be replaced to reduce tea bag wastage.

Subsequently, it can be concluded according to employees that the old tea bagging machines generate high tea bag wastage.

4.2.10. Claim 10: The current production method should be changed in order to mitigate problems related to tea bag production wastage.

Table: 4.14: Descriptive Statistics of Claim 10

Claim 10: The current production method should be changed in order to mitigate problems related to tea bag production wastage.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	N/A	3	13.0	13.0	13.0
	No	5	21.7	21.7	34.8
	Yes	15	65.2	65.2	100.0
	Total	23	100.0	100.0	

According to Table 4.14, it can be concluded that 65.2% of the employees agree with the Claim 10.

Therefore, according to employees' perception, the current production method should be changed to mitigate problems related to tea bag production wastage.

4.2.11. Testing for Correlation of Claims

The summary of the descriptive statistics and frequency distributions for each claim tested through Likert scale questions is given in the following Table 4.15.

Table: 4.15: Summary of Descriptive Statistics

Description	Status (Agree/ Disagree)
Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	Disagree
Claim 2: Black tea /Green tea with herb generates low wastage in production.	Agree
Claim 3: 'Envelope' Tea bags generate high wastage in production.	Disagree
Claim 4: 'String and tag' tea bags generate high wastage in	Agree

production.	
Claim 5: Ahlstrom material generates low wastage in production.	Disagree
Claim 6: Glatfelter material generates low wastage in production.	Agree
Claim 7: High frequency of machine changeover will generate high wastage amount in Tea bags /envelopes.	Disagree

In addition to the Likert scale questions, the summary of conclusions for the final 3 questions of the questionnaire can be presented as below Table 4.16.

Table: 4.16 : Summary of Descriptive Statistics

Description	Conclusion
Claim 8: The work shift that generates highest wastage of tea bags is,	Day
Claim 9: Some of the old tea bagging machines should be replaced to reduce tea bag wastage.	Yes
Claim 10: The current production method should be changed in order to mitigate problems related to tea bag production wastage.	Yes

According to Table 4.15 and 4.16, irrespective of the management level, experience, area of expertise and work shift many of the employees have responded to form the presented results.

To further check the correlation between the tested claims in Table 4.15 and Table 4.16, following analysis were carried out.

Testing for the Correlation Claim 1 and Claim 2

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
Ordinal by Ordinal	Gamma	-.670	.206	-2.253	.024
	Spearman Correlation	-.471	.185	-2.444	.023[c]
Interval by Interval	Pearson's R	-.481	.180	-2.514	.020[c]
N of Valid Cases		23			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Table: 4.17: Correlations between Claim 1 and Claim 2

It can be concluded that Claim 1 and Claim 2 are correlated. Therefore there is a significant relationship between Claim 1 and Claim 2.

As a result, the cross-tabulation of Claim 1 and Claim 2 has been considered.

Table: 4.18: Cross Tabulation between Claim 1 and Claim 2

Claim 1: Flavored Black tea/ Green tea generates low wastage in production. * Claim 2: Black tea /Green tea with herb generates low wastage in production. Crosstabulation

			Claim 2: Black tea /Green tea with herb generates low wastage in production.				
			Disagree	Neutral	Agree	Fully agree	Total
Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	Fully disagree	Count	0	0	1	1	2
		% within Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	0.0%	0.0%	50.0%	50.0%	100.0%
		% within Claim 2: Black tea /Green tea with herb generates low wastage in production.	0.0%	0.0%	7.1%	100.0%	8.7%
	Disagree	Count	1	2	9	0	12
		% within Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	8.3%	16.7%	75.0%	0.0%	100.0%
		% within Claim 2: Black tea /Green tea with herb generates low wastage in production.	20.0%	66.7%	64.3%	0.0%	52.2%

	Neutral	Count	0	1	0	0	1
		% within Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	0.0%	100.0%	0.0%	0.0%	100.0%
		% within Claim 2: Black tea /Green tea with herb generates low wastage in production.	0.0%	33.3%	0.0%	0.0%	4.3%
	Agree	Count	4	0	4	0	8
		% within Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	50.0%	0.0%	50.0%	0.0%	100.0%
		% within Claim 2: Black tea /Green tea with herb generates low wastage in production.	80.0%	0.0%	28.6%	0.0%	34.8%
Total		Count	5	3	14	1	23
		% within Claim 1: Flavored Black tea/ Green tea generates low wastage in production.	21.7%	13.0%	60.9%	4.3%	100.0%
		% within Claim 2: Black tea /Green tea with herb generates low wastage in production.	100.0%	100.0%	100.0%	100.0%	100.0%

According to the cross tabulation, a majority of employees disagree with Claim 1 and agree with Claim 2.

Therefore it can be concluded that Black tea with liquid flavoured does not generate low wastage while Black tea /Green tea with herbs will generate low wastage according to employees' perception.

Testing for Correlation between Claim 3 and Claim 4

Table: 4.19: Correlation between Claim 3 and Claim 4

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
Ordinal by Ordinal	Gamma	-.366	.285	-1.143	.253
	Spearman Correlation	-.258	.214	-1.222	.235[c]
Interval by Interval	Pearson's R	-.206	.169	-.967	.345[c]
N of Valid Cases		23			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

It can be concluded that Claim 3 and Claim 4 are not correlated. Therefore there is no significant relationship between Claim 3 and Claim 4 according to employee's perception.

Table: 4.20: Cross Tabulation between Claim 3 and Claim 4

Claim 3: 'Envelope' Tea bags generate high wastage in production. * Claim 4: 'String and tag' tea bags generate high wastage in production. Crosstabulation

			Claim 4: 'String and tag' tea bags generate high wastage in production.				Total
			Disagree	Neutral	Agree	Fully agree	
Claim 3: 'Envelope' Tea bags generate high wastage in production.	Fully disagree	Count	0	1	1	1	3
		% within Claim 3: 'Envelope' Tea bags generate high wastage in production.	0.0%	33.3%	33.3%	33.3%	100.0%
		% within Claim 4: 'String and tag' tea bags generate high wastage in production.	0.0%	33.3%	6.7%	100.0%	13.0%
	Disagree	Count	4	0	13	0	17
		% within Claim 3: 'Envelope' Tea bags generate high wastage in production.	23.5%	0.0%	76.5%	0.0%	100.0%
		% within Claim 4: 'String and tag' tea bags generate high wastage in production.	100.0%	0.0%	86.7%	0.0%	73.9%
	Neutral	Count	0	2	1	0	3
		% within Claim 3: 'Envelope' Tea bags generate high wastage in production.	0.0%	66.7%	33.3%	0.0%	100.0%

	% within Claim 4: ‘String and tag’ tea bags generate high wastage in production.	0.0%	66.7%	6.7%	0.0%	13.0%
Total	Count	4	3	15	1	23
	% within Claim 3: ‘Envelope’ Tea bags generate high wastage in production.	17.4%	13.0%	65.2%	4.3%	100.0%
	% within Claim 4: ‘String and tag’ tea bags generate high wastage in production.	100.0%	100.0%	100.0%	100.0%	100.0%

Testing for Correlation between Claim 5 and Claim 6

Symmetric Measures

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
Ordinal by Ordinal	Gamma	-.188	.306	-.603	.546
	Spearman Correlation	-.148	.245	-.687	.500[c]
Interval by Interval	Pearson's R	-.168	.249	-.782	.443[c]
N of Valid Cases		23			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

There is no significant relationship between Claim 5 and Claim 6, therefore according to the employee's perception, there is no significant relationship between filter paper types and wastage.

Table: 4.21: Cross Tabulation of Claim 5 and Claim 6

Claim 5: Ahlstrom material generates low wastage in production. * Claim 6: Glat Filter material generate low wastage in production. Crosstabulation

			Claim 6: Glat Filter material generates low wastage in production.			
			Disagree	Neutral	Agree	Total
Claim 5: Ahlstrom material generates low wastage in production.	Fully disagree	Count	1	1	1	3
		% within Claim 5: Ahlstrom material generates low wastage in production.	33.3%	33.3%	33.3%	100.0%
		% within Claim 6: Glat Filter material generate low wastage in production.	14.3%	8.3%	25.0%	13.0%
	Disagree	Count	3	4	2	9

		% within Claim 5: Ahlstrom material generates low wastage in production.	33.3%	44.4%	22.2%	100.0%
		% within Claim 6: Glat Filter material generate low wastage in production.	42.9%	33.3%	50.0%	39.1%
	Neutral	Count	0	7	0	7
		% within Claim 5: Ahlstrom material generates low wastage in production.	0.0%	100.0%	0.0%	100.0%
		% within Claim 6: Glat Filter material generate low wastage in production.	0.0%	58.3%	0.0%	30.4%
	Agree	Count	3	0	1	4
		% within Claim 5: Ahlstrom material generates low wastage in production.	75.0%	0.0%	25.0%	100.0%
		% within Claim 6: Glat Filter material generate low wastage in production.	42.9%	0.0%	25.0%	17.4%
Total		Count	7	12	4	23
		% within Claim 5: Ahlstrom material generates low wastage in production.	30.4%	52.2%	17.4%	100.0%
		% within Claim 6: Glat Filter material generate low wastage in production.	100.0%	100.0%	100.0%	100.0%

4.3. Secondary Data Analysis

The quantitative data analysis of this study was conducted to identify the relationship between below identify variables. The data were collected from the secondary source, during the period of January to December in 2017. Such a continuous iterative process allows the researcher to identify patterns, themes and significant and distribution of the data set. The linear regression method was adopted to formulate statistical relationship of identified variables.

Figure: 4.8: Variance of Total Production, Total Wastage versus Date of Manufacturing

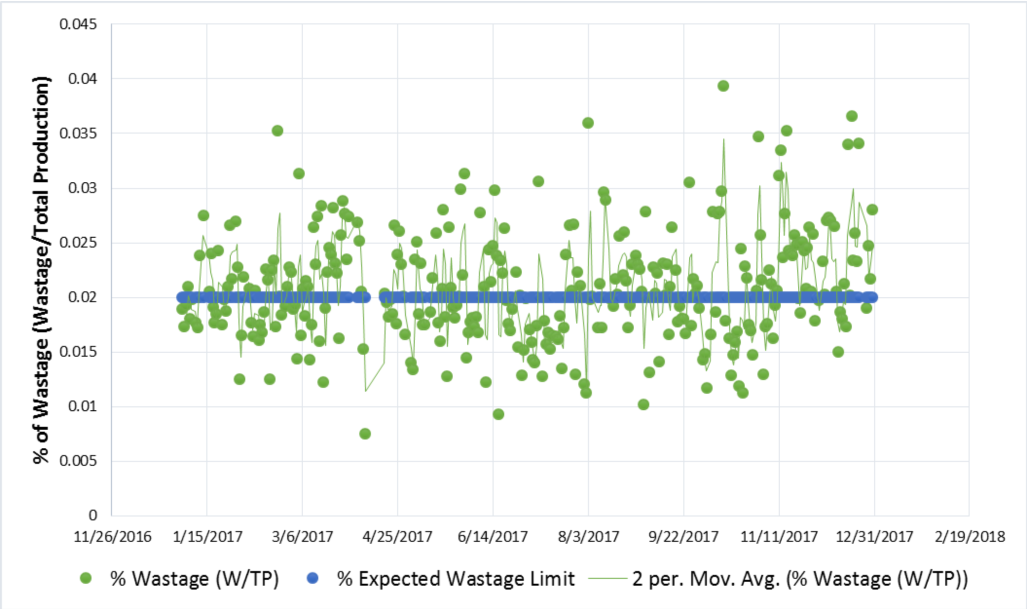

Figure: 4.9: Variance of Percentage of Wastage versus Date of Manufacturing

4.3.1. Introduction to Variables

The following are the variable that has been considered in this study

T_w: Total Wastage

Total wastage with regard to this study defines, the total wastage of tea within a daily production and converted into a number of tea bags, thereafter number of tea bags further converted into tea packing materials, therefore, this study is mainly focused on wastage of packing materials,

Unit of the measurement: number of tea bag

T_P: Total Production

Total production in this study defines daily production of tea bags from different tea bagging machines and different tea bag types

Unit of the measurement: number of tea bags

T_c: Total Machine Change overs

Total Change over in this study defines a number of changes from one product variety into another product variety produce by different tea bagging machines.

Unit of the measurement number of change over from machines

i: Tea Type

Tea type in this study defines as black tea or Green tea or herbs which are used produce tea bags.

List of tea types

- BG: Black Tea /Green Tea
- HRB: Herbs

i = {Tea Type; BG, HRB}

Unit of the measurement; Number of Tea Bags

j: Tea Bag Type

Tea bags type in this study defines as string and tags and envelopes,

List of tea bag types

- STR: String & Tag
- ENV: Envelope

j = {Tea bag Type; STR, ENV}

Unit of the measurement; Number of Tea Bags

k: Tea Bagging Machine Type

Tea bags machine type in this study defines a different type of machinery which used to produce different types of tea bags.

- Con: Constanta
- Com: Compacta
- Mai: Maisa
- Fus: Fuso
- Ima: IMA

k = {Tea bagging machine Type; Con, Com, Mai, Fus, Ima}

Unit of the measurement; Number of Tea Bags

$T_{w,i}$: Total Wastage of Tea Type "i"

Total wastage of tea type in this study defines a number of tea bags wastage during a day shift.

Unit of the measurement; tea in kilogram

$T_{w,j}$: Total Wastage of Type bag "j"

Total wastage of tea bag type in this study defines the number of tea bay type whether it is string and tag or envelope during a daily production.

Unit of the measurement; Number of Tea Bags

$T_{P,k}$: Total Production of Machine Type "k"

Total production of machine type in this study defines the number of tea bags produce from each machine

Unit of the measurement; Number of machines

$T_{C,k}$: Total changeover of Machine Type "k"

Total Changeover of machine type in this study defined as the number of change over from particular

Unit of the measurement; Number of changeover of each machine

4.3.2. Formulation of Statistical Relationships

Model 1: Statistical Relationship between Total Wastage and Total Production

In order to check the presence of a significant statistical relationship between total daily wastage (T_W) and total daily production (T_P) the following analysis has been carried out targeting 309 operational days of the production.

The variability of T_w is explained by considering T_p as the independent variable.

Therefore, in this analysis, the following research question and research objective are addressed.

Table: 4.22: Research question and research objective tested in Model 1

Research Question	Research Objective
i) Does "total daily production" cause to significantly increase tea bag wastage.	a) To identify that packing materials wastage is impacted by total production.

The following hypothesis testing is carried out.

- H_0; There is no impact of Total production on Total tea bag wastage.
- $H_{a1:}$ There is impact of Total production on Total bag wastage.

(at significance level, $\alpha = 0.05$)

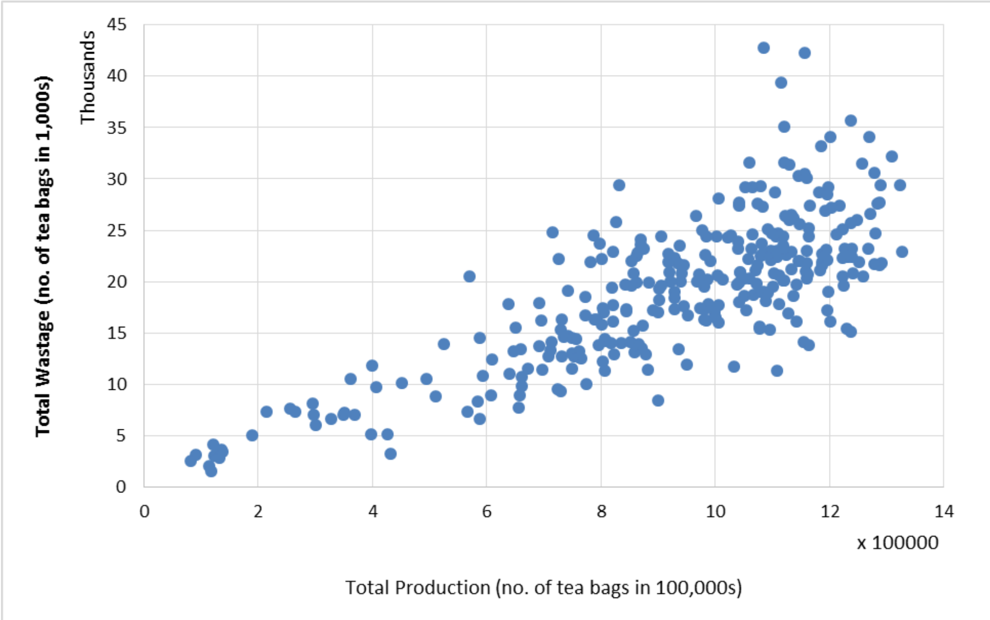

Figure: 4.10: Variability of Total Wastage versus Total Production

According to the Figure 4.10, the variability of Total Wastage against Total Production is nonlinear.

<u>Correlation test between Total Wastage and Total Production</u>

Table: 4.23: Correlation between parameters considered for Model 1

Correlations

		Total Production	Total Wastage	ln (Total Production)	ln (Total Wastage)
Total Production	Pearson Correlation	1	.781**	.941**	.846**
	Sig. (2-tailed)		.000	.000	.000
	N	309	309	309	309
Total Wastage	Pearson Correlation	.781**	1	.733**	.931**
	Sig. (2-tailed)	.000		.000	.000
	N	309	309	309	309
ln (Total Production)	Pearson Correlation	.941**	.733**	1	.880**
	Sig. (2-tailed)	.000	.000		.000
	N	309	309	309	309
ln (Total Wastage)	Pearson Correlation	.846**	.931**	.880**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	309	309	309	309

**. Correlation is significant at the 0.01 level (2-tailed).

According to the correlation test, it can be concluded with a 95% confidence that Total Production and Total Wastage are correlated.

Further, the natural logarithms of the two parameters have also been considered for correlation due to the nonlinear characteristics displayed in Figure 4.10. The transformed variables also are correlated.

Transformation of Variables

The predictor and the response variables in this analysis were elected after transforming both "Total Production" and "Total Wastage" into the natural logarithms.

1. Predictor ; ln (Total Production) = $\ln T_P$
2. Response ; ln (Total Wastage) = $\ln T_W$

Formulation of Linear Model

Table: 4.24: Model Summary of Model 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.880[a]	.774	.773	.24701	.774	1049.266	1	307	.000	1.650

a. Predictors: (Constant), ln (Total Production)

b. Dependent Variable: ln (Total Wastage)

Table: 4.25 : Coefficients of Model 1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.960	.393		-7.540	.000
	ln (Total Production)	.931	.029	.880	32.392	.000

a. Dependent Variable: ln (Total Wastage)

$$\ln(\text{Total Wastage}) = 0.931 \ln(\text{Total Production}) - 2.960$$

$$\ln T_W = 0.931 \ln T_P - 2.960$$

$$\ln T_W = \ln {T_P}^{0.931} - \ln e^{2.960}$$

$$T_w = \frac{{T_P}^{0.931}}{e^{2.960}}$$

The significance of the Model

Table: 4.26: Analysis of Variance for Model 1

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	64.022	1	64.022	1049.266	.000[b]
	Residual	18.732	307	.061		
	Total	82.754	308			

a. Dependent Variable: ln (Total Wastage)

b. Predictors: (Constant), ln (Total Production)

The P-Value and F values are the significance of the parameters. Therefore, the model is significant. This indicates that total production impacts total wastage. Thus, the null hypothesis is rejected at 5% significance level.

R Squared Value of the Model is also 77.4 %, therefore, the model is valid.

Diagnostic Tests of Residuals (Errors)

Test 1: Normality of Errors

- The residuals of the model are not normally distributed.

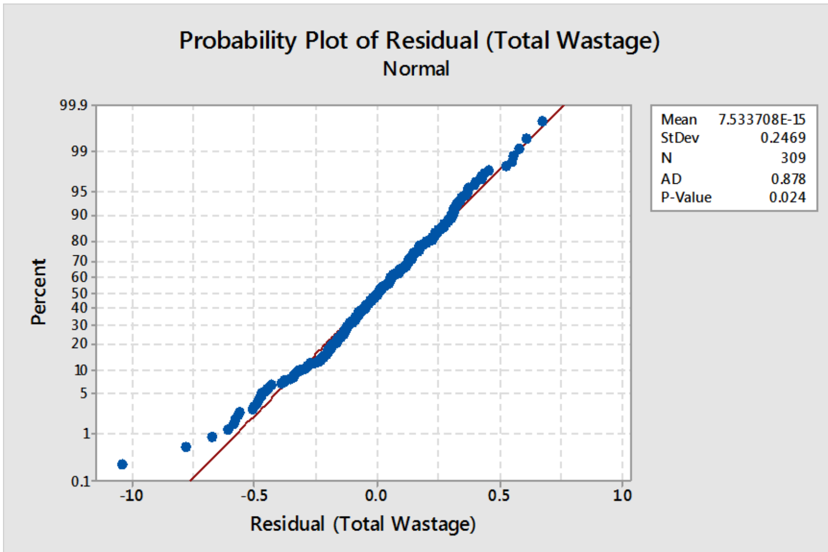

Figure: 4.11: Probability plot of residuals of Model 1

Test 2: Durbin Watson Statistic

- Durbin-Watson Statistic = 1.65224
- The residuals do not have an autocorrelation.

Test 3: Randomness and Unpredictability of Residuals with Fitter Values

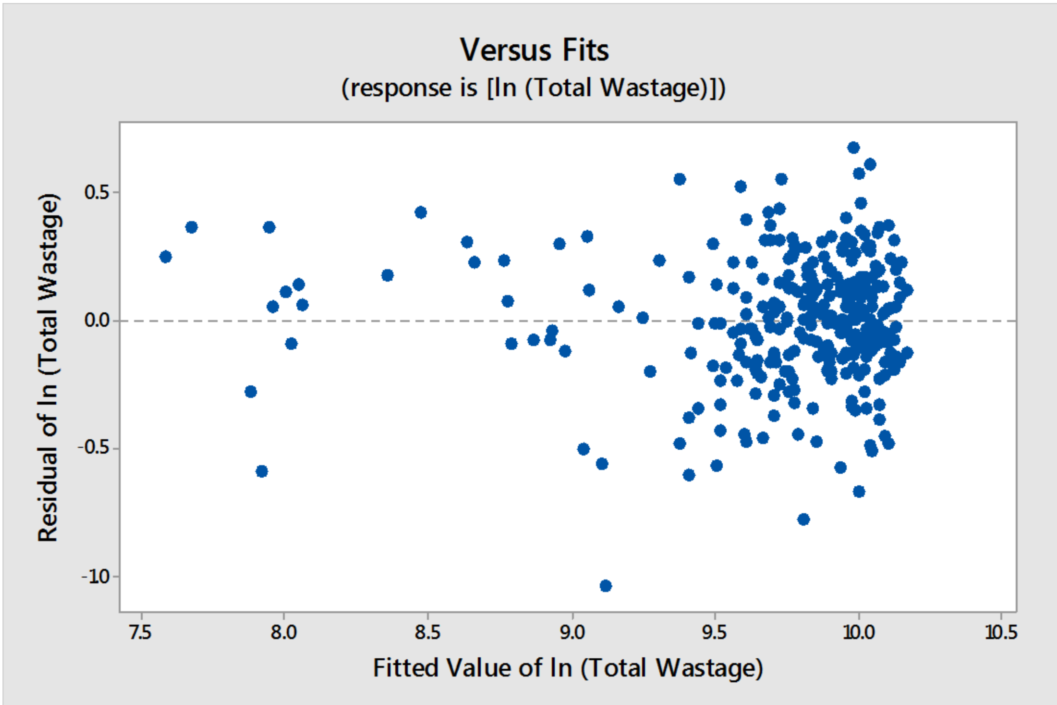

Figure: 4.12 : Fitted value versus residual value for Model 1

Residuals are random and unpredictable.

<u>Percentage Error of Fits</u>

The average percentage of error is 0.00001 %. Therefore the model is recommended.

Model 2: Statistical Relationship between Total Wastage and Wastage of each tea type

In order to check the presence of a significant statistical relationship between total daily wastage (T_W) and total daily wastage of each tea type. ($T_{W, BG}$ / $T_{W, HRB}$) the following analysis has been carried out targeting 309 operational days of the production.

The variability of T_w is explained by considering $T_{W, BG}$ and $T_{W, HRB}$ as independent variables. Therefore, in this analysis, the following research question and research objective are addressed.

Table: 4.27: Research question and research objective related to Model 2

Research Question	Research Objective
ii) Does "type of tea" cause to significantly increase tea bag wastage?	b) To identify that packing materials wastage is impacted by the type of tea.

The following hypothesis testing is carried out.

- H_0; There is no impact of Tea type on Total tea bag wastage.
- H_{a2}: There is impact of Tea type on Total tea bag wastage.

(at significance level, $\alpha = 0.05$)

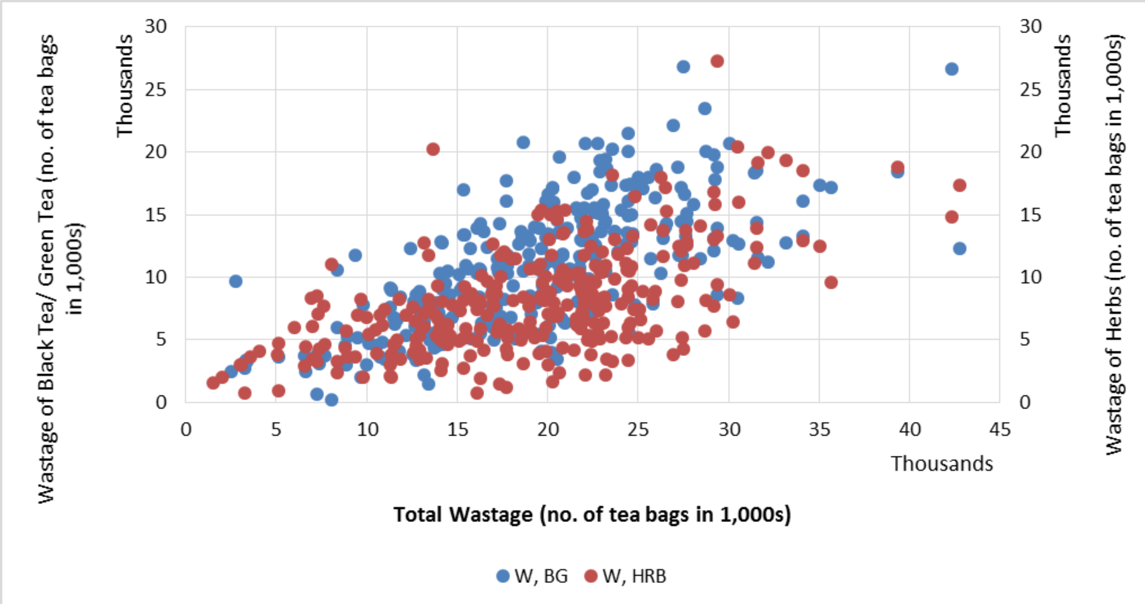

Figure: 4.13: Variability of Total Wastage versus Wastage of Tea types

According to the figure 4.13, the variability of Total wastage against Type of tea is nonlinear

<u>Correlation test of Total wastage</u>

Table: 4.28: Correlation matrix between Total wastage and Wastage of each tea type

Correlations

		ln (Total Wastage)	ln (Total Wastage [Black Tea/ Green Tea])	ln (Total Wastage [Herbs])
Pearson Correlation	ln (Total Wastage)	1.000	.707	.550
	ln (Total Wastage [Black Tea/ Green Tea])	.707	1.000	-.016
	ln (Total Wastage [Herbs])	.550	-.016	1.000
Sig. (1-tailed)	ln (Total Wastage)	.	.000	.000
	ln (Total Wastage [Black Tea/ Green Tea])	.000	.	.394
	ln (Total Wastage [Herbs])	.000	.394	.
N	ln (Total Wastage)	289	289	289
	ln (Total Wastage [Black Tea/ Green Tea])	289	289	289
	ln (Total Wastage [Herbs])	289	289	289

The variables, namely Total Wastage, Total Wastage [Black Tea/ Green Tea] and Total Wastage [Herbs] were transformed to their Natural logarithm forms and were tested for correlation.

It can be considered with 95% confidence that there is a significant correlation between the considered 3 parameters for the model.

Formulation of Linear Model

Table: 4.29: Model summary of Model 2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.707[a]	.500	.498	.26468	.500	286.786	1	287	.000	
2	.903[b]	.815	.814	.16110	.316	488.692	1	286	.000	1.756

a. Predictors: (Constant), ln (Total Wastage [Black Tea/ Green Tea])

b. Predictors: (Constant), ln (Total Wastage [Black Tea/ Green Tea]), ln (Total Wastage [Herbs])

c. Dependent Variable: ln (Total Wastage)

Table: 4.30 : Coefficients of Model 2

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.622	.249		22.564	.000
	ln (Total Wastage [Black Tea/ Green Tea])	.458	.027	.707	16.935	.000
2	(Constant)	2.296	.214		10.746	.000
	ln (Total Wastage [Black Tea/ Green Tea])	.464	.016	.716	28.169	.000
	ln (Total Wastage [Herbs])	.369	.017	.562	22.106	.000

a. Dependent Variable: ln (Total Wastage)

ln (Total Wastage) = 0.464 ln (Total Wastage [Black Tea/ Green Tea]) + 0.369 ln (Total Wastage [Herbs]) + 2.296

$$\ln T_W = 0.464 \ln T_{W,\,BG} + 0.369 \ln T_{W,\,HRB} + 2.296$$

$$T_w = e^{2.296} . {T_{W,BG}}^{0.464} . {T_{W,HRB}}^{0.369}$$

<u>The significance of the Model</u>

Table: 4.31: Analysis of Variance for Model 2

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.091	1	20.091	286.786	.000[b]
	Residual	20.106	287	.070		
	Total	40.198	288			
2	Regression	32.775	2	16.387	631.403	.000[c]
	Residual	7.423	286	.026		
	Total	40.198	288			

a. Dependent Variable: ln (Total Wastage)

b. Predictors: (Constant), ln (Total Wastage [Black Tea/ Green Tea])

c. Predictors: (Constant), ln (Total Wastage [Black Tea/ Green Tea]), ln (Total Wastage [Herbs])

The P-Value F values are the significance of the parameters. Therefore the model is significant.This indicates that the total wastage impacts type of tea .Thus the null hypothesis is rejected at 5% significance level.

R square value of the Model is also 81.5%, therefore, the model is valid.

Diagnostic Tests of Residuals (Errors)

Test 1: Normality of Errors

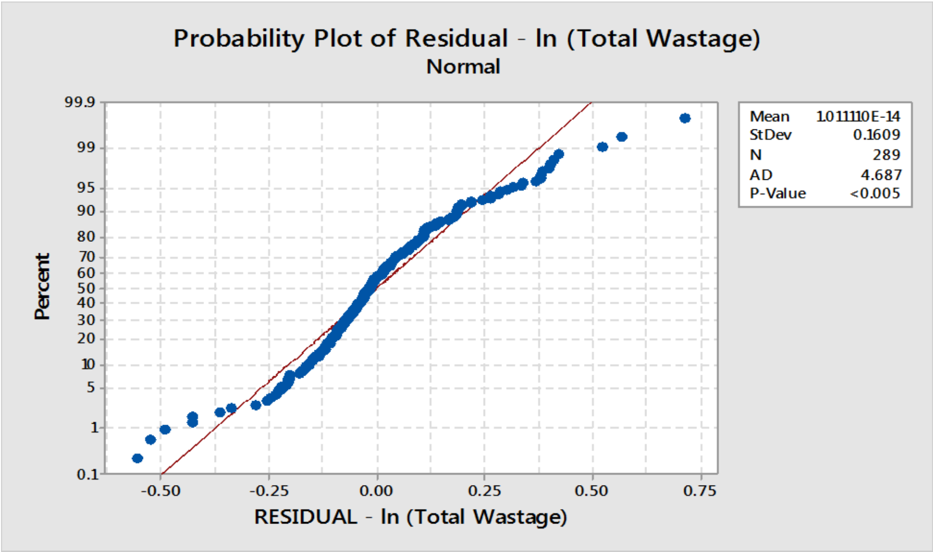

Figure: 4.14: Normality test for residuals

Test 2: Durbin Watson Statistic

Durbin-Watson Statistic = 1.75608

Test 3: Randomness and Unpredictability of Residuals with Fitter Values

Percentage Error of Fits

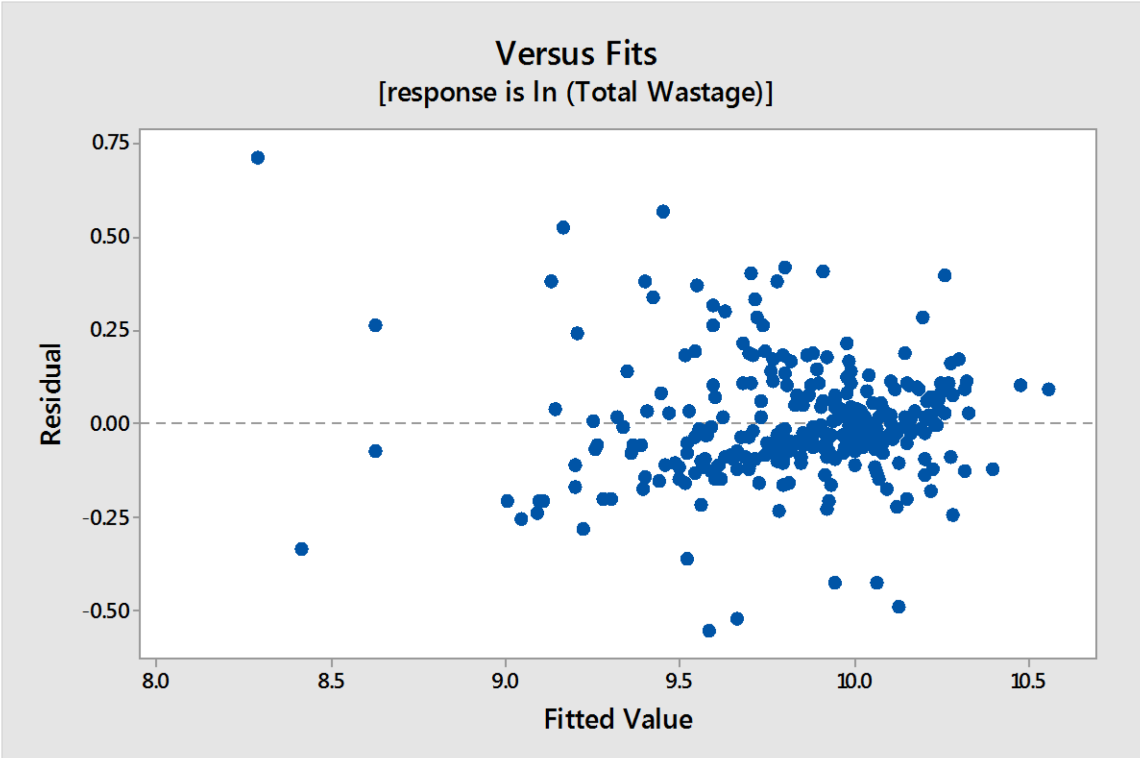

Figure: 4.15: Fits and residuals of Model 2

Residuals are random and unpredictable.

<u>Percentage Error of Fits</u>

The average percentage of error is 0.00001 %. Therefore, the model is recommended.

Model 3: Statistical Relationship between Total Wastage and wastage of each tea bag type

To check the presence of a significant statistical relationship between total daily wastage (TW) and total daily wastage of each tea bag type. (TW, STR / TW, ENV) the following analysis has been carried out targeting 287 operational days of the production.

The variability of Tw is explained by considering TW, STR and TW, ENV as independent variables.

Therefore, in this analysis, the following research question and research objective are addressed.

Table: 4.32: Research question and research objective related to Model 3

Research Question	Research Objective
iii) Does "tea bag type" cause to significantly increase tea bag wastage?	c) To identify that packing materials wastage is impacted by the type of tea bag.

The following hypothesis testing is carried out.

- H_0; There is no impact of Tea bag type on Total tea bag wastage.
- H_{a3}: There is impact of Tea type on Total tea bag wastage.

(at significance level, $\alpha = 0.05$)

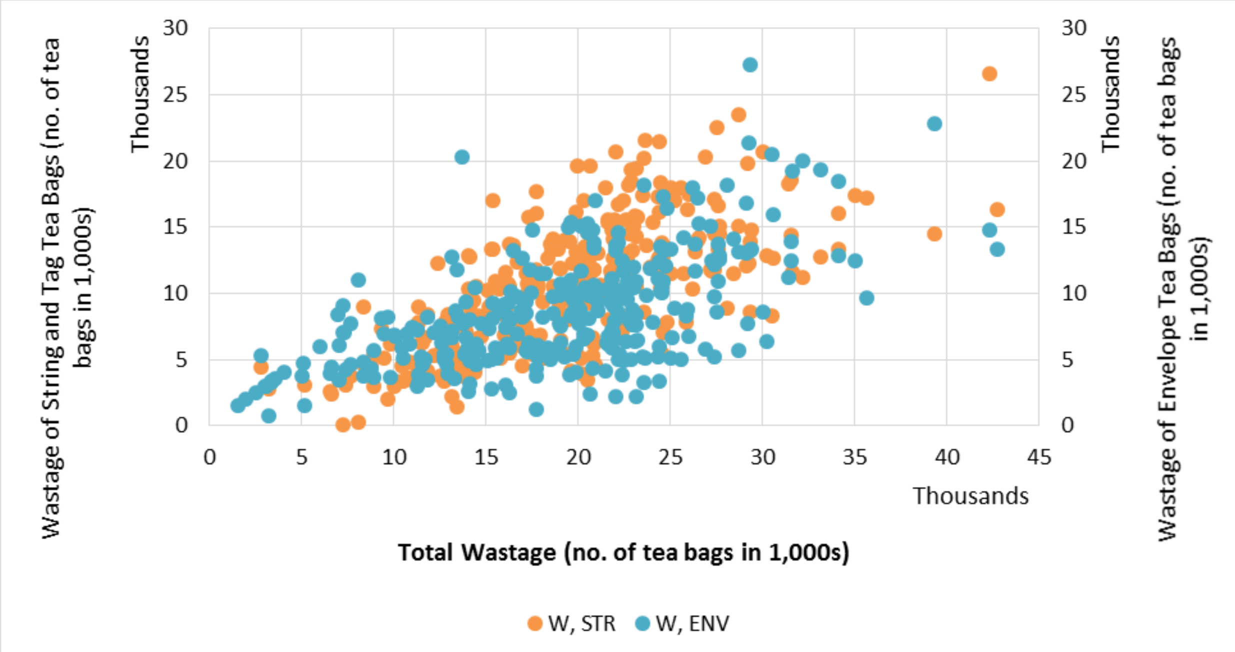

Figure: 4.16: Variability of Total Wastage against wastage of each tea bag type

According to the figure 4.16, the variability of Total Wastage against Tea bag type is nonlinear.

Testing for Correlation

Table: 4.33: Correlation test for Total Wastage and Wastage of each tea bag type

Correlations

		ln (Total Wastage)	ln (Total Wastage of String and Tag)	ln (Total Wastage of Envelope)
Pearson Correlation	ln (Total Wastage)	1.000	.684	.548
	ln (Total Wastage of String and Tag)	.684	1.000	.016
	ln (Total Wastage of Envelope)	.548	.016	1.000
Sig. (1-tailed)	ln (Total Wastage)	.	.000	.000
	ln (Total Wastage of String and Tag)	.000	.	.391
	ln (Total Wastage of Envelope)	.000	.391	.
N	ln (Total Wastage)	287	287	287
	ln (Total Wastage of String and Tag)	287	287	287
	ln (Total Wastage of Envelope)	287	287	287

According to the correlation test, it can be concluded 95% confidence that total wastage and tea bag type are correlated.

Transformation of Variables

The predictor and the response variable in this analysis were elected after transforming both "Total wastage String and Tag" and "Total wastage Envelope" into the natural logarithms.

Dependent variable; ln (Total Wastage) = $\ln T_W$

Predictor; ln (Total Wastage of String and tag) = $\ln Tw,_{STR}$

Predictor; ln (Total Wastage of Envelope) = $\ln T\ w,_{ENV}$

Formulation of Linear Model

Table: 4.34: Model summary of Model 3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.684[a]	.467	.465	.28327	.467	249.932	1	285	.000	
2	.869[b]	.755	.754	.19232	.288	334.309	1	284	.000	1.481

a. Predictors: (Constant), ln (Total Wastage of String and Tag)

b. Predictors: (Constant), ln (Total Wastage of String and Tag), ln (Total Wastage of Envelope)

c. Dependent Variable: ln (Total Wastage)

Table: 4.35 : Coefficients of Model 3

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.004	.243		24.748	.000
	ln (Total Wastage of String and Tag)	.419	.026	.684	15.809	.000
2	(Constant)	2.417	.256		9.435	.000
	ln (Total Wastage of String and Tag)	.413	.018	.675	22.982	.000
	ln (Total Wastage of Envelope)	.405	.022	.537	18.284	.000

a. Dependent Variable: ln (Total Wastage)

$$\text{In } T_W = 0.413 \ln T_{W,\,STR} + 0.405 \ln T_{W,\,ENV} + 2.417$$

The significance of the Model

Table: 4.36: Analysis of variance for Model 3

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.055	1	20.055	249.932	.000[b]
	Residual	22.868	285	.080		
	Total	42.923	286			
2	Regression	32.419	2	16.210	438.269	.000[c]
	Residual	10.504	284	.037		
	Total	42.923	286			

a. Dependent Variable: ln (Total Wastage)

b. Predictors: (Constant), ln (Total Wastage of String and Tag)

c. Predictors: (Constant), ln (Total Wastage of String and Tag), ln (Total Wastage of Envelope)

The P value and F values in table 4.36 are Significance of the Parameters. Therefore the model is significant. This indicates that total wastage impacts tea bag type .Thus the null hypothesis is rejected at 5% significance level. R Squared Value of the Model is also 75.5 %, therefore, the model is valid.

Diagnostic Tests of Residuals (Errors)

Test 1: Normality of Errors

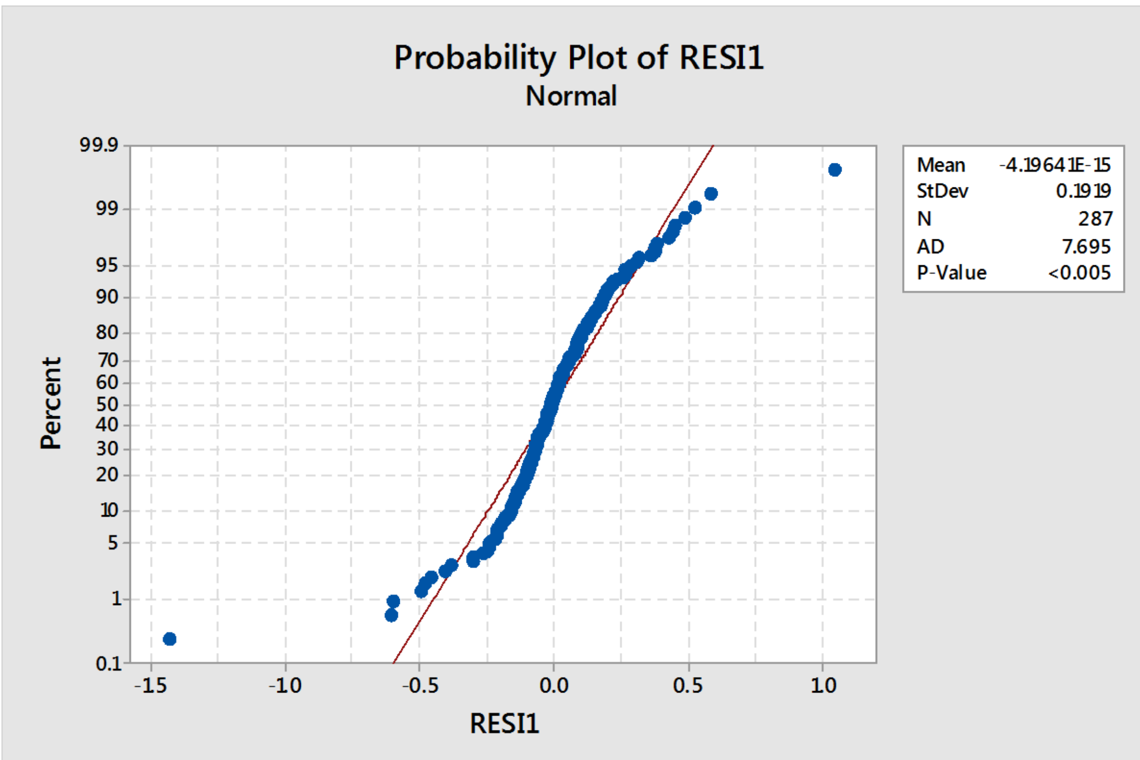

Figure: 4.17: Normality test of residuals for Model 3

Test 2: Durbin Watson Statistic

-Durbin-Watson Statistic = 1.48478

-The residual does not have an autocorrelation.

Test 3: Randomness and Unpredictability of Residuals with Fitter Values

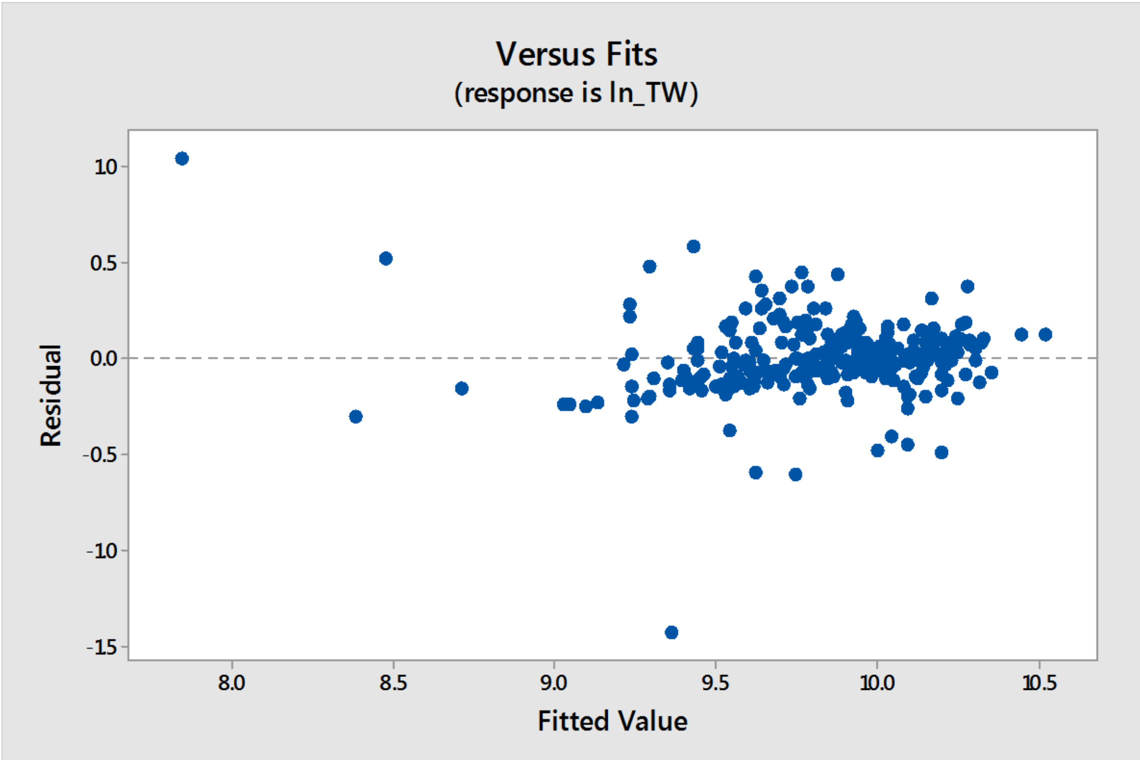

Figure: 4.18: Residuals versus fits for Model 3

<u>Percentage Error of Fits</u>

The average percentage of error is 0.00001 %.Therefore the model is recommended.

Model 4: Statistical Relationship between Total Wastage and filter paper type

Through this analysis, the following research question and research objective are addressed.

Table: 4.37: Research question and objectively related to Model 4

Research Question	Research Objective
iv) Does "filter paper type" cause to significantly increase tea bag wastage?	b) To identify that packing materials wastage is impacted by filter paper type.

The following hypothesis testing is carried out.

- H_0 ; There is no impact of filter paper type on Total tea bag wastage.
- H_{a4}: There is impact of filter paper type on Total tea bag wastage.

The significance of the Parameters

Table: 4.38: Criteria for Filter paper types

Factor	Levels	Values
Filter Paper	2	Ahlstrom, Glat Filter

Table: 4.39 : Significance of Filter paper types

Source	DF Num	DF Den	F-Value	P-Value
Filter Paper Type	1	296.277	31.41	0.000

Table: 4.40: Mean comparison of wastage for each filter paper type

FP	N	Mean Total Wastage	St. Deviation	95% CI
Ahlstrom	153	21220	6239	(20223,22216)
Glat felter	155	16784	7594	(15579,17989)

The validity of the Model

F distribution with 1 DF in the numerator and 306 DF in the denominator

Table: 4.41 : F value at 95% confidence level

$P(X \leq x)$	x
0.95	3.87203

When considered the corresponding F value as in Table 4.41, the F value of mean comparison is significant.

Therefore, it can be concluded with 95% confidence that there is a significant influence of filter paper type. Therefore the null hypothesis is rejected.

Model 5: Statistical Relationship between Total Wastage, Total Production and Total number of machine change overs

In order to check the presence of a significant statistical relationship between total daily wastage (T_W) total changeover of machine type and Total production. (T_{CO}, T_P) the following analysis has been carried out targeting 309 operational days of the production.

The variability of Tw is explained by considering ($T_{CO,}$ T_P) as independent variables. Therefore, in this analysis, the following research question and research objective are addressed

Table: 4.42: Research question and objective related to Model 5

Research Question	Research Objective
i) Do “number of machine change over” cause to significantly increase tea bag wastage?	a) To identify that packing materials wastage is impacted by machine change over.

The following hypothesis testing is carried out.

- H_0 ; There is no impact of number of machine over on Total tea bag wastage.
- H_{a5} : There is impact of number of machine over on Total tea bag wastage.

(at significance level, $\alpha = 0.05$)

Individual Plots

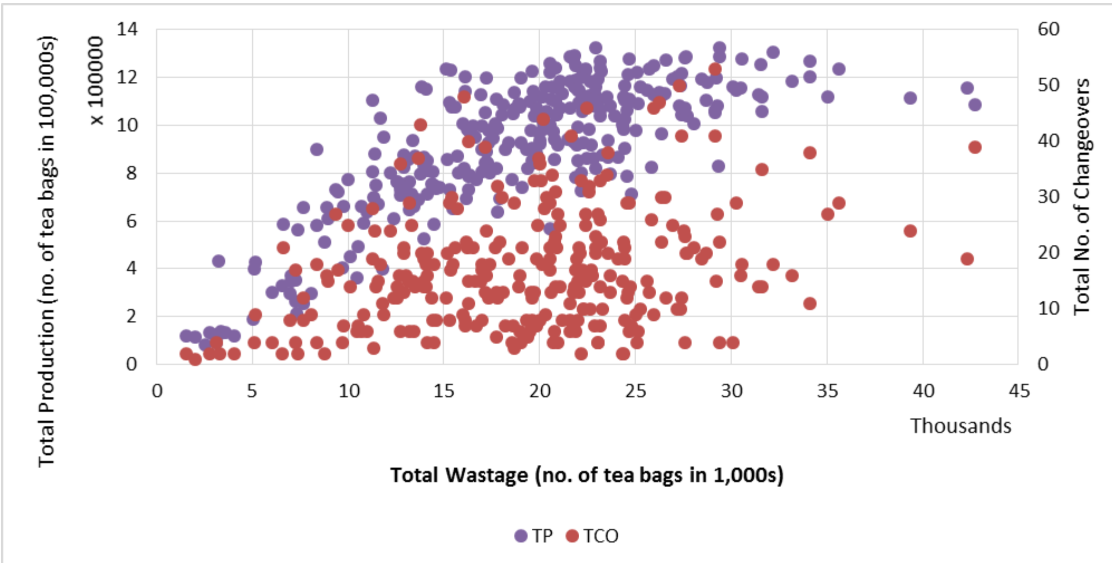

Figure: 4.19: Variability of Total Wastage versus Total Production and Total no. of changeovers

According to the Figure 4.19.The variability of Total Wastage against Total Production is nonlinear.

Testing For Correlation

Table: 4.43: Correlation between variables for Model 5

Correlations

		ln (Total Wastage)	Total No.of Change Overs	ln (Total Production)
Pearson Correlation	ln (Total Wastage)	1.000	.335	.880
	Total No.of Change Overs	.335	1.000	.322
	ln (Total Production)	.880	.322	1.000
Sig. (1-tailed)	ln (Total Wastage)	.	.000	.000
	Total No.of Change Overs	.000	.	.000
	ln (Total Production)	.000	.000	.
N	ln (Total Wastage)	309	309	309
	Total No.of Change Overs	309	309	309
	ln (Total Production)	309	309	309

According to the correlation test, it can be concluded with a 95% confidence that total wastage Total production and Total No, of Change Overs, are correlated.

Further, the natural logarithms of three parameters have also been considered for correlation due to the nonlinear characteristics displayed in Figure 4.19.The transformed variable also are correlated.

Transformation of Variables

The predictor and the response variable in this analysis were elected after transforming both "Total wastage", "Total Production" and Total No.of Change Overs into the natural logarithms.

Dependent variable; ln(Total Wastage)= ln T_W

Predictor; ln (Total Production) = ln T_P

Predictor; ln (Total No. of Change Overs) = ln T_C

Formulation of Linear Model

Table: 4.44: Model Summary of Model 5

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.881[a]	.777	.775	.24580	.777	531.865	2	306	.000	1.653

a. Predictors: (Constant), ln (Total Production), Total No.of Change Overs

b. Dependent Variable: ln (Total Wastage)

Table: 4.45 : Coefficients of Model 5

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.734	.407		-6.724	.000
	Total No.of Change Overs	.003	.001	.057	2.010	.045
	ln (Total Production)	.912	.030	.861	30.172	.000

a. Dependent Variable: ln (Total Wastage)

$$\ln(\text{Total Wastage}) = 0.912 \ln T_C + 0.003 \ln T_P - 2.734$$

$$T_w = \frac{e^{0.003.T_C} . {T_P}^{0.912}}{e^{2.734}}$$

The significance of the Model

Table: 4.46: Analysis of variance for Model 5

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	64.268	2	32.134	531.865	.000[b]
	Residual	18.488	306	.060		
	Total	82.756	308			

a. Dependent Variable: ln (Total Wastage)

b. Predictors: (Constant), ln (Total Production), Total No.of Change Overs

The P value and F values are Significance of the Parameters. Therefore the model is significant. This indicates that total wastage impacts total production and total changeover .Thus the null hypothesis is rejected at 5% significance level R Squared Value of the Model is also 77.7 %, therefore, the model is valid.

Diagnostic Tests of Residuals (Errors)

Test 1: Normality of Errors

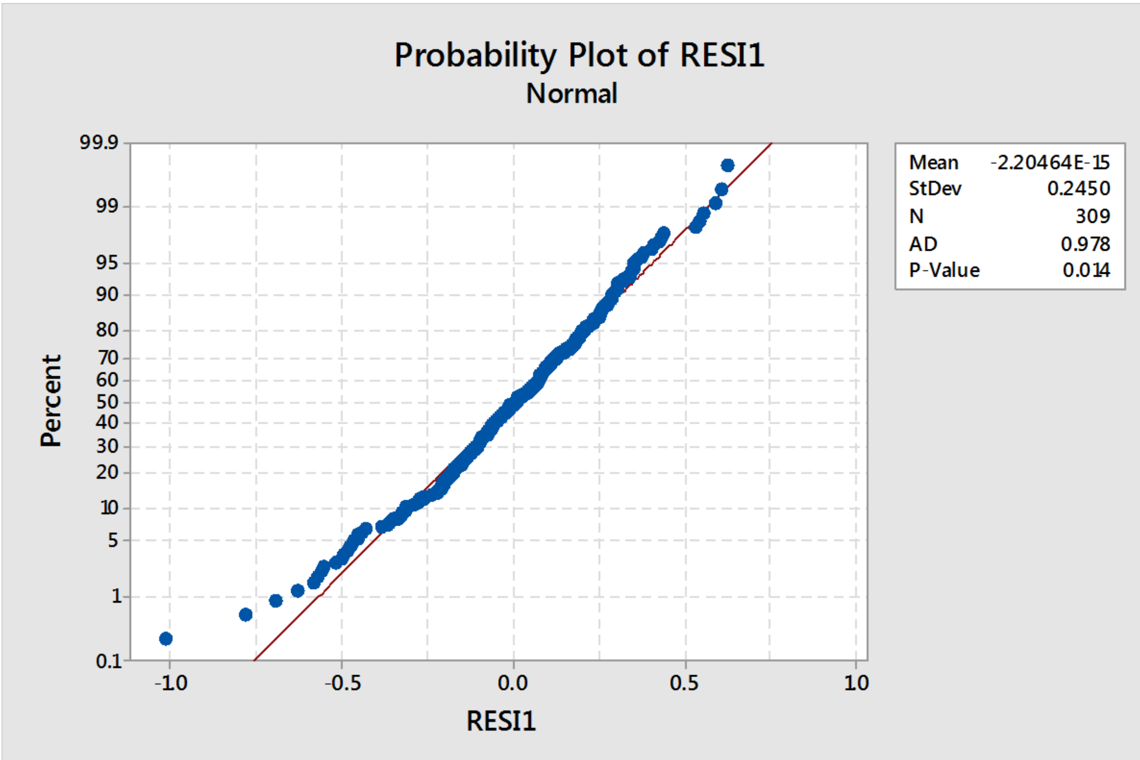

Figure: 4.20: Normality test of Residuals for Model 5

Test 2: Durbin Watson Statistic

- Durbin-Watson Statistic = 1.65253
- The residual does not have an autocorrelation.

Test 3: Randomness and Unpredictability of Residuals with Fitter Values

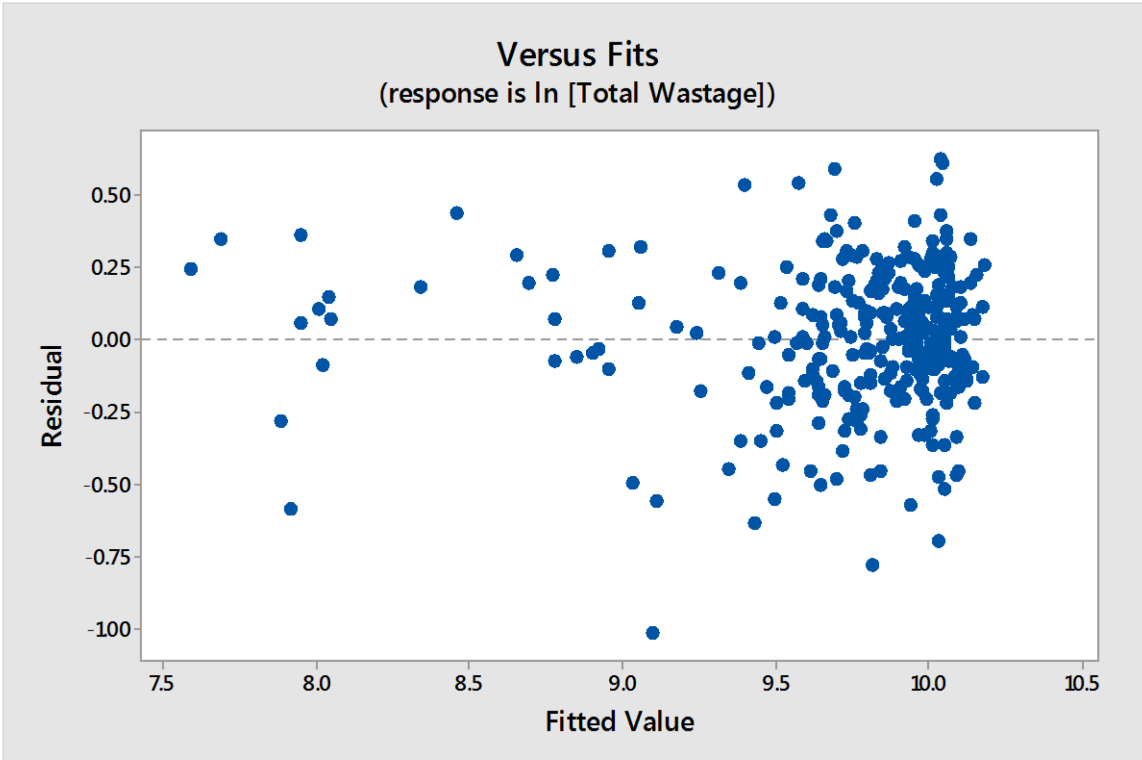

Figure: 4.21: Residuals vs fitted values for Model 5

Percentage Error of Fits

The average percentage of error is 0.00001. Therefore the model is recommended.

Model 6: Statistical Relationship between Total Wastage and Total Production of each machine type and Total no. of change overs for each machine type

In order to check the presence of a significant statistical relationship between total daily wastage (TW) and total production of each machine bag type TP con, TP com, TP_{IMA} and Total Change Overs of each machine type. (TCO_{IMA}, TCO_{COM}, TCO_{CON}) the following analysis has been carried out targeting 279 operational days of the production.

The variability of Tw is explained by considering as TP con, TP com, TP_{IMA} and TCO_{IMA}, TCO_{COM}, TCO_{CON} independent variables. Therefore, in this analysis, the following research question and research objective are addressed

Table: 4.47: Research question and objective related to Model 6

Research Question	Research Objective
i) Do "number of machine change overs for each machine type" cause to significantly increase tea bag wastage?	a) To identify that packing materials wastage is impacted by machine change overs of each machine type.

The following hypothesis testing is carried out.

- H0 ; There is no impact of changeover of each machine type on Total tea bag wastage.
- Ha_6 : There is impact of changeover of each machine type on Total tea bag wastage.

Individual Plots

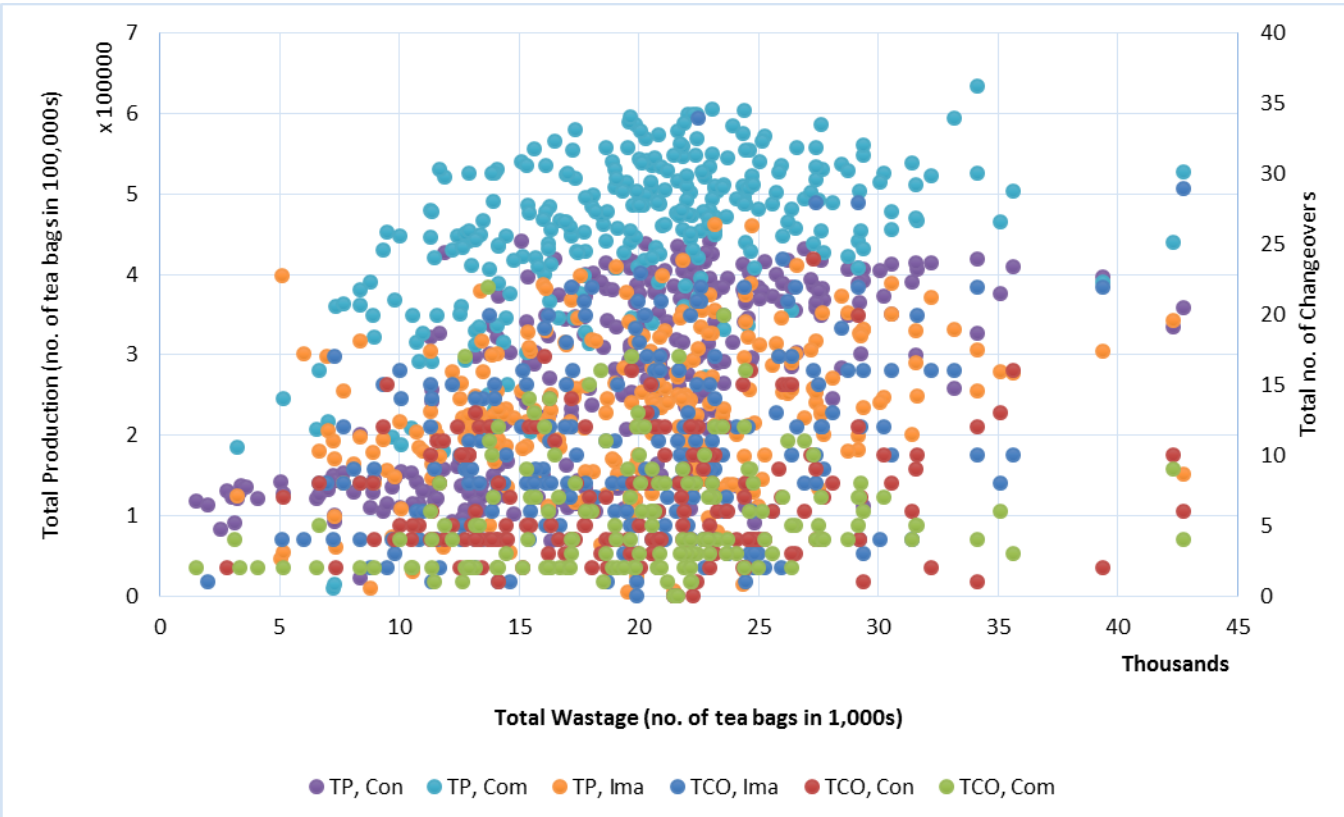

Figure 4: .22: Variability of Total Wastage versus Total Production and Total Changeovers for each machine type

According to the Figure 4.22, the variability of the total wastage against total production of each machine type and total changeover of each machine type is nonlinear.

Testing For Correlation

Table 4.48: Correlation matrix of variables

Correlations		ln (Total Wastage)	Total Changeovers of Ima	Total Changeovers of Constanta	Total Changeovers of Compacta	ln (Total Production of Constanta)	ln (Total Production of Compacta)	ln (Total Production of IMA)
Pearson Correlation	ln (Total Wastage)	1.000	.177	.081	.120	.605	.499	.255
	Total Changeovers of Ima	.177	1.000	.214	.092	.119	.136	.215
	Total Changeovers of Constanta	.081	.214	1.000	.390	.084	-.005	.017
	Total Changeovers of Compacta	.120	.092	.390	1.000	.281	.034	-.034
	ln (Total Production of Constanta)	.605	.119	.084	.281	1.000	.363	.041
	ln (Total Production of Compacta)	.499	.136	-.005	.034	.363	1.000	.122
	ln (Total Production of IMA)	.255	.215	.017	-.034	.041	.122	1.000
Sig. (1-tailed)	ln (Total Wastage)	.	.002	.088	.023	.000	.000	.000
	Total Changeovers of Ima	.002	.	.000	.063	.023	.011	.000
	Total Changeovers of Constanta	.088	.000	.	.000	.080	.467	.391
	Total Changeovers of Compacta	.023	.063	.000	.	.000	.284	.288
	ln (Total Production of Constanta)	.000	.023	.080	.000	.	.000	.249
	ln (Total Production of Compacta)	.000	.011	.467	.284	.000	.	.021
	ln (Total Production of IMA)	.000	.000	.391	.288	.249	.021	.

Correlations		ln (Total Wastage)	Total Changeovers of Ima	Total Changeovers of Constanta	Total Changeovers of Compacta	ln (Total Production of Constanta)	ln (Total Production of Compacta)	ln (Total Production of IMA)
N	ln (Total Wastage)	279	279	279	279	279	279	279
	Total Changeovers of Ima	279	279	279	279	279	279	279
	Total Changeovers of Constanta	279	279	279	279	279	279	279
	Total Changeovers of Compacta	279	279	279	279	279	279	279
	ln (Total Production of Constanta)	279	279	279	279	279	279	279
	ln (Total Production of Compacta)	279	279	279	279	279	279	279
	ln (Total Production of IMA)	279	279	279	279	279	279	279

According to the correlation test, it can be concluded with a 95%confidence that Total wastage against machine wise total production and machine wise total changeover are not correlated. Thus, the alternative hypothesis is rejected .

Further, the natural logarithms of the two parameters have also been considered for correlation due to the nonlinear characteristics displayed in figure 4.22.The transformed variable is given below.

Transformation of Variables

The predictor and the response variable in this analysis were elected after transforming both "Total wastage" "Total Production" of machine type and Total No.of Change Overs of machine type into the natural logarithms.

Dependent variable; ln (Total Wastage) = ln T_W

Response: ln (Total Production of Constanta), ln (Total Production of Compacta), ln (Total Production of IM) = ln $T_{P, Con}$/ ln $T_{P, Com}$/ ln $T_{P, Ima}$

Response:: ln (Total Changeover of Constanta), ln (Total Changeover of Compacta), ln (Total Changeover of IMA) =ln $T_{CO, Con}$/ ln $T_{CO, Com}$/ ln $T_{CO, IMA}$

Formulation of Linear Model

Table: 4.49: Model Summary of Model 6

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.605[a]	.366	.363	.28987	.366	159.749	1	277	.000	
2	.675[b]	.455	.451	.26910	.090	45.405	1	276	.000	
3	.703[c]	.494	.489	.25978	.039	21.151	1	275	.000	1.183

a. Predictors: (Constant), ln (Total Production of Constanta)

b. Predictors: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta)

c. Predictors: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta), ln (Total Production of IMA)

d. Dependent Variable: ln (Total Wastage)

Table: 4.50: Coefficients of the Model 6

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.437	.429		10.354	.000
	ln (Total Production of Constanta)	.436	.034	.605	12.639	.000
2	(Constant)	1.490	.591		2.521	.012
	ln (Total Production of Constanta)	.352	.034	.488	10.235	.000
	ln (Total Production of Compacta)	.307	.046	.321	6.738	.000
3	(Constant)	.303	.626		.484	.628
	ln (Total Production of Constanta)	.352	.033	.489	10.620	.000
	ln (Total Production of Compacta)	.284	.044	.297	6.403	.000
	ln (Total Production of IMA)	.121	.026	.199	4.599	.000

a. Dependent Variable: ln (Total Wastage)

Table: 4.51 : Excluded variables of Model 6

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Total Changeovers of Ima	.106[b]	2.223	.027	.133	.986
	Total Changeovers of Constanta	.030[b]	.631	.529	.038	.993
	Total Changeovers of Compacta	-.055[b]	-1.095	.275	-.066	.921
	ln (Total Production of Compacta)	.321[b]	6.738	.000	.376	.868
	ln (Total Production of IMA)	.231[b]	5.022	.000	.289	.998
2	Total Changeovers of Ima	.077[c]	1.714	.088	.103	.976
	Total Changeovers of Constanta	.042[c]	.940	.348	.057	.991
	Total Changeovers of Compacta	-.031[c]	-.670	.503	-.040	.916

	ln (Total Production of IMA)	.199[c]	4.599	.000	.267	.985
3	Total Changeovers of Ima	.038[d]	.857	.392	.052	.936
	Total Changeovers of Constanta	.038[d]	.891	.374	.054	.991
	Total Changeovers of Compacta	-.023[d]	-.517	.606	-.031	.914

a. Dependent Variable: ln (Total Wastage)

b. Predictors in the Model: (Constant), ln (Total Production of Constanta)

c. Predictors in the Model: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta)

d. Predictors in the Model: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta), ln (Total Production of IMA)

The significance of the Model

The P-Value and F Values are not significant of the total changeover parameters but they are significant for the total production parameters. Therefore there is no model can be formulated with respect total changeovers. R Squared Value of the model is also 49.4 %, therefore, the model is not valid.

Table: 4.52: Analysis of variance for Model 6

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	13.423	1	13.423	159.749	.000[b]
	Residual	23.275	277	.084		
	Total	36.697	278			
2	Regression	16.711	2	8.355	115.381	.000[c]
	Residual	19.987	276	.072		
	Total	36.697	278			
3	Regression	18.138	3	6.046	89.587	.000[d]
	Residual	18.559	275	.067		
	Total	36.697	278			

a. Dependent Variable: ln (Total Wastage)

b. Predictors: (Constant), ln (Total Production of Constanta)

c. Predictors: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta)

d. Predictors: (Constant), ln (Total Production of Constanta), ln (Total Production of Compacta), ln (Total Production of IMA)

Diagnostic Tests of Residuals (Errors)

Test 1: Normality of Errors

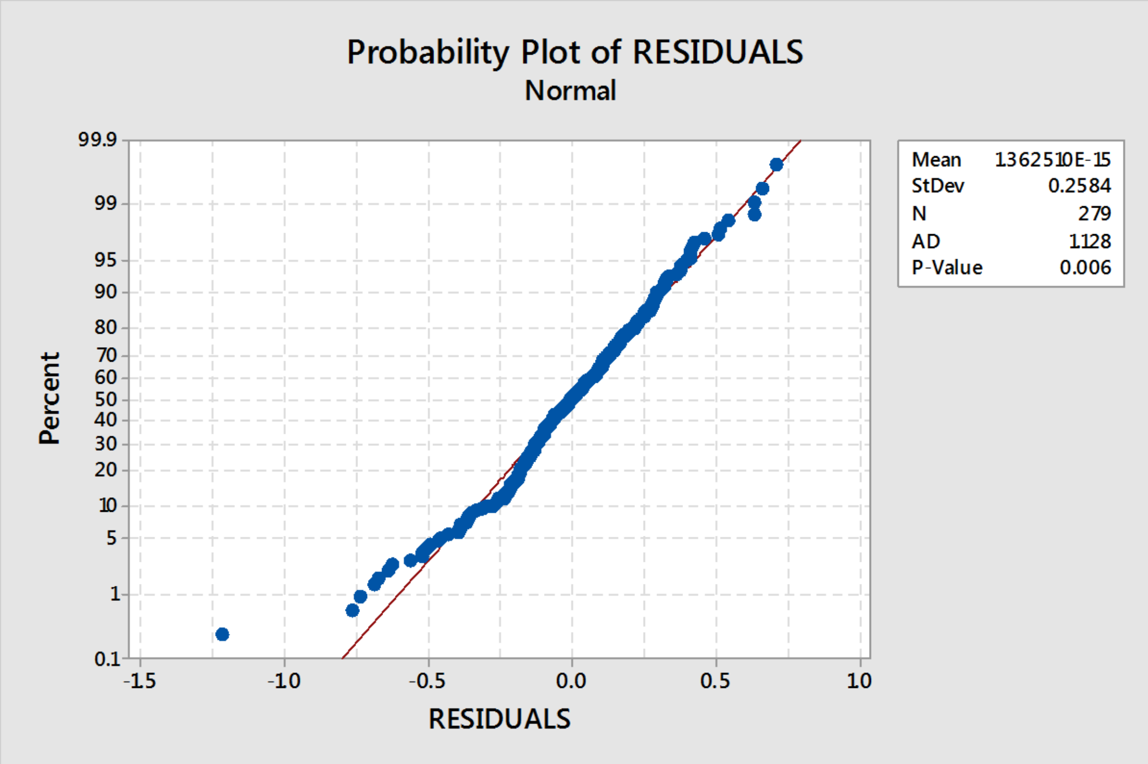

Figure: 4.22: Normality test for residuals of Model 6

Test 2: Durbin Watson Statistic

Durbin-Watson Statistic = 1.18274

Test 3: Randomness and Unpredictability of Residuals with Fitter Values

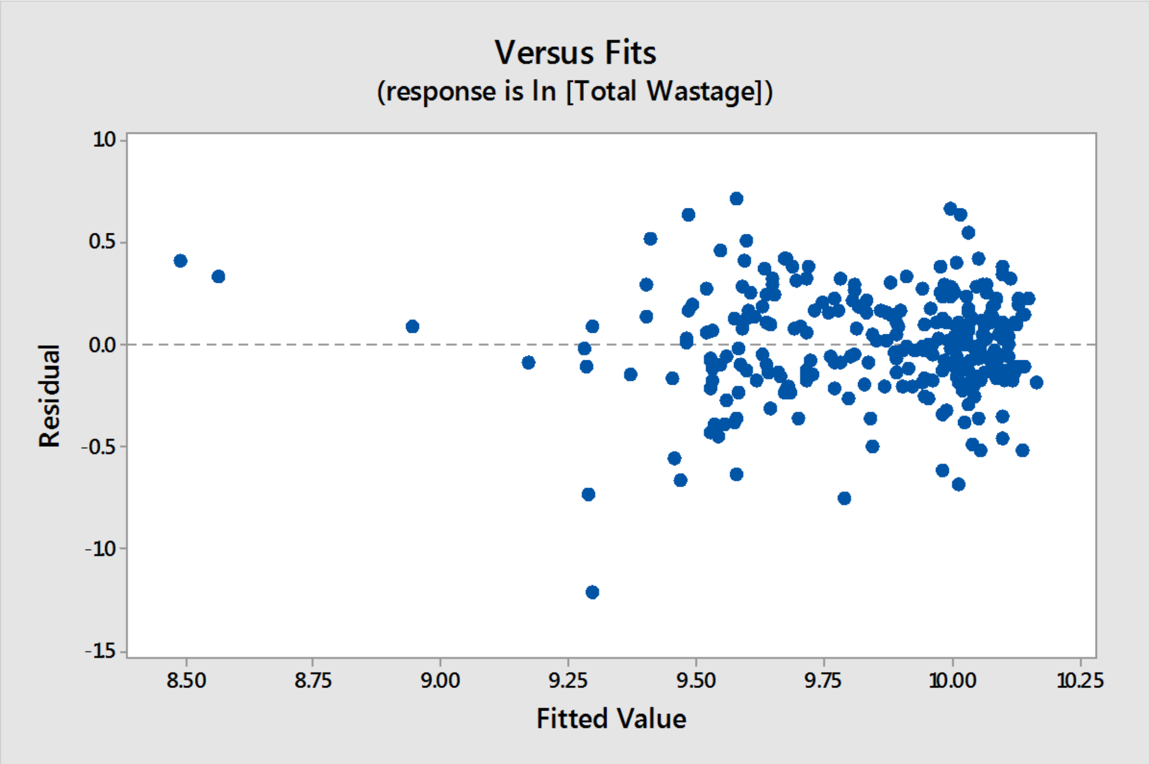

Figure: 4.23: Residuals versus fitted values for Model 6

Percentage Error of Fits

Since the model is not recommended the average percentage of error is high.

***VIVA comments "Regression may be carried out using all variables together – multiple regression*'

Final Model

Total Wastage versus Total Production of Constanta, Total Production of Compacta, Total Production of Ima, Total Changeovers of Constanta, Total Changeovers of Compacta and Total Changeovers of Ima

Total Wastage, Total Production of Constanta, Total Production of Compacta, Total Production of Ima, Total Changeovers of Constanta were transformed to their natural log forms.

Correlations were checked as follows,

Table 4.53: Correlation Matrix of Variables

Correlations

		ln (Total Wastage)	Total Changeovers, Ima	Total Changeovers, Constanta	Total Changeovers, Compacta	ln (Total Production, Constanta)	ln (Total Production, Compacta)	ln (Total Production, Ima)
Pearson Correlation	ln (Total Wastage)	1.000	.177	.081	.120	.605	.499	.255
	Total Changeovers, Ima	.177	1.000	.214	.092	.119	.136	.215
	Total Changeovers, Constanta	.081	.214	1.000	.390	.084	-.005	.017
	Total Changeovers, Compacta	.120	.092	.390	1.000	.281	.034	-.034
	ln (Total Production, Constanta)	.605	.119	.084	.281	1.000	.363	.041
	ln (Total Production, Compacta)	.499	.136	-.005	.034	.363	1.000	.122
	ln (Total Production, Ima)	.255	.215	.017	-.034	.041	.122	1.000
Sig. (1-tailed)	ln (Total Wastage)		.002	.088	.023	.000	.000	.000
	Total Changeovers, Ima	.002		.000	.063	.023	.011	.000
	Total Changeovers, Constanta	.088	.000		.000	.080	.467	.391
	Total Changeovers, Compacta	.023	.063	.000		.000	.284	.288
	ln (Total Production, Constanta)	.000	.023	.080	.000		.000	.249
	ln (Total Production, Compacta)	.000	.011	.467	.284	.000		.021
	ln (Total Production, Ima)	.000	.000	.391	.288	.249	.021	

Stepwise regression was used to determine the model between the parameters and Total Wastage

Table 4.54: Model Summary of Final Model

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
3	.703[c]	.494	.489	.25978	.039	21.151	1	275	.000	1.183

d. Dependent Variable: ln (Total Wastage)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	18.138	3	6.046	89.587	.000[d]
	Residual	18.559	275	.067		
	Total	36.697	278			

d. Predictors: (Constant), ln (Total Production, Constanta), ln (Total Production, Compacta), ln (Total Production, Ima)

Table 4.55 Coefficients of the final model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
3	(Constant)	.303	.626		.484	.628
	ln (Total Production, Constanta)	.352	.033	.489	10.620	.000
	ln (Total Production, Compacta)	.284	.044	.297	6.403	.000
	ln (Total Production, Ima)	.121	.026	.199	4.599	.000

a. Dependent Variable: ln (Total Wastage)

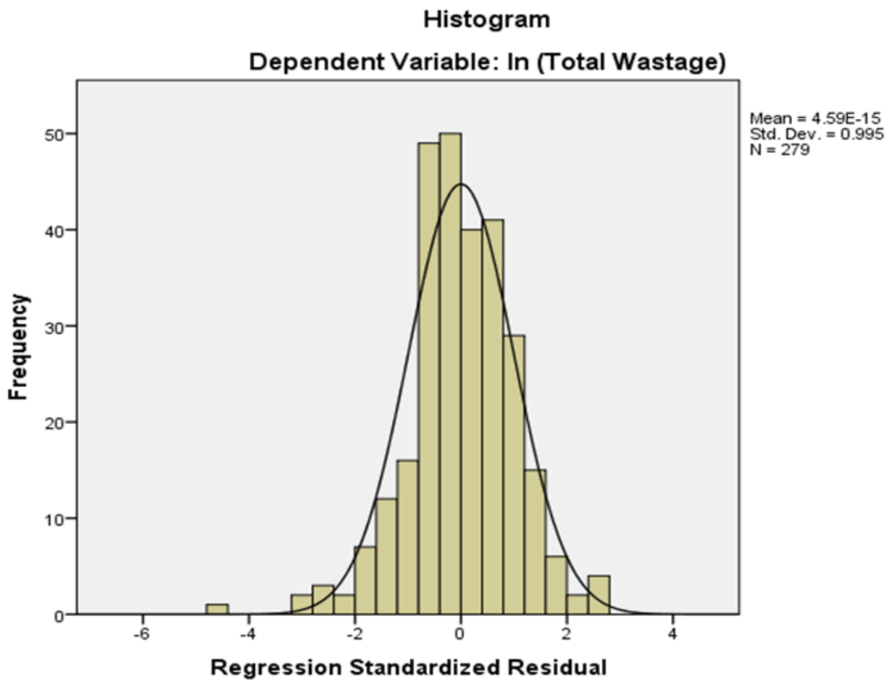

Figure 4.24 Histogram of residual value of final model

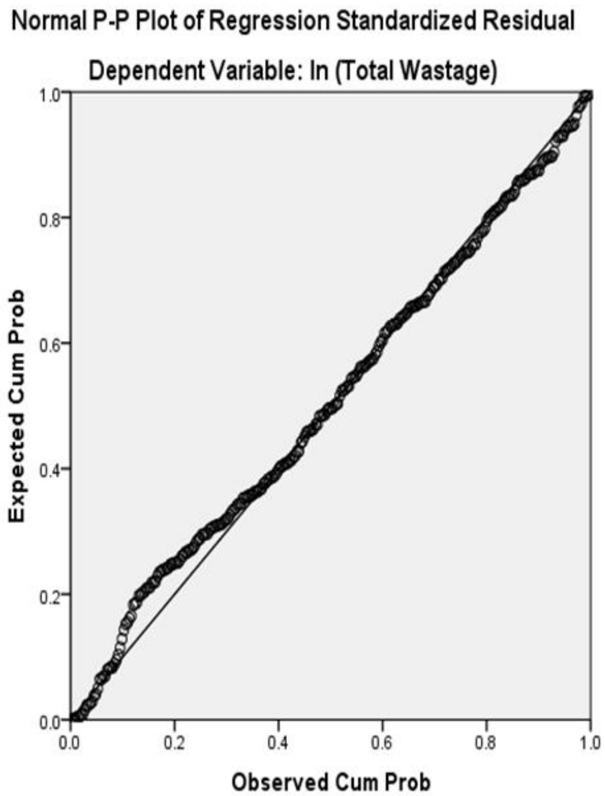

Figure 4.25Normality test for residual of final Model

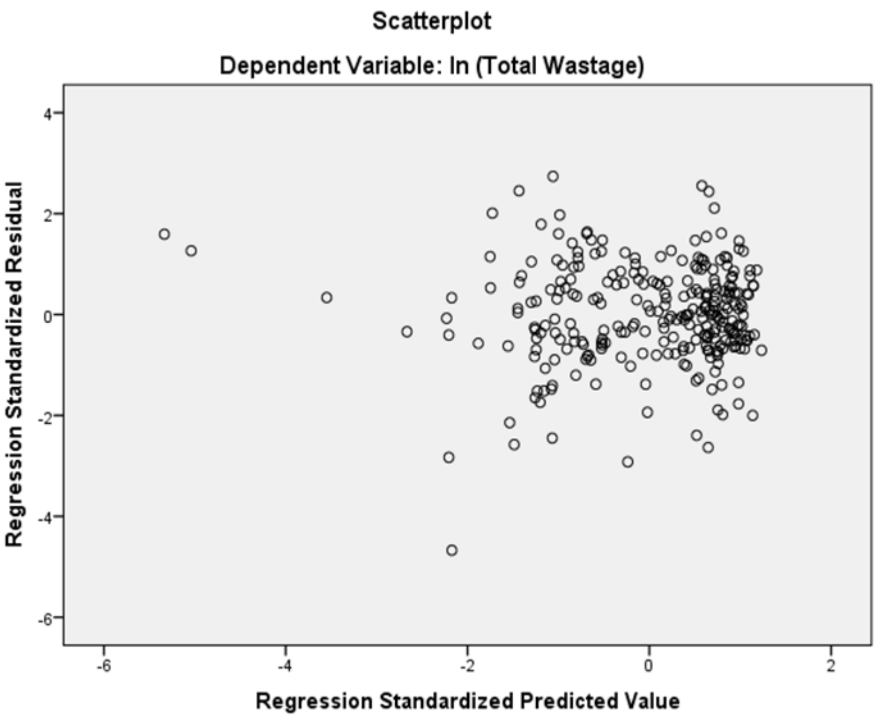

Figure 4.26 Residuals Versus Fitted Values for Final model

Final Model

None of the parameters related to changeovers were found to be significant in the final model,

The final model is as follows,

ln Total Wastage = 0.303 + 0.352 ln (Total Production, Constanta) + 0.284 ln (Total Production, Compacta) + 0.121 ln (Total Production, Ima)

Tw = e0.303 x (Total Production, Constanta) 0.352 x (Total Production, Compacta) 0.284 x (Total Production, Ima) 0.121

Therefore it can be concluded that the most significant contributions to Total Wastage happen due to Total production of each machine type rather than the number of Machine changeovers.

The most influential factor to total wastage is Total Production of Constanta while Total Production of Compacta and Ima follows.However even though the model is significant, the ability to explain the variability of Wastage from this model is poor as the R Square value is 49.4%

Supply Chain implication

Subsequent to the study carried out ,it had been identified that most significant supply chain implication is delivery lead time from production to end customers .In addition to that quality of raw materials supply, quality of tea supply have been also a significant supply chain implication that was identified throughout the study. The solutions to above supply chain implications have been address in chapter 6 under conclusion and recommendation.

5. DISCUSSION OF RESULTS

5.1. Discussion on Primary Data Analysis

As mentioned above the primary data analysis has been carried out based on the responses gathered through the structured questionnaire which was offered as an interview for a sample of employees who were picked using stratified cluster sampling method. According to table 4.1, the respondent composition shows that packing assistant representation in the sample is higher than the other positions.

<u>Addressing research objective (a)</u>

The following claims in the questionnaire were targeted to address “research objective a”

- Claim 1: Flavored Black tea/ Green tea generates low wastage in production.
- According to Table 4.5 and Figure 4.1, it can be concluded that 60.9% of the employees disagree with the Claim 1.Therefore, according to employees’ perception, Flavored Black tea / Green tea does not generate low wastage in production
- Claim 2: Black tea /Green tea with herb generates low wastage in production.
- According to Table 4.6 and Figure 4.2, it can be concluded that 65.2% of the employees agree with the Claim 2.Therefore, according to employees’ perception, Black tea /Green tea with herb generates low wastage in production
- Claim 3: ‘Envelope’ Tea bags generate high wastage in production.
- According to Table 4.7 and Figure 4.3, it can be concluded that 87% of the employees disagree with the Claim 3.Therefore, according to employees’ perception, ‘Envelope’ Tea bags do not generate high wastage in production
- Claim 4: ‘String and tag’ tea bags generate high wastage in production.

- According to Table 4.8 and Figure 4.4, it can be concluded that 69.5% of the employees agree with the Claim 4.Therefore, according to employees' perception, 'String and tag' tea bags generate high wastage in production
- Claim 5: Ahlstrom material generates low wastage in production.
- According to Table 4.9 and Figure 4.5, it can be concluded that 52.2% of the employees disagree with the Claim 5.Therefore, according to employees' perception, Ahlstrom material does not generate low wastage in production
- Claim 6: GlatFilter material generates low wastage in production.
- According to Table 4.10 and Figure 4.6, it can be concluded that 82.6% of the employees are neutral and 17.4% of the employees agree with the Claim 6.Therefore, according to employees' perception, GlatFilter material generate low wastage in production.
- Claim 7: High frequency of machine changeover will generate high wastage amount in Tea bags /envelopes.
- According to Table 4.11 and Figure 4.7, it can be concluded that 87.0% of the employees disagree with the Claim 7.Therefore, according to employees' perception, High frequency of machine changeover will not generate high wastage amount in Tea bags /envelopes.
- According to Table 4.12, it can be concluded that 78.3% of the employees consider the "Day" shift, as the work shift that generates the highest wastage of tea bags.
- According to Table 4.13, it can be concluded that 69.6% of the employees agree with the Claim 9.Therefore, according to employees' perception, some of the old tea bagging machines should be replaced to reduce tea bag wastage.
- According to Table 4.14, it can be concluded that 65.2% of the employees agree with the Claim 10.Therefore, according to employees' perception, the current production method should be changed in order to mitigate problems related to tea bag production wastage
- By analyzing the responses for the above claims the factors that are affecting to generate packing materials wastage will be identified according to employees' perception.
- According to the analysis of Primary data, gathered from the structured questionnaire the employees of the organization have been able to capture many problematic areas

of the packing function that was not paid enough attention by the management that causes tea bag wastage.

Addressing research objective (b)

The following claims in the questionnaire were targeted to address "research objective b"

According to Table 4.17It can be concluded that Claim 1 and Claim 2 are correlated. Therefore there is a significant relationship between Claim 1 and Claim 2. Therefore it can be concluded that Black tea with liquid flavoured does not generate low wastage while Black tea /Green tea with herbs will generate low wastage according to employees' perception.

According to Table 4.19It can be concluded that Claim 3 and Claim 4 are not correlated. Therefore there is no significant relationship between Claim 3 and Claim 4 according to employee's perception.

According to Table 4.21, There is no significant relationship between Claim 5 and Claim 6, therefore according to the employee's perception, there is no significant relationship between filter paper types and wastage.

When summarized the above finding with regard to "objective b" The most statistically significant and correlated problems discovered during the interview are as follows.

1. Flavored Black tea/ Green tea tends to generate less wastage while Black tea/ Green tea with herbs tend to generate more wastage.

Also, it was discovered that there are following tendencies when analyzed employees' perception even though the claims are individual and statistically not correlated with the limitations of sample size however in order to validate the realistic situation of above scenarios, secondary data were analyzed using a statistical model of regression analysis.

2. Envelope tea bags generate lower wastage.
3. String and tag tea bags generate higher wastage.
4. Glat filter papers generate lower wastage.
5. Ahlstrom filter papers generate higher wastage.
6. High frequency in changeovers does not generate higher wastage.
7. A work shift that generates higher wastage is the 'Day' shift
8. Old tea bagging machines should be replaced to reduce tea bag wastage.
9. Current production method should be changed to mitigate problems related to- tea bag wastage.

5.2. Discussion on Secondary Data Analysis

As mentioned above the data were collected from the secondary source, during the period of January to December in 2017. This data allowed the researcher to identify patterns, themes and significant distribution of the data set and validate the primary data respond. The linear regression method was adopted to formulate statistical relationship of identified variables.

Addressing research objective (c)

Model 1: Statistical Relationship between Total Wastage and Total Production
When taken to account the statistical relationship between Total Wastage and Total Production, it can be concluded with 95% confidence that the Total Wastage is positively correlated to Total Production and it can be depicted by the following equation.

Equation: 5.1: Relationship between Total Production and Total Wastage

$$T_w = \frac{{T_P}^{0.931}}{e^{2.960}}$$

According to the equation total daily wastage is a growth model of total production with a power of 0.931 The model is statistically recommended.

Model 2: Statistical Relationship between Total Wastage and Wastage of each tea type
When taken to account the statistical relationship between Total Wastage and Total Wastage of each tea type, it can be concluded with 95% confidence that the Total Wastage is positively correlated to Total wastage of each tea type and it can be depicted by the following equation.

Equation: 5.2: Relationship between total Wastage and Wastage of each Tea type

$$T_w = e^{2.296}.{T_{W,BG}}^{0.464}.{T_{W,HRB}}^{0.369}$$

According to the equation total, daily wastages are a growth model of total wastage of Black tea Green tea (power of 0.464) and total wastage of Herbs tea (power of 0.369). The model is statistically recommended.

Model 3: Statistical Relationship between Total Wastage and wastage of each tea bag type
When taken to account the statistical relationship between Total Wastage and Total Wastage of each tea bag type, it can be concluded with 95% confidence that the Total Wastage is positively correlated to Total wastage of each tea bag type and it can be depicted by the following equation.

Equation: 5.3: Relationship between Total Wastage and wastage of each tea bag type

$$T_w = e^{2.417}.T_{W,STR}{}^{0.413}.T_{W,ENV}{}^{0.405}$$

According to the equation total daily wastage is a growth model of total wastage of String & Tag tea bag type (power of 0.413) and total wastage of Envelope tea bag type (power of 0.405). The model is statistically recommended.

Model 4: Statistical Relationship between Total Wastage and filter paper type
When taken to account the statistical relationship between Total Wastage and filter paper type, it can be concluded that Ahlstrom filter paper generates more wastage than Glat filter paper and the respective means of Wastage under these filter paper types are significantly different.

Table: 5.1: Mean wastage of each filter paper type

FP	N	Mean Total Wastage	St. Deviation	95% CI
Ahlstrom	153	21220	6239	(20223,22216)
Glat felter	155	16784	7594	(15579,17989)

However, there is no significant linear model between the two parameters.

Model 5: Statistical Relationship between Total Wastage, Total Production and Total number of machine change overs

When taken to account the statistical relationship between Total Wastage and a Total number of machine change overs per day it can be concluded with 95% confidence that there is no significant correlation between Total wastage and a Total number of machine change overs.

However, the Model 1 can be further improved by introducing the Total number of change overs of machines, depicted by the following equation.

Equation: 5.4: Relationship between Total Wastage, Total Production and Total number of machine change overs

$$T_w = \frac{e^{0.003.T_C}.{T_P}^{0.912}}{e^{2.734}}$$

This is an improved version of equation 5.1. According to the equation, 5.4 total daily wastage is a multiplication of a growth model of total production with an exponential model of Total changeovers. The model is statistically significant.

Model 6: Statistical Relationship between Total Wastage and Total Production of each machine type and Total no. of change overs for each machine type

When taken to account the statistical relationship between Total Wastage and Total Production under each type of machine and Total number of change overs for each type of machine per day, it can be concluded with 95% confidence that there is no significant correlation between Total wastage and Total number of machine change overs for each type of machine.

However, there seems to be a positive correlation between Total Wastage and Total production under each machine type which cannot be transformed into a significant statistical model due to limitations in data.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

According to the discussion,

- The study has identified that there is a problem in the production method when analyzed employees perception in related to Claim10 of the questionnaire. This has also been confirmed by the statistical model displayed by above equation 5.1.
- Claim 1 and 2 are correlated, therefore according to employees perception BT, GT generate more wastage at the same time Herbs generate less wastage. This has also been confirmed by the statistical model displayed by above Equation 5.2. further, it has been identified that Green Tea, Black tea has a high amount of power than Herbs which can be mentioned as 0.464
- Claim 3 and 4 are not correlated and not significant according to the employee's perception mainly due to the small sample size of the questionnaire. However, this has been captured by the Equation 5.3 which statistically explains the realistic scenario. By the above-mentioned equation, it has been identified that String and tag tea bag has a high amount of power than Envelope tea bag.
- Claim 5 and 6 are not correlated and not significant according to the employee's perception again due to the small sample size. When analyzed claim 5 it is observed that employees disagree with the claim that Ahlstrom filter paper generates low wastage. The employees are also neutral with the Glatfelter makes lower wastage. This has been captured by the table 5.2.1 that the mean wastage of the Ahlstrom filter paper is higher than Glatfelter which can be mentioned as 21220.
- Claim 7 is not significant according to the employee's perception. Therefore according to the employee's perception, daily production wastage is not impacted by a number of change over. It has been also identified that number of changeover is not a significant uni-variate parameter that impacts total wastage. However total changeovers is a significant parameter when considered altogether with total production which is represented by equation 5.4.
- As an improvement to the equation 5.4, a statistical model between machine changeovers and total production for each machine type was attempted. It was found that change overs of each machine type are not significantly impacting total wastage even though total production of each machine type are significantly impacting as individual variables.

The following Table 6.1 covers the overall conclusions of both qualitative and quantitative analysis carried out during this study.

Table: 6.1 Summary of Conclusion

Summary of Conclusions	
Qualitative Analysis (Primary Data)	Quantitative Analysis (Secondary Data)
a) Flavored Black tea/ Green tea tends to generate more wastage while Black tea/ Green tea with herbs tend to generate less wastage.	a) The Total of Wastage is less impacted by Wastage of Flavored Black tea/ Green tea bags than of Black tea/ Green tea with Herbs.
b) Envelope tea bags generate lower wastage. c) String and tag tea bags generate higher wastage.	b) The Total of Wastage is more impacted by Wastage of String and Tag tea bags than of Envelope tea bags.
d) Glat filter papers generate lower wastage. e) Ahlstrom filter papers generate higher wastage.	c) The mean wastage of Ahlstrom tea bags is significantly higher than Glatfelter.
f) High frequency in changeovers does not generate higher wastage.	d) The number of changeovers has no significant influence on the Total Wastage as a singular parameter. e) However, the Total number of changeovers significantly affect the Total Wastage when considered together with Total Production.
g) A work shift that generates higher wastage is the 'Day' shift.	f) There is not enough secondary data to conclude the effect to Total Wastage by work shift.
h) Current production method should be changed to mitigate problems related to tea bag wastage. i) Old tea bagging machines should be replaced to reduce tea bag wastage.	g) Total Production significantly influences the Total Wastage and it is concluded that on average 2% of the Total Production of tea bags is wasted under the existing process. However, the production process is not statistically under control as the variation of wastage tends to increase up to 3.5% of total production.

6.2. Recommendation

Based on results of above study it was concluded that the Total Production significantly influences the Total Wastage and it is concluded that in average 2% of the Total Production of tea bags is wasted under the existing process.

However, the production process is not statistically under control as the variation of wastage tends to increase up to 3.5% of total production.

The following recommendations were given considering the operational area of Tea bag production in the organization:

- Machine wise wastage monitoring system should be implemented
- Wastage by each machine should be recorded by separately
- Production method should be a change
- Number of change overs should be minimized
- Skill labour should be assigned to the particular job
- Labour capacity should increase where necessary
- New state of the art tea bags machines should be introduced
- Top management should pay more attention towards material management.
- Use of software like MSP, ERP, SAP, WHM etc. should be done to avoid manual errors in material management.
- To avoid delay due to the rejection of materials by quality control department or it should be recommended to maintain buffer stocks of pacing materials.
- To avoid communication problems, it is recommended that all the indents, requests, notes; records should be kept in the written format.
- To reduce the wastage due to improper material handling, material handling equipment's like conveyor belts, trolleys, cranes, etc. should be used.
- ABC analysis should be done for value analysis of the inventory.
- Before placing any order every order should apply EOQ technique to reduce excess inventory carrying cost overrun.
- It is recommended to follow the procedure given below to implement the material management effectively:

6.3. For further research

However, this study can be further extended to find out the impact on the cost of production with regard to PM wastage, to find out production vs. wastage by machines. Impact on inventory management of PM by wastage, impact on tea export supply chain by wastage.

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Appendix

Structure of the questionnaire-stage 1

University of Moratuwa
Faculty of Engineering
Department of Transport & Logistics Management

Research Topic

"Factors affecting Daily production wastage of tea bagging manufacturing"

Questionnaire 1

General information **mandatory ***

1) Name of the company*

2) Industry of your firm belongs to *

3) Export volume per year in terms of TEU'S*

4) Your position in the organizational hierarchy *

Manager
Executive
Supervisor
Assistant manager engineering
Machine Operators
Technicians
Packing assistant

5) Size of your organization *

0 - 4 employees
5 – 24 employees
25 - 199 employees
More than 200 employees

6) What is your experience in this field?

1 to 5 years
6 to 10 Years
11 to 20 Years

7) What is your functional area?*

Overall Production in charge
Supervisory
Engineering
Technical
Packing

8) What shift you are mostly allocated in a week*

Day

Night

Structure of the questionnaire -stage 2

Based on the type of tea that is used for daily production V 01

9) Black tea with liquid flavored generates low wastage*

Fully agree
Agree
Disagree
Neutral
Fully disagree

10) Black tea /Green tea with herbs will generate low wastage *

Fully agree
Agree
Disagree
Neutral
Fully disagree

Based on the type of tea bag type that is used for daily production V 02

11) Tea bag with Envelope will generate high wastage*

Fully agree
Agree
Disagree
Neutral
Fully disagree

12) Tea bag with String and tag will generate high wastage *

Fully agree
Agree
Disagree
Neutral
Fully disagree

Structure of the questionnaire -stage 3

Based on the type of filter paper that is used for daily production V 03

13) Do you think Ahlstrom materials generate low wastage *

Fully agree
Agree
Disagree
Neutral
Fully disagree

14) Do you think Glat Filter materials generate low wastage *

Fully agree
Agree
Disagree
Neutral
Fully disagree

Based on the frequency of changeover V 04

15) High frequency of machine changeover will generate high wastage amount in Tea bags /envelopes

Fully agree
Agree
Disagree
Neutral
Fully disagree

Based on the shift tea bags will be vary V 05

16) Which shift generates high wastage of tea bags?

Day

Night

17) Any other reasons that affect tea bags wastage if any please mention.

18) Do you thing current production method should be changed in order to mitigate the wastage

19) If any what type of method to be adopted

20) Do you think some of the old tea bagging machine should be replaced