

# Monographs on Tea Production In Ceylon

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ONE DAY COURSE IN TEA MANUFACTURE

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## FOREWORD

By

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Some of the best teas in the world are grown and made in Ceylon; but nobody can deny that some others are not of great merit. The properties of the leaf, as it is brought in from the field, set an upper limit to what can be made of it. Up to that limit, the methods and the exact details of manufacture can greatly influence the properties and price of the final product. The talks published here are intended to help in raising the standards of manufacture, so as to make the best of the leaf.

It is not possible to give a single set of precise quantitative rules for making tea; in the first place, the raw material varies from place to place and the best results to be aimed at vary—coloury teas from the low country and flavoury teas from the high country. In the same way, at one place the objective will vary with the seasons, which naturally affect the kind of leaf. Further, what it is possible to do also varies with the weather. Consequently there is plenty of room for individual judgment.

The danger of this situation is that too much emphasis might be placed on the artistry of tea making, to the neglect of facts which are scientifically known. Artists in tea making are known in Ceylon, but they are rare and they pass away. At their best, they are in great difficulties when new techniques are brought in. For most men, the accumulated knowledge of others is the only foundation on which to build.

Fortunately, we are not dependent for this knowledge on oral tradition alone. A great deal of detailed work has been done on scientific lines and it is often possible to forecast the results of changing the details of manufacture. That kind of knowledge can be put down on paper and has been published in Mr. Keegel's Monograph on "Tea Manufacture in Ceylon". In this we have an invaluable combination of fundamental biochemical and physical knowledge, results of empirical tests of a very practical sort, and wide experience of manufacture in Ceylon. The information provided in the present publication will, it is hoped, when the appetite for the more substantial fare in the Monograph.

In Ceylon we take a justifiable pride in the best teas made in the Island. But it would be dangerous to be complacent. Conditions are changing. In the middle 1960's it is probable that attractive instant teas will become freely available and conventional teas may have a difficult time. If production of tea were to rise too fast for consumption, the companies to survive might well be those that have both a low cost of production and a high quality product. Conditions in Ceylon are not so favourable to low-cost production as they are in parts of Africa and South America. But with the initial advantages of skill and good leaf from the field, Ceylon should get ahead and stay ahead in manufacture. The present publication is intended to help all factories now to reach the standards of the best. For the future, new techniques are being investigated, and for the more distant future, new biochemical knowledge, which is being sought, may revolutionise manufacture.

## PREFACE

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The papers in this publication were delivered to Teamakers in the various planting districts of Ceylon, and were specially selected to cover in the course of a day as much as possible the basic theory of manufacture, its practical aspects and common problems. The subject of thermometry and hygrometry was included because of its importance and the emphasis now being placed on the control of temperature and humidity in the various processes. The talks were not intended to teach people how to make tea but to assist them in getting a better understanding of tea manufacture.

Much enthusiasm was shown at these meetings, as indicated by the very large number of questions that were asked and the discussions which followed. These questions and the answers that were given would no doubt be of interest to the beginner or even the more advanced student of tea manufacture. They are therefore included in the hope that they will be helpful to the reader when he is confronted with any particular problem.

I should like to take this opportunity of mentioning the important contribution made by Mr. Victor Ratnayake, Chairman of the Planters' Association of Ceylon. It was he who initiated these courses and he showed his personal interest by his presence at some meetings. Dr. D. L. Gunn in his capacity as Director, T.R.I., also assisted in a generous measure by his encouragement and advice. Officials of the Planters' Association, Chairmen and Secretaries of district associations similarly accorded their co-operation and assistance, and to all these gentlemen I express my grateful thanks.

Finally, I have great pleasure in offering my special thanks to the members of my Division who shared with me the conducting of these courses. I extend my cordial thanks to Messrs. L. S. Weragoda, A. H. R. Balthazaar, and W. C. A. de Silva for their contribution and assistance, without which, the success achieved at these meetings would not have been attained.

E. L. KEEGEL.

March, 1963.

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## CHAPTER 1

### THE THEORY OF TEA MANUFACTURE

E. L. Keege

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Over the past many years we have acquired a vast amount of information on the manufacture of tea. What I propose to tell you is nothing new, but I hope that by giving you a clear picture of the fundamentals, it will help you to deepen your understanding of tea manufacture. By coming to know, for example, what causes the conversion of the raw green leaf to a palatable product and the factors on which it depends, you would no doubt learn to recognise some of the defects in manufacture and how best to rectify them.

Orthodox manufacture has been with us long enough to know some of the pitfalls to be avoided. We know for instance that overheating of the leaf at any stage of its manufacture is detrimental. We also know that by lengthening the fermentation we improve colour, that long withers bring about the same effect and so on. I need not repeat many other obvious facts which are known from long experience, trial and error methods and practical observations. But just as much as there are many well-known facts about manufacture, there exist countless theories, many of which are groundless, some based on hearsay and others contrary to the scientific knowledge we have on the subject.

There are some who are too ready to believe anything. If they hear of a certain technique, new to them, which has apparently given good results, it is copied straightaway without rhyme or reason. They do not consider for a moment their own manufacturing conditions, the type of leaf on their own particular estates, or the type of equipment they use, and then wonder why they get different results.

Then there are others who make deductions from investigations carried out at random. Comparisons of methods may be done, some probably on the same day, some on different days and wrong conclusions drawn. Statements about the effect of any such modification in manufacture mean precisely nothing if more than one variable is involved.

It is therefore not at all surprising that many theories concerning manufacture exist giving rise to misunderstandings and confusion. This unfortunate state of affairs is due in no small measure to ignorance of the chemical constituents of the leaf and the manner in which they are changed in the processing of tea. Without some knowledge of the chemical changes which occur, you could never be sure of the result from the adoption of any particular method or understand what produces a certain effect.

We do not pretend to know all the constituents which go to make up the taste of tea. Investigations on the chemical composition of the flush have not advanced far enough to correlate the content of any particular chemical constituent with any particular character of the tea. It must be some time before chemists would be able to make an accurate assessment of this matter, but we do know that the principal constituents of tea leaf which concern us most are a group of soluble substances,

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which can be referred to as oxidizable matter or tea catechins. They are colourless, have an astringent bitter taste and account for some 20% of the dry matter in tea leaf. They very largely contribute to the three main characteristics of tea, namely, colour, strength and quality.

For black tea to be produced these catechins (or oxidizable matter) have to be oxidized or 'fermented' as the process is generally referred to, and for this to take place they depend on natural ferments in the tea leaf called enzymes. These are present in very minute quantities but possess remarkable powers. They are distributed throughout the leaf tissue and stalk but are separated from the oxidizable matter. For oxidization to take place they must come in contact with the oxidizable matter in the presence of air.

Now the activity of this enzyme is closely related to temperature, being very slow in action at temperatures below 60°F, most active between 80 and 90°F, and rapidly destroyed at high temperatures. It plays a most important part in tea manufacture, which is generally not recognized. There appears to be nothing more to the essential principles of tea manufacture than the exposure of the cells of the tea leaf to the action of air and enzymes.

Without going deeper into the chemical aspects of tea manufacture, we need not concern ourselves at present with anything more abstruse than catechins and enzymes. To put it simply, the taste of tea will not only depend on the amount of these constituents originally present in the leaf but also on the extent to which these constituents are changed in the process of manufacture.

All our analytical work has shown that the bud and the first leaf are the richest in catechins. The second leaf is not far behind but the third and the older leaves are deficient—so is the stalk below the second leaf. On the other hand, the stalk has the most enzyme and the bud and the first leaf come next. Coarse leaf has very little enzyme. Though the stalk has this favourable advantage over the leaf, yet it does not make a good tea because of its lower catechin content. It should also be remembered that there is considerable variation in the chemical composition and enzyme activity in the leaf from season to season and even at different altitudes. However, rate of fermentation depends on the enzyme content of the leaf and it has been found that these two are closely related—the higher the enzyme content the faster the rate of fermentation.

Since the fundamental objective in the manufacture of black tea is to express the cell contents of the leaf and oxidize them, we must naturally take all the precautions necessary to rupture the maximum amount of leaf cells under conditions favourable to the maximum activity of the enzymes. If these points are borne in mind to start with, you know at least the correct direction which has to be followed.

**Withering:**—The first question you might naturally ask is why wither leaf and what bearing has this on the final product. One very important reason is that our rollers are not designed for unwithered leaf. The second reason is that the teas, because of trade requirements, must possess some semblance of twist. So withering whether we like it or not, is indispensable for the manufacture of black tea so long as we have to continue to satisfy the trade.

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Much has been spoken of a chemical wither, that a word or two about it may not be out of place. Chemically it is almost certain that some constituents which affect quality are converted into other compounds, as evidenced by the deterioration of quality as the wither is prolonged. The amount of catechins is not changed however. But the point to remember is that, whatever chemical changes take place, they do not make for improved quality—in fact they lead to a fall in quality. The longer the period of withering the greater the loss also of such desirable properties as brightness and briskness of a liquor.

We have also evidence to show that this fall in quality is accompanied by an improvement in colour. So to talk of adjusting the physical wither to coincide with a chemical wither in order to make the best tea is sheer nonsense. The simple fact is that you adjust your period of wither according to the type of tea you wish to get.

In attempting to shorten a wither with a view to retaining some of the desirable properties of a tea, there is always the danger of employing too high a temperature. To keep the temperature of the leaf as low as possible one fundamental requirement is rapid evaporation. If this is slowed down the temperature of the leaf approaches that of the dry bulb. This is not serious if the dry bulb happens to be low, but if it exceeds 90°F it would have an adverse effect. It is therefore obvious that if forced withering, as it is called, is to be adopted to make the best of the leaf, large volumes of air and reasonably low temperatures are necessary. It would of course be pointless to consider the acceleration of a wither at high elevations at certain times of the year when there is little inherent quality in the leaf.

As for the degree of wither, controversy exists on the relative merits of soft and hard withers. The reason for this is that we have been unable to obtain a correlation between any particular wither and quality, because of the many factors involved. The number of possible permutations and combinations of modifications in rolling and fermentation, apart from variation in thickness of spread, period and conditions of withering, is so very large that it is a task of some magnitude to investigate the question thoroughly. For instance you may get the same results from soft and hard withers if you shorten the fermentation in one case and lengthen it in the other, or do lighter rolling in the former and harder rolling for the latter. Then again, if no proper humidification methods are available a soft wither would give better results than a hard wither. Where ambient temperatures are low hard withers would be preferable and so on. The number of variables is almost infinite. It is our opinion that a fairly wide range in the degree of wither is permissible in tea manufacture.

**Rolling**—When we come to rolling, the ideal approach of course would appear to be to prevent the leaf from being fermented till the mechanical functions of bruising the leaf (rupturing the cells) are completed. In the alternative the leaf could be so drastically treated that fermentation in the whole mass of the leaf starts immediately. These conditions unfortunately cannot be achieved in the conventional roller and we have to put up with a state of affairs where the leaf is fermenting at one temperature in the rollers and at another on the fermenting racks. Apart from this undesirable feature we also have the situation where the rupturing of the cells has to be a gradual process. If we attempt to rupture all the leaf cells, say in a single roll, the appearance of the tea

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will suffer. On the other hand if we try to maintain a very satisfactory appearance, the duration of the rolling has to be prolonged. So we strike a balance in rolling.

Thus your total period of rolling is mainly determined by the extent to which you are able to extract the juices from the leaf in relation to the standard of appearance of the made tea. The total duration of rolling may be one hour, two, or three hours with any number of rolls or any rolling period you may wish. It is ridiculous, to say the least, that a 30 minute roll gives the best results. It is just one of those things accepted by convention without the slightest scientific reason for it.

Because of variations in leaf, wither, rolling equipment and ambient conditions there cannot be such a thing as a normal rolling period. For example, if your wither is hard you naturally require harder rolling than with a soft wither and the harder the rolling you employ the shorter the duration of rolling required. It is indisputable that for quality the shorter the duration of rolling the better, provided that you are able to extract the juices of the leaf without undue development of heat. This simple yardstick is not infallible because you may think you are getting the required rupturing of leaf by the dhool outturn obtained, whereas it may be brought about by a shearing action, which is no different from that which cuts the leaf. So to get the best rolling your dhool must come from a wringing action, and if you have the right battens and the right cone excessive pressure is not required.

The employment of heavy pressure leads to a rise in temperature, but we cannot let it go too high because of its adverse effect on quality and on the activity of the enzymes. At the same time we do not want the leaf to remain too long in the rollers. The greater the quantity of leaf that has to remain for a longer time in the rollers the softer the liquor. So the more dhool you obtain initially the better for quality, but if colour is of more importance you keep the bulk of the leaf longer in the rollers by extracting less dhool. The somewhat popular system of continuous rolling is just a question of giving your leaf more rolling to improve colour without the necessity of using more rollers. But you lose some quality in so doing.

Now, however carefully rolling is carried out it is too much to expect that all the cells in the dhool you obtain have been ruptured or all the juice extracted. Whilst some cells may be ruptured without any expression of juice, some proportion of the dhool may be coated with juice from other parts of the flush. It is quite impossible to say exactly what happens, but it is indisputable that the smaller the size of the dhool the greater the extraction of the juices, provided of course, that the leaf has not been broken up too quickly. Therefore, obviously roll-breaker mesh should be as small as possible. You cannot naturally make all your dhool very small in size because of rolling and firing difficulties. A reliable guide is to make it the size of a B.O.P. grade when fired, by suitable adjustments in mesh, length of tray and rate of feeding.

Many tea-makers still fail to recognize the importance of the roll-breaker in tea manufacture. The method of using it has a significant effect on the characteristics of a tea, far more than most people think. Do not look upon the machine as merely one on which you depend for obtaining a certain percentage outturn of dhool but rather on the size of the dhool. The size of dhool not only governs the degree of rolling but the rate of fermentation.

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**Fermentation:**—We cannot separate rolling from fermentation—they are both directly tied together. I have already indicated something of the mechanism by which the main constituents of green leaf are converted into the coloured compounds which we drink. Release of the tea juices causes the enzymes to act on the catechins, forming desirable reddish yellow soluble compounds. The fermentation process does not end there. A non-enzymic action also takes place. These soluble compounds are converted into other darker coloured compounds, not as bright as the compounds brought about by enzymic oxidation. The former are now referred to as thearubigins and the latter theaflavins. From the information to date theaflavins contribute to quality, strength and some colour and the thearubigins primarily colour. The higher the temperature the more rapid the formation of thearubigins and less the quality. The longer leaf is fermented similar is the effect. If the conversion goes too far some of these coloured substances turn dull, and brown in colour and become insoluble resulting in lack of briskness and strength. Theoretically therefore, if we wish to ensure quality, we must have the maximum of the substances formed by enzymic oxidation and the minimum of non-enzymic changes. A good tea should have the right combination of the theaflavins and the coloury thearubigins. If the fermentation process is allowed to go on indefinitely, all the theaflavins are lost. They go not only to thearubigins but to even some other compounds, which are not useful for good tea.

In practice it is not possible to prevent non-enzymic fermentation because in the first place the fermentation period has to be sufficiently long enough to allow the enzymes to complete their work, and secondly we are unable to extract the juices without the development of heat. In order therefore to minimize any undesirable changes we should not retard the rate of enzymic fermentation in the rollers, by depriving the leaf of air or raising its temperature unduly. The means within our disposal are:—

1. small roller charges;
2. good circulation of leaf under pressure;
3. cooling the rolling room

That is to say, you stimulate the fermentation by quick liberation of juices and providing suitable temperature conditions for the enzymes to act on the juices in the shortest possible time. Delay in doing this or overheating the leaf means that you will be encouraging the formation of thearubigins at a greater rate than desirable for quality.

It has been found that sufficient air is held up in rolled leaf and possibly in the air spaces of leaf structure for a nearly normal oxidation of tea catechins to take place. This explains why there is very little difference in the fermentation between the top and bottom layers of leaf spread for fermenting. But if sufficient air is not initially provided in the rolling process a thick spread would be detrimental because then you will only be assisting the conversion of theaflavins to thearubigins.

We have not sufficient data as yet to give any conclusive answer to the temperature and period of fermentation. It would appear from the evidence available to date that the question of temperature of fermentation is not one, on which any dogmatic statement could be made, because it is not only closely connected with the conditions of rolling but also with those of fermenting. At the same time we should remember that

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the term 'fermentation' is rather vague—a tea, for example, which has had its optimum fermentation from the quality standpoint would probably with regard to colour not be sufficiently fermented. Then again a low temperature is favourable for quality, whereas a high temperature promotes the development of colour.

With so many complex factors in the fermentation process all that we can say is that temperatures above 90°F would not appear to be favourable for the fermentation process for general requirements. In many up-country factories it is possible with a carefully regulated programme to keep leaf temperatures below the maximum limit. But in low and mid-country factories, even with the best humidifying system, it would not be possible for the greater part of the year to obtain these conditions, for the simple reason that the rise in temperature of the leaf in a roller may be as high as 25° above the temperature of the room. So if temperatures are to be kept as low as possible, I would repeat the advice I gave earlier, namely, small roller charges and good circulation of leaf under pressure.

It is pointless at this stage in trying to theorise how period of fermentation should be adjusted in relation to temperature. Investigation of the problem in relation to practical conditions is one of the most complex that can be undertaken in tea manufacture because of the temperature variations a whole batch of leaf is subject to before it is fired. Furthermore, standards of fermentation differ, and coupled with this is the fact that different parts of the flush have different enzymic activity and a different catechin content. That is not all,—an additional complication is the fact that each batch of leaf rolled in the conventional manner comprises 3 or 4 or more different dhools extracted under entirely different conditions.

Rough and ready indexes of fermentation today are the taste of the tea and its colour. The most that a tea-maker can do in the circumstances therefore is to adjust his period of fermentation according to these factors. But to get the desired objective it is not merely a question of just shortening or lengthening the fermentation of a whole batch of leaf. Each dhool has to be considered individually from the point of view of its contribution to the main selling grades in relation to its outturn and characteristic features. For example if your 1st dhool outturn is a mere 10%, it would be the height of folly to increase its duration of fermentation in order to improve the colour of a B.O.P. grade, which is say 70% of the crop. Again if the dhool outturn from your first two rolls exceeds 50%, practically all of which goes to a B.O.P. you would surely be doing the wrong thing in paying more attention to the 3rd and 4th dhools. I hope you see what I mean. Your order of firing the dhools must therefore take into consideration your method of rolling. Remember that if you roll four times there are twenty-four possible combinations. If you carry out five rolls, there are one hundred and twenty ways of firing your dhools.

I now come to the colour of the infusion (infused leaf). If your infusion happens to be greenish there is very little you can do about it. The colour of the infusion has no relation to liquor, but the brightness of the infusion generally has. We have reason to believe that the same conditions which affect the brightness or dullness of a liquor affect the brightness and dullness of an infusion. It is rare to get a dull infusion associated with a bright liquor or *vice versa* except in some clones. So

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if you want to keep your infusions bright keep temperatures as low as possible. Dullness of an infusion is not entirely caused by high temperatures. Bacterial action is another contributory factor. Therefore see that your fermenting surfaces are clean.

The foregoing points, broadly speaking, cover the main changes that we must concern ourselves with if we are to understand what goes on in the leaf till it is ready for firing. Temperature, period of firing and moisture content of fired teas are no longer matters of controversy. They will be discussed, however, in the papers that are to follow.

I trust that this paper will assist you in changing some of the opinions you may have on the manufacture of tea, and that by applying the theoretical knowledge we have on the subject you would no doubt be better equipped to improve on the methods you have been accustomed to carry out.

## CHAPTER 2

### THE PRACTICE OF TEA MANUFACTURE

A. H. R. Balthazaar

The process of black tea manufacture may appear simple to a casual observer, but a closer investigation will reveal the numerous factors that influence the ultimate product. It is quite impossible to deal with every aspect of such a wide subject in a talk of this length, so I shall confine myself to the fundamentals.

**Withering:**—Before proceeding further, I should like to refer to the distinction between natural and artificial withering.

In an artificial wither, "conditioned" air is passed over the leaf for withering; in a natural wither, the air passed over the leaf is taken from outside the factory and not heated. Quite contrary to the belief held by some, withering carried out with outside air and with the aid of fans is also natural withering. Natural withering carried out in this manner, has the following advantages:—

1. it would be easier to wither leaf to a pre-determined time,
2. the leaf could be more evenly withered and also to a pre-determined moisture content, and
3. a continuous steady flow of air could be maintained, avoiding gusts of wind or stagnation of air, as when natural withering is carried out with windows open.

Leaf arriving at the factory should be weighed quickly and spread evenly, at pre-planned rates on the tats. If the leaf is wet, the lofts should be warmed before spreading it, in order to get rid of surface moisture as fast as possible. The spreading of leaf should be carried out in the direction opposite to the flow of air, a precaution often overlooked.

Whether leaf is fresh or withered it must be remembered that it is still living; it takes up oxygen for its respiration, and this is accompanied by evolution of carbon-dioxide and heat. The heat evolved must be dissipated by adequate circulation of air, the absence of which would lead to a rise in temperature of the leaf and harm the quality of the final product. Hot-house conditions in a loft should be avoided at all costs. A prevalent notion is that unless conditions are very warm-withering is delayed. It would be bad enough to wither leaf under such conditions but matters are made still worse when windows are closed as soon as the fans are stopped.

Apart from the care needed in ventilating a loft in order to promote free evaporation of moisture from the leaf the temperatures employed for withering should take into account the state of the leaf. When leaf is very wet, no harm would result from the employment of high temperatures, but as withering proceeds the leaf becomes a partly dry body and tends to increase in temperature. Higher temperatures should therefore be strictly avoided towards the end of the process. This

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means that though there may be a certain latitude in the temperature to be employed in the initial stages, it would not at all be advisable to use heated air to complete the wither. It is far better to complete it by natural means provided that by doing so the period of wither is not unduly lengthened.

**Rolling:**—The operation of charging a roller can be considered to begin with the knocking down of withered leaf from the tats. The sifting of withered leaf over a No. 4 mesh roll-breaker (in the loft) and accurately weighing it prior to charging a roller, is a very good practice.

Steady feeding of leaf into a roller, for which a reasonable period of time should be given, is very essential. Initially, the withered leaf may be fed fast into a roller, but towards the later stages, it should be charged slowly. Otherwise, circulation is restricted and leaf has to be forced into the machine. The process of rolling thus has a bad beginning which it may not be possible to rectify till the start of the second roll.

Application of pressure and pressure regulation must always be carried out not only with the purpose of obtaining a desired percentage of dhool but also to squeeze the juice out of the leaf, and in doing so impart a twist. It has to be applied judiciously after considering the type of wither and the requirements of the ultimate product. Tearing of the leaf in the early rolls before the leaf gets twisted and before the juice is squeezed out has a detrimental effect on both appearance and liquor. Since the application of pressure causes a rise in temperature of the leaf it should be controlled. Temperatures of over 90°F should be avoided as far as possible.

An important but somewhat neglected point is that pressure should not be applied as soon as charging is completed. If the pressure cap is lowered too soon, caking results and circulation is impeded.

Apart from allowing some time between completion of charging and application of pressure, it is advisable to let down the pressure cap gently. If this simple precaution is neglected the leaf may get so badly caked as to cause an undue rise in temperature. A part of the leaf will also remain unrolled till the pressure is released.

Rolling without the application of pressure is only useful for extraction of tip, but for appearance and liquor some pressure is required. The application of pressure will of course raise the temperature of the leaf which can be checked by release of pressure. When deciding on appropriate periods of pressure it is essential to realise that the harder the pressure the more frequent is it necessary to raise the pressure cap. If charges are high heavy pressure could lead to excessive temperatures and restriction of circulation. Power consumption also goes up.

The importance of appearance and tip in a low-country tea necessitates lighter rolling of the leaf. Therefore the application of pressure must be done with the utmost care. Little or no pressure in the early rolls facilitates the extraction of the maximum amount of tip. However, no useful purpose will be served in continuing with hardly any pressure with the intention of getting whole tips. The value of tip depends not only on its length but also on its colour. To impart the much desired golden colour in tip, sufficient juice has to be extracted from the leaf,

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by the use of pressure and good circulation, and then deposited on the minute hairs. Therefore, if tip is lacking in colour one reason causing it could be the lack of pressure.

“Twist” too needs some degree of pressure if it is to be considered tight. Therefore, after the extraction of tip the next consideration should be to twist and wring out the juice gradually, with a view to improving the appearance and liquor of the tea. Pressure should be increased gradually and the leaf rolled as long as economical working will allow. There is no hard and fast rule of course for the number of times leaf should be rolled or for how long. Leaf could be rolled from 3 to even 6 times and the duration of a roll could also vary, but 30 minutes is found to be convenient. There is no reason whatsoever why you should not roll for 15 minutes or even 40 minutes. The decision should be governed by the facilities available and the elevation of the factory.

In passing, I wish to mention a few matters about rolling which may be overlooked:—

1. Appearance and tip as needed by low-country standards, can best be obtained by short periods of rolling and by increasing the number of rolls. Tip in a high grown tea is of no value. Liquoring properties are sacrificed if too much attention is paid to conserving it.
2. A poor fermenter may well benefit by more rolling—but in the early rolls prolonged rolling ruins tip. If tip is not of importance, continuous rolling is one of the means of improving the teas from leaf with poor fermenting properties.
3. Leaf with an outturn of 38 to 52% outturn made tea to withered leaf is rollable, provided the wither is perfectly even. Where any doubts exist about the degree of wither to be arrived at, you cannot go wrong by taking a medium wither of about 45% outturn of made tea to withered leaf. There are exceptions of course such as conservation of tip and accentuation of colour, otherwise a full wither is always desirable. Whatever the wither, two fundamental rules are, that in dealing with hard withered leaf you employ more pressure in rolling, and that soft withered leaf should be treated more gently.
4. Optimum roller speeds are:—

Single acting—35–40 r.p.m.

Double acting—40–45 r.p.m.

Higher speeds are permissible only if the cranks are too small or the rollers overcharged. However, fast roller speeds are detrimental to tip and appearance.

5. A roller with severe battens if used in the early rolls results in choppy, flaky, poorly-twisted teas with a light liquor.
6. The degree of twist in big bulk is a means of judging the extent of rolling.

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7. The preservation of quality in high-grown tea is aided by the shortest charging interval possible.

**Roll-breaking**—The process of roll-breaking seems to be the most crude and neglected operation in manufacture, and unfortunately receives the least attention as a rule.

The main object of roll-breaking is to remove the smaller particles of rolled leaf, which if left in the roller for too long a time would result in their over-fermentation and interfere with the circulation of leaf in the roller. The other primary object is to cool the bulk. To carry out these two objects satisfactorily it is therefore necessary to see that the dhool obtained is of the right size and that the process is not delayed. At the same time, overcooling of the dhool should also be avoided as it would tend to retard its fermentation.

The factors which affect the size of dhool, are mesh size and its condition, speed of vibration, slope and length of tray, and method of feeding. It will thus be seen that considerable care and attention are needed to make a success of the roll-breaking operation.

A combination of two mesh sizes with the smaller much at the delivery end is the most modern recommendation for high-grown leaf. This gives an efficient sifting with even dhool production. Too long a tray, slow feeding, a slow speed, incorrect amplitude and slope, and sweeping back of leaf on the mesh, result in uneven dhools. Nos. 5 and 6 would meet most requirements.

Leafy grades such as low-country B.O.P's and pekoes require a large mesh size—so does the extraction of tip. But, the size of the mesh has its limitations, for if it is too large, unrolled leaf could pass through. On the other hand, if it is too small, it could restrict the extraction of tip.

No. 4 mesh meets the average requirements of most low-country factories for the early dhools. For the later dhools which are smaller in size, due to more rolling and breaking up—the same No. 4 roll-breaker mesh would not prove to be so satisfactory. No. 5 or a combination of Nos. 4 and 5 would be preferable.

It is worth while to mention that it is disadvantageous in low-country manufacture to aim at very even dhools from the early rolls. The "kambi" or "kappy" fraction of a dhool, the main component of the F.B.O.P. grade, would be lost. Quite contrary to up-country techniques a larger mesh at the delivery end of a roll-breaker would in some cases turn out to be satisfactory provided under-rolled leaf is not removed.

The bulk unloaded from a roller should be brought as soon as possible for roll-breaking, to avoid it being subject to excessive heat when kept heaped on the floor, or in trolleys, or in basins. A steady feed of leaf on to the roll-breaker is essential. Ball-breakers in a feed hopper are an advantage, and contrary to popular belief do not untwist the leaf.

The duration of roll-breaking depends on the width of the tray and the rate of feeding. Every machine has a definite capacity. Therefore, it is important to see that the time allowed for roll-breaking is related to the capacity of the machine and the amount of leaf handled.

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Double roll-breaking of dhool is an operation to be avoided as much as possible in the case of high grown teas as it takes much more time and may even slow down fermentation. As a temporary measure to overcome some difficulty, however, it may be done. Double roll-breaking of the bulk is recommended for early rolls only for the extraction of tip and is therefore only suitable for the low-country.

**Fermentation:**—This starts as soon as rolling commences and is not confined only to the period during which the leaf lies on the fermenting racks. It really commences from the time the cells are bruised in the rollers. Even if all precautions are taken it is an impossible task to maintain the leaf in a roller at a constant temperature. Moreover an operation other than rolling, such as roll-breaking also alters the temperature of the leaf. Thus it will be seen that not only is there a difference in temperature of the different dhools but each dhool itself is subject to a variable temperature during the whole course of its fermentation. Besides these factors, room temperature varies from factory to factory and so does the thickness of spreading of the dhool. It is therefore quite impossible to specify any particular period of fermentation that can be universally adopted.

Though a high humidity is desirable for fermentation but not absolutely essential, the more important consideration is the temperature of the leaf itself. It would seem absurd after cooling leaf in the process of roll-breaking, sometimes beyond the lowest temperature suitable for satisfactory fermentation, to cool it further on the fermenting racks. Practices such as turning over dhools, spreading a wet cloth and adding water should be avoided. If surface drying is to be minimized a thicker spread is the answer.

The most important contribution that humidification makes is the lowering of the room temperature. Whatever humidifying system is used, there should be proper air circulation to get the maximum cooling effect. If ventilation is poor, the cooling effect would not be very marked because of the heat generated by machines, workmen and so on. It is necessary therefore to check wet bulb temperatures inside and outside the room. If the wet bulb temperature of the room is much higher than that outside, it indicates insufficient ventilation.

**Firing:**—The essential role of tea drying is to arrest the fermentation and to produce a tea with good keeping qualities. Fermentation is arrested by subjecting the dhool as it enters the drier to a sufficiently high temperature so that the enzymes responsible for fermentation are inactivated. Once the enzymes are inactivated the moisture is evaporated gradually until a tea with good keeping properties is obtained.

Of primary importance in firing, is the matching of the intake of the drier to the output of the rolling room. If this is not done, there will be either an accumulation of dhool, resulting in over-fermentation, or the drier will be loaded with under-fermented leaf. Yet another possibility is for the drier to run empty.

The manner in which tea is fired plays an important part in the preservation of quality and flavour. The main object should be to strike a mean between the preservation of quality and the keeping properties of tea. This is achieved by firing at an inlet temperature of

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190°–195°F and with an exhaust temperature of 120°–130°F. Under these conditions of firing, the moisture content of the tea discharged from a drier is between 2 and 3%.

A drier is taken too much for granted. It should not be forgotten that driers, however modern some may be, are not faultless. Any irregularities in temperature and spreading should not be ignored. An occasional check on the functioning of spreaders is well worthwhile. Another point that should receive close attention is the cleaning of the previous day's tea left on the drier trays. All that is required to be done is to brush off the leaf attached to the tray perforations by running the drier empty for a few minutes before loading. How many factories take the trouble to do this? It is not realized that air flow is impeded when tray perforations are permanently blocked with tea particles.

**Grading:**—The main characteristics of a low-country tea, by which its value is judged are tip, and appearance. Therefore, when grading, efforts must be made to preserve these features.

To produce a good low-country tea, a high standard of leaf is obviously required. Flakiness is caused by old tough banji and a poor wither. One general rule is that each dhool should be treated on its own merits and any special feature in it conserved. The amount of tip or 'reds' should be governing factors before mixing dhools, and it might even be found preferable to sift each dhool separately. Stalky dhools should be picked before cutting, and big bulk should also be winnowed and picked before sorting. It is of utmost importance in grading to extract "true" grades conforming strictly to market requirements.

With regard to grading of high grown teas a point of controversy is whether it is preferable to make more fannings than B.O.P. or *vice versa*. It should be realised by now that the increase in outturn of a particular grade often results in the deterioration of the grade itself. On the other hand, its outturn can be increased with an accompanying improvement in its liquoring properties at the expense of another grade. In the case of the B.O.P. and B.O.P.F. grades any of these two effects is possible, depending on the methods employed. For example, if the fannings grade outturn is increased by excessive cutting of the made tea no improvement can be expected. But if the result is obtained by more rolling, the B.O.P. suffers, and the fannings grade improves. So one must be particularly careful in drawing a conclusion from the price difference of the B.O.P. and B.O.P.F. grades. The only rational way therefore of knowing whether a higher percentage of B.O.P. or a higher percentage of B.O.P.F. is more profitable, is to compare the average price of both grades obtained from one treatment with that from another, and not rely entirely on the difference in value between the two grades.

The work carried out in the sifting room requires ventilation and cleanliness. Unless the weather is dry it is not advisable to keep the windows of this room open. The necessary ventilation is provided by keeping open the door leading to the firing room.

One important point to be noted is that, if the withering fans are working too, they may tend to draw in wet outside air through the sifting room. This could be avoided by having a plentiful supply of air for the fans.

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**Packing:**—Final firing is a practice that does go on even today to a certain extent, but could be easily avoided by proper attention to the teas after they have left the driers. The condition of the bins too plays an important part, and if not lined and fairly air-tight, they could cause high moistures in tea. The moisture content of teas should not exceed 5% at the time of packing.

## CHAPTER 3.

### THERMOMETRY AND HYGROMETRY

W. C. A. de Silva

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Tea manufacture is essentially a chemical process, by which the naturally occurring substances in the tea leaf are made to undergo certain changes in order that the final product possesses most, if not all, of the desirable characteristics of a good tea. In any chemical process many variables must be either continually controlled or measured.

Temperature and humidity of the air are two of the important variables that are encountered in the manufacture of tea. Therefore for the success of tea manufacture, these two variables must be properly controlled; and as such there should be a proper understanding of the principles of thermometry and hygrometry.

The idea of warmth or heat is derived from our sense perception and the term *temperature* was introduced to express the degree of hotness of a body. The physiological sensation of hotness and coldness is an experience common to us all. But unfortunately our hand is not a reliable indicator of temperature. Moreover, the human hand is not sufficiently sensitive to detect small changes in temperature; neither is it capable of withstanding extremes of temperature.

In order to fulfil these purposes, thermometers and temperature scales have been devised to make possible the precise quantitative measurement of temperatures as contrasted with its qualitative and subjective classification. In these, use is made of some property which varies continuously with temperature. For most practical purposes we take as our scale, the scale depending on the position of the top of a thread of mercury in a glass tube. Its position is observed at freezing point and again at the boiling point of pure water, at *standard atmospheric pressure*. In the Fahrenheit scale, which is used for most practical purposes, the temperature of melting ice is taken as 32°F and that of boiling water at standard atmospheric pressure of 212°F. These are called the fixed points. The distance between the fixed points is then divided into 180 parts, each being one Fahrenheit degree.

The boiling point of pure water varies with atmospheric pressure, and as pressure varies with altitude, it necessarily follows that the boiling point will be different at different altitudes. For our purpose it is sufficient to remember that the boiling point decreases with increase of elevation. The boiling point of water at sea level will be 212°F, the standard value. At an elevation of 2,100 feet it will be about 208°F, while at 4,225 feet it will be 204°F. This variation of boiling point with elevation has an important bearing on the firing temperatures adopted in factories at different elevations.

It must be stressed once again that whenever we require the temperature of some substance or body, we should never rely on our sense perception. A thermometer must be used for its measurement, and it must be used correctly. That is to say, any error due to parallax must be avoided. This can be best done by keeping the line joining the eye to the top of the mercury thread at right angles to the stem of the instrument.

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It must also not be forgotten that a thermometer registers its own temperature and therefore in using it to determine the temperature of any substance it must be brought into intimate contact with that substance and must be left there a sufficient length of time to acquire its temperature.

A word or two about the method of finding out whether a thermometer registers the correct reading, I am sure, may be useful to most of you. The only instrument that is required for this purpose is an accurate standard thermometer, and all you have to know beforehand is the boiling point of pure water at the elevation of your factory. This boiling point could be found from Monograph No. 4 (Tea Manufacture in Ceylon).

If the temperature range of the thermometer under investigation permits it to be immersed in boiling water it is fairly simple to test the accuracy by noting the temperature recorded in pure boiling water, and then comparing the reading with that of the standard boiling point at that elevation. The standard thermometer too could be checked in this manner.

Even if the temperature range of a thermometer does not permit it to be immersed in boiling water, the accuracy could be checked by comparing the reading given with that of the standard thermometer. For this purpose, the thermometer under observation and the standard thermometer should be placed in cold water and the temperature gradually raised. If the temperatures recorded by the two as the water is warmed are more or less the same, then the thermometer under test could be taken as accurate. This could be confirmed again by noting the readings, as the water is cooled. It is important that while these observations are being made the water be continuously stirred.

**Hygrometry** is concerned with the properties of water vapour and the measurement of moisture content in air. Therefore before we study the principles of hygrometry, it is necessary to have at least an elementary knowledge of the properties of vapours.

When a liquid such as water evaporates it is said to enter the gaseous or vapour state. The amount and rate of evaporation will depend mainly on three factors:

1. the amount of moisture already present in air;
2. the volume of air; and
3. the temperature of air.

Evaporation will not continue indefinitely because at any given temperature a certain volume of air can hold only a certain amount of water. When this stage is reached the air is said to be saturated. When the water vapour content in air is less than the maximum it can hold, the air is said to be unsaturated. It is also known that when the temperature is increased, the capacity of air to take up moisture increases. In other words the maximum amount of water vapour air can hold at a higher temperature is greater than the maximum it can hold at a lower temperature. On the other hand, if the temperature is lowered sufficiently, a stage will be reached when condensation takes place in the form of dew.

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Another interesting phenomenon accompanied by evaporation is that of cooling. This can be demonstrated quite simply, by drawing a current of air through a volatile liquid such as heater contained in a metal vessel. As evaporation proceeds there will be a drop in temperature and even condensation of water vapour in the form of dew will take place on the outer surface of the metal container.

Water like any other liquid tends to evaporate and atmospheric air always contains some water vapour. The air may be saturated or unsaturated depending on the prevailing conditions. The actual quantity of vapour present is rarely equal to the maximum the air can hold, and our ideas concerning the condition of the atmosphere with reference to its moisture content, are often fallacious if they are formed without actual measurement. It is only by comparing the masses of vapour present in a definite volume of air under various circumstances that the true facts can be ascertained. Instruments used for this purpose are called *hygrometers*, while the ratio

$$\frac{\text{Weight of water vapour present in any volume of air}}{\text{Weight of water vapour required to saturate the same volume at the same temperature}}$$

is called the *dampness ratio* or *Relative Humidity (R.H.)* and is usually expressed as a percentage. Another related quantity in connection with the moisture content of air is its *Absolute Humidity*. This refers to the actual weight of water (or moisture) present in a certain volume of air.

**Relative Humidity** is a measure of the degree of saturation. 100% R.H. shows that air cannot absorb any more moisture at the particular temperature, while 0% R.H. indicates that air is completely free of moisture and is dry. If the R.H. is 75%, it shows that the air contains only 75% of the maximum amount of water vapour it can hold, and that it could absorb another 25% of maximum before it is saturated. Similarly 90% R.H. means that air contains 90% of the maximum amount of water at the temperature, and so on.

Both Relative and Absolute humidities can be determined by a number of different instruments. The simplest and the one generally used is the Mason's *wet and dry bulb hygrometer*. This instrument consists of two identical thermometers arranged on a stand; one is exposed to the air (dry bulb) and the bulb of the other (wet bulb) is covered with thin muslin that is kept moist by dipping its lower end into a small vessel of water.

The hygrometer depends on the principle that water takes up heat when it vapourises. In this way if the wet bulb is exposed to an atmosphere that is not saturated with water vapour, then water will evaporate from the surface of the muslin which in turn will result in the recording of a temperature lower than the temperature of air. The drier the air, more rapidly will evaporation take place from the wet bulb and lower will be its temperature. In other words a bigger difference between dry bulb and wet bulb temperatures means air is drier than otherwise. By reading the two temperatures an estimate may be made of the hygrometric state, if reference is made to psychrometric tables.

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To obtain results with minimum error the following points should be borne in mind:—

1. Instrument must be clean.
2. Water reservoir should be filled with rain or distilled water and should be sufficiently full so as to allow the wick to dip freely.
3. The muslin must be kept in a good condition and renewed or washed at frequent intervals.
4. Hygrometer should be freely exposed to the atmosphere and never boxed in. It should never be exposed to direct sunlight.
5. In reading a hygrometer, the eye should be placed level with the top of the mercury in the tube and the reading must be taken as quickly as possible.

Let us now consider how best we could use thermometers and hygrometers in tea manufacture and in controlling the processes.

**Withering:**—This is brought about by the evaporation of water from the leaf. As evaporation proceeds changes take place continuously both in the condition of the leaf and in the condition of the air. The more important of the two is the condition of the leaf.

If evaporation is to take place from a body the vapour pressure of the surrounding atmosphere must be less than the vapour pressure of the body. Evaporation becomes more difficult as the body becomes drier since the vapour pressure of the body decreases. So to bring about evaporation, the vapour pressure of the atmosphere has also to be decreased the drier the body becomes, and this can be achieved by raising the temperature of the air.

For an artificial or natural wither heat is necessary for evaporation of moisture trapped inside the leaf. This requires quite a large amount of heat, and to obtain a proper wither heat must be applied continuously either by artificial means or natural means during the whole process.

This is often supplied by means of hot air from the driers or atmosphere; but if the ambient air is rather dry, it can be used—it will, of course, lose heat.

The evaporative capacity of air depends on

1. its temperature,
2. its hygrometric difference, and
3. its volume and the speed at which it travels.

Though the drying capacity of air increases with temperature, the volume and speed if increased can be equally effective.

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At the commencement of the withering process evaporation of moisture is comparatively rapid and green leaf behaves as a wet body. Because of this the temperature of the leaf will be about the same as the wet bulb temperature. As withering proceeds the vapour pressure of the leaf decreases. A direct result of this is that evaporation becomes more and more difficult and at the same time the temperature of the leaf increases above the wet bulb temperature. That is to say the leaf merges from a wet body to a drier body. It follows therefore that if the temperature of the leaf is to be kept low, both wet and dry bulb temperature of air used should be gradually lowered as evaporation proceeds. The lowering of wet and dry bulb temperatures however will reduce the efficiency of air as a drying agent, so we have to counterbaiance it by providing sufficient air to enable the process to be completed in a reasonable time. This is one reason why it is preferable to use heated air at the beginning of the process than in the later stages. The other reason is that it helps the rapid removal of surface moisture, presence of which might cause bacteria to produce dull infusions and soft liquors.

We are all aware that high temperatures are detrimental to quality, but the critical temperature above which quality is impaired depends mainly on two factors, namely, the period for which the temperature is maintained and the wet bulb temperature. The advice therefore that can be given in the present state of our knowledge is to keep the temperature as low as possible and at the same time to have a sufficient hygrometric difference. It is generally advisable to keep the temperature below 80°F.

It is a common belief that air which shows a hygrometric difference of about 7°F is best suited for withering purposes; and when it falls below this value it is thought that air conditioning in some way is necessary. This is a completely false notion. There is no hard and fast rule about the optimum hygrometric difference, because what is really necessary is air with the required evaporative capacity, which depends on two other factors. The optimum hygrometric difference is closely related to both the dry bulb temperature and the volume of air. If there is a good supply of air, (which in turn depends on fan capacity) it is possible to get a good wither without prolonging it, even when the hygrometric difference is as low as 4°F. Should the hygrometric difference be below 4°F, the air needs conditioning. On the other hand, if the air supply is deficient, hygrometric differences up to 10°F might be necessary. It must not also be forgotten that bigger hygrometric differences after air is heated can only be obtained when both the wet and dry bulb temperatures are high. If the air is too dry, (that is when the hygrometric difference goes above 10°F) it may result in the drying out of the youngest leaves thus preventing any fermentative changes in the roller. A high temperature has the same effect. Thus high hygrometric differences as well as high temperatures, both cause unevenness in the wither. However, at certain times of the year big hygrometric differences are obtained in the atmospheric air, but though dry bulb temperatures may not be low, the wet bulb temperature is so low that it has no adverse effect on quality, though some unevenness in the wither is inevitable. So in withering one must not only consider the dry bulb temperature, but the wet bulb temperature as well.

Whenever natural conditions are not suitable, recourse is made to artificial methods of withering. The warm air from the driers is bulked

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with cold outside air to obtain the required evaporative capacity. The temperature of mixture depends on

1. the temperature of hot air,
2. the temperature of cold air, and
3. the proportions in which they are mixed.

For example, if hot air at 160°F is mixed with cold air at 60°F in the proportion of 1 to 10 the resulting dry bulb temperature will be approximately equal to  $1 \times 160 + 10 \times 60$

$$\frac{\quad}{10 + 1} = 69^\circ\text{F.}$$

Thus bulked air at various temperatures can be obtained by merely altering the proportion in which air is bulked and the temperature to which it is heated. The calculation of the wet bulb temperature is much more difficult. But it is useful to remember that the wet bulb temperature rises by about 1°F for every 3° to 4°F rise in the dry bulb temperature, if the drier is not being used for firing tea when the air is bulked. If the drier is used for firing tea, a rise of 2°F or more occurs for 3 to 4°F rise in the dry bulb temperature.

**Rolling and Fermentation:**—Rolling is that process by which the withered leaf acquires a twist, which after firing results in a black twisted appearance. In acquiring the twist the cells in the tea leaf are bruised and the juice brought into contact with the air. This initiates the enzymic oxidation of tea juices, popularly known as fermentation. Thus it is seen that fermentation really starts inside the rollers.

Of all the external factors influencing the fermenting process in tea manufacture temperature is undoubtedly one of the most important, because enzymic activity is influenced by temperature. Temperature changes do occur both in the rolling and roll-breaking operations. Therefore in discussing the effect of temperature on fermentation, the processes of rolling and roll-breaking must not be ignored.

It is a common concept, that heat is detrimental to quality. This is entirely a wrong idea. On the contrary heat is very essential for the development of quality and other tea characteristics. It is excessively high temperatures that are bad.

According to biochemical studies, the optimum enzymic activity occurs at around 81°F. It does not follow however that at this temperature the characteristics of a tea are at their optimum. From experimental data we have reason to believe that even at a temperature of about 90°F favourable characters are developed. At low temperatures below 60°F the enzyme is rather slow in action, while at temperatures higher than 90°F rapid oxidation can produce undesirable characteristics. Any temperature above 120°F destroys almost all the enzymes and arrests fermentation.

It is an experience common to us all, that heat is generated during the rolling process. This heat is partly due to the evolution of heat accompanied by the oxidation of tea juices and partly due to the friction between the roller charge and table. Under normal working conditions

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the rise in temperature inside a roller is seldom less than 10°F and a rise of about 15 to 20°F is not unusual. Even a 30°F rise sometimes occur; but this should be regarded as excessive. In any case, the aim should be to produce temperatures in the range of 80 to 90°F inside the rollers.

Mechanical production of heat and consequent rise in temperature depend on:

1. the type of wither,
2. the roller charge, and
3. the method and period of pressure application.

Rolling of overwithered leaf brings about an undue development of heat, partly because of the low moisture content and partly because of the heavy pressure required for its rolling.

Increase of roller charge and increase of the amount of pressure applied also tends to raise the temperature. This is specially so, during the later rolls. The best that can be done is to avoid overcharging of rollers, and to use longer periods of pressure for early rolls and shorter periods of pressure for later rolls.

Since roll-breaking and fermenting of dhool on the racks alter the leaf temperature considerably, an ideal temperature in the various processes is not of any practical importance. It would be far more useful to know what temperature is harmful and the period for which its influence is most marked. Experiments aimed at finding an answer to this important question have given us the following tentative results:

1. For quality and flavour, temperatures greater than 90°F must be avoided.
2. About and below 70°F, fermentation is slow and the period has to be extended to obtain colour. Quality is not unduly sacrificed in achieving this objective, but a decline in flavour occurs.
3. Strength is not appreciably affected by temperature.
4. Though high temperatures may reduce greenness there are indications that when this character is intrinsically present in the leaf it is accentuated by high temperatures of over 90°F for periods of  $\frac{1}{2}$  hour or more.
5. Temperatures greater than 95°F are inadvisable even for a short duration during rolling.
6. Temperatures in the range 80 to 90°F are not harmful to quality provided the overall period of fermentation at these temperatures does not exceed 2 hours.
7. During the flavoury season, temperatures of 80 to 90°F are permissible. Lower temperatures are however preferable.
8. During off quality seasons, high temperatures in rolling are advantageous but temperatures greater than 90°F are not recommended.

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When high temperatures are met with in the rolling and fermenting rooms it is advisable to install some arrangement by means of which the room temperature may be maintained around 70°F. The most efficient way of obtaining these conditions is by the use of mist chambers. This artificial humidification is generally obtained by forcing water under pressure through a narrow orifice in such a way as to obtain an almost invisible fine spray of water. If this water is to be vapourised rapidly the spray should be very fine and must expose as large a surface as possible. The heat required for the vapourisation is obtained from the surrounding atmosphere, which in turn produces a cooling effect—the limit being the wet bulb temperature of the outside air.

In addition to the cooling effect, humidification helps to produce a more even fermentation, since it prevents surface drying. It also reduces the loss of moisture from leaf being rolled. But humidification should not be overdone to cause deposition of moisture in the room.

Finally it must be noted that when humidification is resorted to, the rolling and fermenting rooms must be opened up at the end of the day's work. This helps to dry the floors and walls and also sweeten the room. If this is not done it is very difficult to prevent the growth of moulds and the possible development of taints in the teas.

**Firing:**—The best temperature for the initial and partial inactivation of enzymes, with no detrimental effect to the final product is found to be in the region of 140°F. This condition is satisfied when the exhaust temperature in a drier is in the range of 120 to 130°F. In order to get this temperature above the leaf on the top tray, the temperature below the top tray must not be less than 140°F. The temperature of the leaf should then increase steadily through the machine. If the exhaust temperature is much over 125°F rapid drying will cause moisture to be trapped in the leaf and though the moisture content of the discharged tea may be satisfactory such teas will have poor keeping properties. In any case it is wasteful of heat. On the other hand, if it is much lower than 125°F, flat teas will be obtained, as a result of stewing. This is because under the moist hot conditions at the top of a drier fermentation can proceed at a very rapid rate.

Tea can be fired at temperatures ranging from 160 to 210°F without much detriment to its properties provided the period of drying, load of leaf and volume of air are so adjusted that the tea discharged has the correct moisture content of 2-3%. Temperatures above 190-195°F have however an adverse effect on quality, flavour and pungency. Therefore firing temperatures above 190-195°F are not recommended. Firing at low temperatures of about 160°F results in the production of teas of better quality than firing at 190°F, but they lack keeping quality even when thoroughly dried and carefully stored. For this reason the practice of firing at temperatures much below 190°F is also not recommended. Firing at 190-195°F gives the best all round results though a lower temperature but above 180°F could be employed with advantage during the height of the flavoury season.

The optimum temperatures in the firing process in the light of experimental evidence are: a firing temperature of 185-195°F and exhaust temperature of 120-130°F.

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However in the low-country, because of the higher boiling point of water, a higher firing temperature may be adopted. There is no harm done even if the firing temperature is 200°F.

**Absorption of moisture by made tea:**—Fired tea is hygroscopic in nature and absorbs moisture very rapidly even if exposed to ordinary air. Absorption of moisture cannot be prevented completely. Absorption is inevitable during cooling of leaf immediately after firing, grading and packing. But the utmost care should be exercised to prevent excessive absorption and tea should be packed with a moisture content not exceeding 5% though the safe limit is 6%. Tea containing more than this moisture will not keep well and should be subjected to a final firing.

Tea like any other hygroscopic substance has its own vapour pressure and the absorption of moisture is governed by this factor. (I have referred to this earlier in my talk). If the vapour pressure of the surrounding atmosphere is more than the vapour pressure of tea there will be absorption and if the former is less there will be a loss of moisture. When the vapour pressure of the air is equal to that of the tea there will be no absorption or loss of moisture. In other words the tea will then be in a state of equilibrium. This condition is satisfied when the relative humidity of the surrounding atmosphere is 60 to 65% and this would certainly be the ideal relative humidity to have in a sifting room. If the relative humidity is not much above 60 to 65%, moisture absorption will be little and grading can even be held up for two days. However, if it is higher than 70-80%, tea should be sifted and stored within 24 hours in order to prevent absorption as much as possible. If the relative humidity is less than 55% the tea loses moisture. This too must be avoided. It is not desirable to put on the market a tea with too low a moisture content, since it is uneconomic to do so.

Maintaining a sifting room at the correct relative humidity is very important in order to prevent undue moisture absorption or loss. It should be damp proof as possible and it should be capable of being kept dry by drawing warm air from the firing room.

Table 1 gives you an idea of the approximate differences that should exist between dry and wet bulb temperatures for various dry bulb temperature ranges and for relative humidities of 60-65% and 70-80% respectively.

TABLE 1

Dry bulb temperature	Difference required for 60-65% R.H.	Difference required for 70-80% R.H.
65-69°F	7- 8°F	4-6°F
70-74°F	8- 9°F	4-7°F
75-79°F	8-10°F	4-7°F
80-84°F	9-10°F	5-8°F

## FACTORY ORGANIZATION

E. L. Keegel

Despite mechanisation and a certain amount of scientific control in tea-making, a greater part of the processing still depends to a great extent on personal judgment, particularly in withering and sifting. There are no scientific methods which could, for instance, precisely reveal when leaf is correctly withered or assist in the grading of teas. In the matter of rolling too, some judgment is required, but when it comes to a question of co-ordinating one process with another the matter does not become a question of decision but one in which the best and most economical use is made of power, labour, fuel and equipment. This in its simplest terms is organization.

Factory organization is not merely a question of keeping your driers fully loaded or the collection of a vast amount of figures. There is much more to it than that. In the first place, it is an orderly arrangement of different operations. From the introduction of such a system, you prepare the ground for eliminating wasted effort and thus be in a better position to increase "through-put" with a smaller labour force. Think of the unnecessary movements of labourers which could be eliminated by placing every piece of equipment in its proper place. By scrutinising every detail that goes to make up an operation, much can be done in increasing the output per operative. What is more, you will succeed in improving the performance of each worker, without in any way adding to the demands made on him either in time or effort.

Not least an aspect of organization, is your rolling programme. By standardising times for rolling and roll-breaking in such a way that you could use one roll-breaker less, for instance, you could dispense with 2 operatives. This might seem trivial but multiply it by 300 and what do you get—a saving of 600 labourers per annum. At the present time when the margin of profit is so small, every little saving counts.

Apart from these considerations, the real essence of proper organization is a system of control which ensures consistent results day after day. One essential requirement in any industry is consistency in the manufactured product. This applies to tea as well. We have no control of course over variations caused by seasonal factors but that is no reason why we should not standardise manufacture. By putting manufacture on an organised footing we would at least bring our teas to a more uniform level than would be possible in a badly disorganised factory.

It should also be remembered that standardization of a product is one step forward in establishing a name on the market and once that has been achieved a well organised factory would experience no difficulty in attempting to improve those characteristics of a tea which would command a premium. Where organisation is lacking, the achievement of such an objective would have to rely on hit and miss methods, involving waste of time and energy. Organisation on the other hand would assist you in reaching this goal by a shorter route in a precise and reliable way and with a better understanding of the factors which bring about a particular result.

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Essential requirements for proper organisation are of course adequate withering accommodation and machinery to deal with large crops. It does not follow, however, that if a factory is short of these requirements manufacture cannot be planned to make the best use of the equipment. It is true that a factory that is under equipped cannot run efficiently and economically but with a little effort we could organise the work in such a factory to raise the standard of the teas produced.

To plan manufacture on organised lines the first thing to do is to determine the intake of your drier. This is the starting point. As you very well know, the capacity of a drier varies with the degree of wither, but after a few days observations you will soon come to know how much fermented leaf the drier could handle for the particular wither you are aiming at. With this figure as a basis you then decide the charge you must employ and the charging interval required to keep your drier continuously loaded with leaf.

It is quite impossible in a short paper of this nature to deal in detail with the various points concerning a rolling programme. Many pitfalls would be encountered in drawing up one and it is only by painstaking efforts that you would be able to overcome major obstacles such as:—

1. Overcharging of rollers or insufficient leaf for later rolls.
2. Clashing of roll-breaker times.
3. Insufficient time for charging rollers or for roll-breaking.
4. Leaf not available for the driers.
5. Using more equipment than what is necessary.

**Batch Charges:**—One rather important point, which most people overlook when designing a programme, is the necessity for allowing sufficient latitude for varying the batch charges. Occasions do frequently arise when the withers are not what they should be and if there is no margin for adjustment either in the driers or in the rollers fermentation periods are bound to be upset. For example, if the wither is too soft and the same initial charges are maintained firing would be delayed. In a long working day, the difference in fermentation between the first and last batches could be very considerable. If on the other hand the wither happens to be hard, and the driers are continuously fed with leaf, you would then find that the fermentation period gets considerably shortened towards the end of the day. Most of you would have gone through such an experience a number of times.

If you attempt to solve the problem by altering the charging interval, disorganisation will result. Some tea-makers would increase firing temperatures; whilst others would shorten the duration of firing when they find the driers running behind time or overload the driers. If firing is going ahead of schedule because of hard withers, thinner spreading would be resorted to, or the driers run at a slower speed. As a last resort you would even have to allow the driers to run empty between batches. Such practices could only lead to erratic firing which is one thing you should avoid at all costs.

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Accordingly, it would be advisable when planning a rolling programme to consider beforehand the possible variations in wither and choose a charge for a particular charging interval, which could be adjusted when the necessity arises without overtaxing rollers or upsetting the sequence in rolling. If the drier is not normally operated at its maximum capacity, you will have an additional means of meeting any such contingencies. I do not say that every factory could be able to arrange manufacture on these lines, but equipment permitting, every avenue should be explored to attain this objective.

In view of the important bearing the capacity of a drier has on factory organisation, it is useful to know how it is related to the degree of wither. For every 1% variation in the percentage outturn of made tea to withered leaf, the output of a drier varies by about 4% and its intake by approximately 2%. We are mainly interested in the latter figure because on this depends the amount of leaf the drier could handle in a stipulated time. That is to say, if your wither for any particular batch varies by only 5% from the wither you normally aim at, an adjustment of 10% of the initial charge is required for the drier to run to schedule. It is rare to expect variations of more than 5% in the wither in a factory which is well run. So in order not to upset fermentation times the weight of a patch of leaf for normal requirements should be such that  $\pm 10\%$  adjustment could be made whenever required without a change in the rolling programme.

One other great advantage of being able to vary the charge is that should you decide to alter your fermentation period at any time of the day because of changes in temperature, you could do so quite easily by reducing or increasing the charge without disturbing the general running of the factory. Full control over fermentation is thus possible in a factory where the rolling equipment permits latitude for varying roller charges. Rigid adherence to a fixed charge is therefore not a very good thing when one takes into account the variations in wither normally experienced. But the charging interval should of course be fixed, whatever the circumstances, because any change in the interval in the course of a day's manufacture would most certainly throw the work in the rolling room into utter confusion.

**Planning:**—Other matters concerning factory organisation, which have to be watched are:—

1. A regular supply of leaf to the rollers. Careful planning in the withering lofts would enable the rate of stripping leaf from the tats to coincide with the rate at which the rollers could accommodate it. A weight of leaf knocked down much in excess of requirements is bad practice and not good for quality since the damage caused to the leaf brings about pre-fermentation. You yourselves know how badly discoloured leaf becomes after it has been knocked down and kept for any length of time. If the leaf is kept in heaps, further deterioration takes place because heat is developed.
2. Another bad practice is the habit of initially charging too many rollers at the same time. Some tea-makers go the whole hog by charging all the rollers when they commence work, in the illusory belief that by doing so, the day's work could be quickened. They forget the simple fact that the length of a working

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day is entirely governed by drier capacity. Charging more leaf in this manner quite obviously would result in overfermentation of subsequent batches. When things get too bad another drier is brought into operation. Surely, you will agree with me, such a state of affairs is not conducive to making the best of the leaf.

3. Delays in roll-breaking. Valuable time is lost by a stupid practice of not starting the roll-breaking operation till every particle of leaf is removed from a roller. Time is precious in a rolling room and every minute of the period allowed for roll-breaking must be usefully employed. Roll-breaking should be started as soon as a roller is discharged and the roller cleaned while roll-breaking is going on. Failure to do this has often been the cause of a programme being found to be unworkable.

Now with regard to the planning of a rolling programme certain points have to be observed. They are:—

1. Rollers should not be idle for long periods. At the same time you do not want a set of circumstances in which you have to recharge a roller in the first rolls the moment it is discharged. Charging of withered leaf has to be carefully done and this takes time.
2. Use of roll-breakers and rollers with maximum efficiency. That is to say, you see that roll-breakers are available at the time each roller is discharged, and try to avoid using two roll-breakers when only one could do the job.
3. You do not tie yourself down to having 30 minute rolls and 10 minutes for roll-breaking. It is time we broke away from custom. Neither is it necessary that each roll should be of the same duration.
4. You do not lay too much stress on dhool outturns. So long as they are not excessive or not much below the recognised standards, there is nothing to worry about. The main thing is to see that a roller is not grossly overcharged.
5. You choose a charging interval not only according to rolling periods but in relation to the type of tea you wish to produce. For instance, if you wish to give the early dhools a very short period of fermentation because of say quality and flavour and at the same time require a little colour in the teas, a short interval may not be so advantageous as a long one since the later dhools may not receive the optimum fermentation. But if a normal period of fermentation is given to the early dhools, a long interval would result in over-fermentation of the others and would not be suitable unless colour is the primary consideration. To decide the issue therefore the question you have to answer is—what is the shortest fermentation that could be given to the dhool first to be fired and the longest fermentation to the dhool fed last to the drier?

From this over-all period you work out the charge required to keep your drier fully loaded. You then consider your rolling equipment and

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if it does not fit in with your calculations you make suitable adjustments in the charge and the charging interval to cover as near as possible the range of fermentation which you consider to be the best for your requirements.

This would be the ideal approach of course to setting about the preparation of a rolling programme, but I can assure you it is no simple task. In any case, to start with, the machinery is a governing factor and unless you have perfectly matched equipment your efforts to draw up such a programme would be wasted. However, there is no need to despair. From a large number of observations we find that for a charging interval of about an hour, fermentation periods of all dhools could be adjusted to meet normal requirements. An interval of 50 minutes has now come to be accepted as a standard, not because you can make a better tea than on say a programme with a 70 minute interval, but because it is the most convenient and economical interval for a 30 minute roll.

I should now like to deal with a few specific points concerning organisation. The first concerns a factory where rolling equipment does not match drier capacity. If roller capacity is inadequate it is far better to allow the drier to run empty between batches than attempt to keep it loaded by overcharging rollers. You could also possibly operate the drier with a reduced air flow. Where roller capacity is in excess and reducing charges or charging intervals is not possible a partial solution is to fire all the big-bulk at the end of the day.

**Roller Charges:**—These have a direct bearing on a rolling programme, since it is not only the initial charge which matters but subsequent charges as well. The initial charge should be so chosen that the rolls which follow could be properly carried out. It should not be assumed for instance, that a certain charge which might be considered to be the optimum for a particular roller for withered leaf would be suitable for a last roll. The reason for this is that in the last rolls the tougher portion of the flush is being dealt with and a higher production of dhool is also required.

As dhool outturns are expressed as a percentage of the *initial charge*, figures for the 2nd and subsequent rolls do not really convey a true idea of the amount of rolling that takes place. In a last roll the actual outturn of dhool represents a considerable proportion of the charge from which it is obtained. For example, say we start with an initial charge of 500 lb. withered leaf, 40% of which is left for the last roll, *i.e.* 200 lb. If at maximum pressure we take out 30% dhool (namely 150 lb.) this is no less than 75% of the actual roller charge.

A roller like any machine is not capable of producing more dhool than what it is designed for. So to make my point clear, referring to the example I just quoted, suppose we had an initial charge of 750 lb. instead of 500 lb. and we are again left with 40% of this charge for the last roll. Instead of 200 lb. we would then have 300 lb. but we would still probably get only 150 lb. dhool. Thus instead of 10% B.B. in the first example we would be left with 150 lb. of B.B. or 20% of the initial charge.

I have given you this hypothetical case, not completely divorced from practice, just to show you the importance of not blindly accepting

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figures given for roller charges. When drawing up a programme, make it a point therefore to adjust your initial charges so that the rollers you use for later rolls are able to produce the dhool you require. It is quite evident from what I have just said that the larger the rollers used for such a purpose the more certain you are of getting the required amount of dhool.

**Use of 2 driers:**—A common practice when using 2 driers is to fire two different dhools at the same time. There is no objection to such a practice provided that you have some definite objective such as altering the period of fermentation of some particular dhool, and not for some flimsy reason that just because you have two driers of different capacities you may think it better to reserve one machine for say the first 3 dhools and the other for the 4th dhool and B.B. Such a system of firing may assist you in keeping the stalk away from the early dhool but unless you are able to get the correct proportion of dhools in relation to the size of the driers you end up the firing of each batch of leaf with odd amounts of different dhools. On the other hand, if you strictly reserve each drier for the dhools in question, you would either have to run the driers empty at certain times or be prepared to put up with variable periods of fermentation.

Careful consideration should be given to the method of firing dhools in two driers without upsetting not only the initial period of fermentation of each dhool but also its overall period. Let me make this clear by giving you a few examples.

Suppose we find that when using a single drier we get the best all-round results by firing at 3 hours and in the order 1, 2, 3, 4 B.B. Assume the respective percentage outturns are 10, 20, 30, 30 and 10. If you are on a 60 minute interval, the periods of fermentation would be as follows:—

1st dhool	—	3.00	—	3.06
2nd „	—	3.06	—	3.18
3rd „	—	3.18	—	3.36
4th „	—	3.36	—	4.00
and B.B.				

Now say you are still on a 60 minute interval but operating 2 driers, one of which matches the total outturn from the 1st and 2nd rolls and the other the total outturn from the remaining rolls. You decide to fire your teas according to the system I have just been discussing. The periods of fermentation would then be as under:—

1st dhool	—	3.00	—	3.20
2nd „	—	3.20	—	4.00
3rd „	—	3.00	—	3.26
4th „	—	3.26	—	4.00
and B.B.				

On comparing these with the previous set of figures, you will see that but for the last dhool, the variation in the fermentation of the other dhools is quite considerable.

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If the driers are of such a capacity that you can fire only the 4th dhool and B.B. in one machine and the first 3 dhools in the other, what do we get?

1st dhool	—	3.00	—	3.10
2nd „	—	3.10	—	3.30
3rd „	—	3.30	—	4.00
4th „	—	3.00	—	4.00
and B.B.				

In this case the 3rd and 4th dhools are most affected.

So if you are making a certain type of tea on a single drier programme you must obviously expect to get a tea with different characteristics if you fire different dhools at the same time. If the system enhances the price of your teas, well and good. Where any doubt exists, splitting each dhool between the two driers would give you the same results as using one drier.

Another matter that should be considered is the possibility of using the same rollers in the same order when operating either one drier or two driers. By making an adjustment in the charging interval and a small alteration in the initial charge, which would have no significant effect on the final product, it is sometimes feasible depending on the rolling equipment, to devise a programme for 2 driers that is fundamentally not different from that for one drier.

The use of different rollers at different times of the year, particularly in a factory where roller tables vary from one machine to another, would naturally give variable results. It is therefore most desirable to take some trouble over the planning of rolling programmes. Do not regard organisation as merely a question of matching the output of the rolling room with the intake of the driers; if it is to be of any value it must be related to the production of teas of uniform quality.

**Roll-Breaking:**—However carefully a programme may be drawn up, and however perfect it may appear on paper, more often than not it is not rigidly adhered to in practice, and it is common to find rolling periods shorter than what they should be or roll-breakers not available at the time they are needed. In most cases the cause is insufficient time for roll-breaking. The size of the roll-breaker in relation to the weight of leaf it has to handle is frequently ignored, and it is taken for granted that 10 minutes is all that is required. No account seems to be taken of the time taken to discharge a roller, the time taken to clean it, the time taken to carry the leaf from the roller to the roll-breaker, the time taken to recharge the roller and the time involved in cleaning the mesh in preparation for the bulk of leaf which follows. The result is that the roll-breaking operation is never satisfactorily carried out to begin with and if withers are soft mesh gets clogged since there is no spare time to clean it, and ultimately roll-breaking periods get delayed. So though you start off with a well organised programme you end up with disorganisation. In a large factory the results could be chaotic.

The key to a successful programme and satisfactory results is the time you allow for roll-breaking. Do not stint it. If you are one of those many tea-makers who double roll-break the dhools, then provide a separate machine for that purpose. If you do not have a spare machine

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it is far better to change the mesh or only take that portion of the dhool which is small in size. The fact that double roll-breaking is found necessary in most factories points to two undesirable features—too large a mesh and too long a tray. They are easily rectified.

One very common fault in double roll-breaking is to re-treat the whole of the dhool. What a waste of time? Half that dhool or probably more would be so large in size that its only destination is the roller—yet it would be put over a second time. Since time is such a vital factor in implementing a rolling programme, I need hardly emphasise, how important it is to scrutinise each and every operation that makes up the roll-breaking process. Unless you do this, rolling room organisation comes down merely to a set of figures chalked on a black-board which bear no relation to what is actually being done.

On the question of figures, of what use is it to indicate beforehand the time each batch should be fed to the drier when the actual times are not recorded. If a drier is being continuously fed with leaf it is impossible, because of variations in wither, to have the same period of fermentation for each batch. By putting such figures before hand you would be only encouraging the drier operative to either underload or overload the drier. One advantage in noting the actual times is that in a long working day the weights of later batches could be adjusted if found necessary—otherwise the risk of underfermentation or overfermentation is always present.

From this talk I hope you will come to recognise the usefulness of organisation. It's importance cannot be over-emphasised. It could be a deciding factor in the success or failure of tea manufacture.

## CHAPTER 5

### COMMON FAULTS IN TEA MANUFACTURE

L. S. Weragoda

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In spite of the publication of several books and articles on scientific tea manufacture, it is still not unusual to find very little attention being paid to detail in many factories, and also that the degree of supervision in each department of manufacture is rather poor.

In this paper, I propose to give you a summary of most of the faults in manufacture that I have observed during my visits to factories in the various planting districts. It is natural that I have to be rather brief in this paper, as it is not possible to enumerate everything we have observed, but I have concentrated on the more important aspects of manufacture.

**Damage to leaf:**—Quite often, before withering commences, leaf is damaged due to careless handling in transporting green leaf from the field to the factory. The main fault is the ramming of leaf into baskets or bags. This practice *does* very materially affect the finished product as fermentation commences the moment the leaf is crushed. It is essential that great care be taken in transporting the freshly plucked leaf, in loosely packed bags or baskets, to the factory. In those estates where the normal field weighing is carried out in the factory, the same fault occurs in transit to the lofts, sometimes even to a worse degree. Excessive damage to leaf not only adversely affects appearance but also liquor.

In some factories there is considerable delay in receiving green leaf from the field. Frequently, leaf is either piled up in the weighing sheds or packed in leaf bags and left lying in the field for considerable lengths of time. It must be realised that the quicker leaf is transferred from the fields to the factory, the better for production of a high grade tea. It is bad practice also to delay spreading.

**Withering:**—One difficulty in attaining the correct degree of wither is due to insufficient movement of air in a loft, caused usually by the fans being starved of air. A point to be remembered in this connection is that the area of the air exit must always be greater than that of the air intake or in any case, equal to each other.

Uneven withers, another fault in most factories, are partly due to uneven airflow in different sections of a loft caused by lack of sufficient openings in the bulking chamber or incorrect positioning of the doors or trap doors in the bulking chamber. It is rather difficult to correct. Sagging tats also contribute to this defect, and the obvious remedy in the first instance is to keep tats in a taut condition. In addition, spreading should be adjusted according to the distribution of air in each loft. You may have to spread thicker on some tats and thinner on others.

The degree of wither is one of the most important points to be remembered when considering a rolling programme for any factory. A wither should never be judged on figures alone. It is an accepted fact that when the outturn of made tea to withered leaf lies within the range of about 43% to 48%, leaf is in a suitable condition for rolling. It has

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been my experience to be told that such withers are obtained but to find on inspection that the withered leaf invariably consists of a mixture of under-withered leaf and badly over-withered leaf. Though the final figure for the degree of wither falls within the accepted range, the true nature of the wither is revealed only in the finished product. Evenness of wither is a fundamental requirement for successful manufacture and no efforts should be spared to achieve it.

**Rolling:**—In quite a number of factories overcharging of rollers takes place because of improper weighing of the withered leaf. Overcharging a roller results in lack of circulation and development of excessive heat in the roller, with a consequent deleterious effect on the properties of the tea. Before rolling commences it is essential that every charge be weighed accurately and the recommended charge should not be exceeded. In this connection another practice is the indiscriminate knocking down of withered leaf, irrespective of the quantity required for a charge. The balance withered leaf is then left piled up for the next charge. Apparently it is not realised that heat builds up in the mass of withered leaf resulting in a certain amount of the drying up of the leaf particularly of those portions which have been bruised.

More serious is the practice of deliberately overcharging rollers to match the capacity of a drier. This is a very shortsighted policy and should never be attempted. It is always preferable to allow the driers to run empty for a short time and keep the rollers charged to their normal capacity. This situation arises due to faulty planning and could be rectified with the installation of additional rolling equipment.

There is a popular misconception about the use of battens and cones fitted to pressure caps of rollers. These may have been of some use in early days, when rollers were not so efficient. There is positively no necessity for any fittings on a pressure cap now, as such fittings would only result in harmful effects on the leaf. With the research carried out in this field, it is now possible to recommend standard size cones for any roller. Incorrect central fittings are still being used, which, combined with heavy pressure, lead to caking of the leaf or throw-out.

Under no circumstances is there any justification for the practice of using an arbitrary figure of  $\frac{1}{4}$  pressure,  $\frac{1}{2}$  pressure,  $\frac{3}{4}$  pressure, etc. for succeeding rolls, as in this practice it is assumed that the pressure cap spring has a constant tension from the date of installation. This is not mechanically possible as the tension of any spring is a variable factor and is also affected by age and constant use. A factor to be noted is that the application of too heavy a pressure in the early rolls, results in poor circulation and tearing of the leaf.

A practice which on no account should be continued is to take a fixed amount of dhool to correspond to percentage outturns requested to be aimed at, and putting back surplus dhools for further rolling. This is a direct result of placing too much emphasis on figures, and the addition of small particles of leaf to a roller results in excessive throw-out or caking of the leaf. In addition, the surplus dhool is broken up in the extra rolling it receives and it may not be possible in the grading stage to include this fraction in the main grades. Dhool outturns are governed by several factors and these should be borne in mind when considering a rolling programme. If the leaf is tough, the outturn will be lower.

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If the wither is too soft, the outturn will drop due to clogging of the roll-breaker mesh, and if the charge is high, here again due to insufficient circulation the outturn will be low.

In those factories where continuous rolling of the bulk is done, if the quantity is too much, a certain portion of it is taken to represent about 10% of the initial charge and is treated as big bulk, irrespective of the fact that it requires further rolling. Here again, it is an arbitrary figure which is rigidly aimed at, no attention being paid to the condition of the rolled leaf. Such malpractices are mostly found in those factories where certain figures for dhool outturns are insisted on.

Some factories use fittings with too drastic an action in the erroneous belief that dhool production in a minimum period of time is the purpose of rolling. This practice results in the leaf being torn. A point to be noted is that the purpose of a batten fixed to a roller table is to increase the frictional effect. Hence wooden tables and battens would seem to be preferable to metal fittings if twist is the main consideration.

A fault which is on the increase today is that, with the idea of enlarging the capacity of a roller, jacket heights are being unduly raised. Very few seem to realise the importance of simultaneously fixing a longer spindle to the pressure cap. If this is not done under-rolling results as the spindle is too short to exert sufficient pressure.

**Roll-breaking:**—In very few factories is roll breaking carried out in a satisfactory manner. Some have a long roll-breaker tray which gives a very uneven dhool and to combat this drawback the dhool is resifted on the same machine. This results in delays to the rolling programme and the rolls are quite often shorter than what they should be. Others, apparently with the idea of obtaining more dhool, force dhool through the roll-breaker mesh, either by manual operation or with a brush. Such practice may be permissible where extraction of tip is the only consideration, but not in the later rolls.

Another fault I have come up against frequently is that caused by varying gauges of wire. Though the perforations per inch are of the right number, they vary in size and thus considerably affect the size of the dhool which passes through them. It is therefore very important to see that the correct gauge of wire is used when roll-breaker meshes are replaced. Failure to do this could lead to serious consequences.

**Fermentation:**—This varies from factory to factory and the correct period can only be determined by a series of trials. A common defect is that quite a number of teamakers bother unduly about correcting greenish infusions and risk liquoring properties at times in an attempt to obtain coppery infusions. At the expense of a bright liquor, longer periods of fermentation are persisted with and though the infused leaf improves in colour, a dull liquor is obtained.

A frequent cause of poor fermentation is excessive draughts on fermenting tables. This can easily be prevented by suitable adjustments to rolling room windows or humidifier fans. The firing order too governs fermentation, and if the principle is adopted of firing the early

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dhools first in the case of hard rolling and the later dhools first in the case of light rolling, very few mistakes are likely to occur. In all cases, 3 hours would be the maximum period of fermentation before any particular batch of dhool is first taken to the drier.

In this enlightened age, it is discouraging to see a few teamakers still spreading dhool on very wet floors or on unwashed fermenting racks. Apparently they yet do not realise that under these conditions bacterial action could cause taints.

**Firing:**—With regard to the operation of a drier it is a common practice to allow exhaust temperatures to rise or fall unduly. If it is not brought about by too many empty trays, it points to lack of supervision. Uneven firing is bound to result.

Too much reliance should however not be placed on the exhaust thermometer reading. It is possible that even though an ideal exhaust temperature is indicated it might be incorrect because of wrong positioning of the thermometer, uneven distribution of air or even a faulty thermometer. The correct place for the thermometer is at the centre of the exhaust duct. It is therefore essential to make frequent tests for moisture of samples of fired teas straight from the drier as this would be a better guide to firing than the exhaust temperature alone. A well fired tea should have a moisture content between 2 and 3%.

Though several publications on tea manufacture have mentioned that fired teas are hygroscopic, it is still the practice in several factories to leave fired teas exposed till the day's manufacture is over, before being boxed. In this connection I wish to stress that fired teas should be left to cool for a period not exceeding 30 minutes, after which they must be boxed and adequately covered. The value of efficient firing is lost if this precaution against excessive moisture absorption is not taken.

**Grading:**—One of the worst faults noticed in a grading room is the practice of passing good teas through a Tarry Nipper Breaker. In some factories even the cutter has been scrapped and all large dhools are put through the Tarry Nipper to produce more broken grades. It should be common knowledge by now that this machine is meant to work in conjunction with an Electrostatic Stalk Extractor for removal of the heavier stalk in inferior teas.

In several factories a complaint frequently made is that the off grade percentages are rather high. One of the contributory factors is the careless cleaning of the tats. A fair percentage of leaf left over from the previous day's green leaf would be dried the following day and when rolled would increase the off grade percentage. Careless picking is another cause, whilst extra winnowing, blunt cutter blades and damaged cells make a further contribution to off grades.

**Storage:**—Poor storage facilities are not so common as they used to be in the past. Yet the air-tightness of bins is worth checking and where any doubts exist the fitting of a metal lining might be considered. Bins should not be left unnecessarily open, but one still finds this being done.

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Finally, I wish to point out that practically all the faults in manufacture I have listed, could with more attention to detail and closer supervision, be eliminated.

Before I close, I may as well quote just one more instance of carelessness and lack of interest. You have just heard a talk on thermometry and hygrometry and its importance to manufacture. I have quite often seen wet bulb thermometers without water in the receptacles provided, wicks so dirty that water would not freely travel along them, and some with only a thread tied round the bulb. It is apparent, therefore, that these instruments are more for display than for actual use. Remember, gentlemen, that if you do not use these instruments as they are meant to be, your chances of producing high grade teas are very slender indeed.

WITHERING

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**Low-Country:**

1. *Question:*—Would it be correct to say that the quantity of tip is increased with a long wither?

*Answer:*—It is not exactly correct to associate quantity of tip with the period of wither because the former primarily depends on the number of buds and the amount of hair present on them. A short wither would produce just as much tip as a long wither provided the buds are not damaged or dried up as a result of using air at too high a temperature. In a long wither the risk of damaging the buds is considerably reduced since natural withering is resorted to. But at the same time a long wither if unduly prolonged could cause as much damage as heated air for short periods.

2. *Question:*—What is considered a normal period of wither?

*Answer:*—There is no such thing as a normal period of wither. What is normal for one estate may be abnormal for another, the reason being that two important characteristics such as colour and quality are influenced by the period of wither. The period of wither to be adopted will depend on which of these two characteristics greater emphasis is placed.

3. *Question:*—What would be the ideal thickness of spreading?

*Answer:*—It is difficult to answer this question since a lot will depend on the withering conditions prevailing, and also on the period of withering aimed at. Generally speaking, the thinner the spread the better.

4. *Question:*—What are the effects of thick spreading?

*Answer:*—One important effect of course is that the wither is slowed down. Another is the unevenness of the wither. There does not appear to be any specific advantage to be gained by spreading leaf thickly unless the intention is to delay the wither.

5. *Question:*—What are the causes of unpleasant odours from leaf withered for about 48 hours?

*Answer:*—These are brought about by some decomposition probably taking place in the leaf. They become more pronounced in a stagnant and hot atmosphere, particularly when loft windows are closed.

6. *Question:*—You say that the outturn of made tea to withered leaf should be about 40% for normal requirements. Could not the wither be harder and yet result in a good tea?

*Answer:*—It could. In fact the present trend seems to be to take harder withers, the reason being that silvery tip is at a premium.

## ONE DAY COURSE IN TEA MANUFACTURE

With soft withers tip is inclined to be golden. There is no reason why even with a harder wither it should not be possible to get the required degree of colour expected of a low-country tea.

7. *Question*:—What is the approximate rate of spread of green leaf for normal withering conditions?

*Answer*:—If by normal is meant an adequate volume of air, a spreading rate of 1 lb. of green leaf per 15 square-feet would be suitable.

8. *Question*:—What is the duration of wither for leaf spread on nylon tats?

*Answer*:—About 3 to 4 hours shorter than leaf spread on hessian, other conditions being equal.

9. *Question*:—Would nylon tat withered leaf produce a good tea?

*Answer*:—Of course it would, but if the volume of air is not sufficient for the amount of leaf spread on nylon the results would not be satisfactory.

10. *Question*:—If thick spreading is adopted, at what temperature should the leaf be withered? Also, which is better—a short period or a long one?

*Answer*:—For thick spreading a long period of wither is preferable at the lowest possible temperature.

11. *Question*:—What is considered to be the optimum difference between wet and dry bulb temperatures for withering?

*Answer*:—A difference of about 8°F.

12. *Question*:—Why is No. 4 mesh recommended for withered leaf sifting?

*Answer*:—Because the use of larger mesh might result in some leaf passing through. Smaller mesh, on the other hand, would not be effective in removing grit.

13. *Question*:—For the completion of a chemical change in withering, what is the period of wither under normal conditions?

*Answer*:—According to our ideas of the chemical changes occurring during withering, there is no period at which these are completed.

14. *Question*:—Is circulation of fresh air essential for withering?

*Answer*:—Yes, for two reasons. One is to accelerate the rate of evaporation of moisture from the leaf and the other to prevent it from going sour. Circulation of fresh air also helps to keep temperatures down.

## WITHERING

15. *Question*:—After withering is over and windows are opened, the leaf tends to absorb moisture. How can this be prevented?

*Answer*:—It is difficult to avoid this, particularly when the weather is wet or the air humid. But a little absorption of moisture, should it take place, is not something to worry about. Rather than close all windows to prevent moist-laden air from entering the lofts, it would be preferable to keep a few windows at least open.

16. *Question*:—As a result of such absorption of moisture would not the wither be uneven?

*Answer*:—No, since this is extraneous moisture which has no connection with the physical condition of the leaf. The absorption is confined to the surface of the leaf and the moisture would evaporate quickly once the temperature of the air rises. In any case, the amount of moisture involved is so small that it would not interfere with the rolling process.

17. *Question*:—Why is a 48 hour wither better than a short wither for the general appearance of a low-country tea?

*Answer*:—There is no direct experimental evidence on this point but a possible explanation is that if a short wither is adopted the leaf may not be sufficiently withered. On the other hand it could be unevenly withered should excessive heat be used to complete the wither in a short time.

18. *Question*:—What is the effect of using very dry air for withering?

*Answer*:—It will naturally result in very rapid evaporation of moisture from the leaf, and if not properly controlled will lead to uneven withers. Tender leaves and buds would dry up before the rest of the flush is withered.

19. *Question*:—What are the advantages of using nylon mesh for withering?

*Answer*:—The advantages are:—

- (i) More leaf can be spread on nylon than on hessian.
- (ii) For the same thickness of spread a shorter wither is obtained from nylon.
- (iii) More even withers.
- (iv) It is also expected to have a longer life than hessian.

20. *Question*:—Will there be an increase in labour costs by the use of nylon mesh?

*Answer*:—Slightly more labour will probably be required for knocking down of the leaf, but this will be more than offset by the greater amount of leaf handled. So in the long run it would be cheaper to use nylon than hessian.

21. *Question*:—When wet leaf is spread on nylon mesh would not the evaporative capacity of the air be reduced because of the inability of nylon to absorb surface water unlike hessian?

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*Answer:*—No. Whether water is absorbed or not the total amount of moisture that has to be removed is the same.

22. *Question:*—What about water dripping through the mesh? Would the wither on the bottom tats be adversely affected?

*Answer:*—No. Free water evaporates rapidly and any surplus collects on the floor. The effects of this phenomenon have been unduly exaggerated, and according to our observations are quite insignificant. (Note:—Several users of nylon at various meetings confirmed our observations).

23. *Question:*—Leaf is normally received three times a day, and arrives at the factory while firing is in progress. Since the exhaust air from the drier is not as dry as that from an empty drier what could be done in the circumstances?

*Answer:*—Bulk the air with the minimum amount of outside air (if wet). Nothing else can be done in the circumstances unless a spare drier is available, which could be specially lit up for providing more heat for withering.

24. *Question:*—Is it correct to add water to over-withered leaf?

*Answer:*—Yes, if the leaf is in such a condition that it would break up into flakes on rolling.

25. *Question:*—If windows are closed to control a long wither, is it detrimental to the wither?

*Answer:*—Such a procedure is sometimes found necessary for control, but although it may not be detrimental to the wither itself, it would have an adverse effect on the general characteristics of the liquor. Some ventilation is desirable. If the wither would be affected by keeping even a few windows open all the time, a partial solution is to dispel the stale air at suitable intervals by opening all the windows for a short time and then closing them. However, whenever possible it is advisable to keep a window or two open throughout the whole of the withering period.

26. *Question:*—What would you consider a good outturn of made tea to withered leaf to aim at for the low country?

*Answer:*—From 40—45% outturn of made tea to withered leaf, a softer wither possibly being preferred if golden tips are required and a harder wither for silvery tip.

### **Mid-Country:**

27. *Question:*—What would be a simple method of finding out whether withering fans are being starved of air?

*Answer:*—A very good indication is a noticeable rush of air through a window or door that is opened on the suction side of the fans while the fans are working.

## WITHERING

28. *Question*:—Thin spreading gives uneven withers with powerful modern fans. Is it correct to continue with spreads of 1 lb. of green leaf per 10 to 12 sq. feet?

*Answer*:—If it is not feasible to divert some of the air to other lofts or work with only a part of the bulking chambers open, it is perfectly in order to adopt the spreads referred to.

29. *Question*:—In order to remove surface moisture as quickly as possible a hygrometric difference of 9—10°F is considered necessary. What is the maximum difference permitted after the leaf is surface dry?

*Answer*:—Depending on the temperature to which the air is heated, the same hygrometric difference of 9—10°F is permissible for normal withering as well. Considering that under mid-country conditions the attaining of this hygrometric difference would necessitate raising the temperature of the air unduly, it would not be advisable to have a difference of more than 7°F.

30. *Question*:—What is the minimum hygrometric difference for good withering?

*Answer*:—The minimum difference is 4°F, provided an adequate volume of air is available.

31. *Question*:—What is the best position for a hygrometer in a loft?

*Answer*:—One position should be where the air enters the loft and another at the other end of the loft. The general practice is to place a hygrometer in the middle of a loft. This is wrong.

32. *Question*:—What should be the minimum distance between the central bulking chamber and the first bank of tats?

*Answer*:—The clearance should be 4 feet at least. If fans are so powerful as to blow leaf off the tats a bigger clearance is necessary.

33. *Question*:—Is a forced wither at a temperature of 82°F (dry) 70°F (wet) preferable to a 20 hour natural wither, if the leaf from the former is to be manufactured in the early hours of the morning and rolling of leaf from the latter carried out at the usual time of about 7 a.m.?

*Answer*:—From the quality standpoint the forced wither would be preferable since the period is much shorter than the other and the leaf is also rolled under cooler conditions. The natural wither could under the conditions stated be expected to produce more colour in the teas.

34. *Question*:—Is it harmful to take a wither harder than that corresponding to a figure of 45% outturn of made tea to withered leaf?

*Answer*:—Yes, it might be for the mid-country unless manufacture is carried out under cool conditions. Harder withers necessitate

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humidified rolling rooms if rolling is not done in the early hours of the morning. However, a lot will also depend on the roller capacity available. Some harm would result from taking hard withers if rollers are over-charged since the harder the wither the greater the rise in temperature of leaf in the rollers.

35. *Question*:—What is the best wither to take in the mid-country? Should it be the same for continuous rolling?

*Answer*:—It is quite impossible to specify any wither because of variations in leaf, rolling equipment and ambient conditions during manufacture. However, it would be safe to say that a medium wither (about 45% outturn of made tea to withered leaf) would meet general requirements. For continuous rolling a different degree of wither from that found satisfactory for orthodox rolling does not appear to be necessary.

36. *Question*:—Suppose with a drier temperature of 160°F and ground floor windows opened it is possible to get a hygrometric difference of 10°F in the lofts, will it be necessary to lower the drier temperature to obtain a smaller hygrometric difference?

*Answer*:—No, it will not be necessary. In any case it is not advisable to operate a drier at low temperatures because of the risk of condensation products affecting the furnace tubes. A simple expedient is to reduce the amount of heated air by means of the fan damper. If the fans are not working at their full capacity, more cold air could also be admitted either by opening more windows on the ground floor or the windows opposite the fans.

37. *Question*:—For the required supply of air to the fans which windows should be opened—those on the ground floor or those opposite the fans?

*Answer*:—There is no hard and fast rule with regard to this, but it would be preferable to have the ground floor windows open because some of the cold air would get mixed with the heated air before it enters the bulking chamber. One could therefore expect a better bulking of the air in the bulking chamber than would be possible by admitting cold air direct from the windows opposite the fans. However, if it is not feasible to provide all the air necessary for the fans from the ground floor, the windows opposite the fans should also be opened, the number depending on the temperature and volume of the heated air from the driers and the temperature of the warm air required.

38. *Question*:—As I have no proper winnower, the sifting room doors have to be kept fully open. This results in hot air being drawn from the firing room thus reducing the amount of hot air required for the withering fans and increasing my withering costs. What shall I do?

*Answer*:—In the circumstances there is nothing else that can be done, since any restriction of the air flow through the sifting room doors would adversely affect the winnowing process.

## WITHERING

39. *Question*.—To reduce costs it is customary to delay the wither of leaf plucked on Saturdays and manufacture it on Mondays. Is this a sound policy?

*Answer*.—Not generally so, the reason being that what is gained by reduced costs may not be offset by reduction in quality and a lower percentage outturn of made tea to green leaf. But if colour and strength of the liquor is the more important consideration, it may pay to hold back the wither.

40. *Question*.—What is the maximum period of withering for retaining quality, whether natural or artificial withering is employed?

*Answer*.—The maximum period would depend on the temperature employed, the higher the temperature the shorter the period. The exact relationship between temperature and period has not yet been definitely established. All that can be said is that the shorter the period the better the quality.

### Up-Country:

41. *Question*.—What are the advantages of sifting withered leaf before rolling? Would not this process result in damage to or loss of tip?

*Answer*.—The only advantage of the operation is that it removes stones, gravel and sand which find their way in leaf from the field and factory floor. They could cause damage to roller tables in particular and also cutters.

It is unlikely tip will be damaged but what goes through the mesh can easily be recovered.

42. *Question*.—Is it more profitable to manufacture Saturday's leaf on Sundays or Mondays?

*Answer*.—It may be profitable to delay the wither during periods when conditions are not conducive to the development of quality, such as those that exist during the S.W. Monsoon in Dimbula. But at other times it would not pay to do so because of the resultant loss in quality. Furthermore, there is the danger of overwithering the leaf. (See also answer to question No. 39).

43. *Question*.—Does a short period of wither help to preserve flavour and quality?

*Answer*.—Most certainly it does.

44. *Question*.—What should be the shortest period of wither during the dry weather when flavour is present?

*Answer*.—As short as possible and as soon as the leaf is in a condition for rolling.

45. *Question*.—What period and temperature are suitable for artificial withering?

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*Answer:*—No particular period or temperature can be recommended, because they are dependent on the volume of air available, amount of crop, type of tea required, etc. Whatever the circumstances, periods exceeding 24 hours and temperatures higher than 90°F do not appear to be suitable.

46. *Question:*—Is it advisable to apply heated air for a short period on the evening leaf, even though the earlier leaf has been withered naturally?

*Answer:*—Yes, unless it is desired to hold back the wither for some specific reason.

There appears to be a mistaken notion about the use of heated air in withering, and the impression still exists that better teas are made from natural withering than from artificial withering. It is time such an idea is dispelled. The abuse of hot air has more often than not led to such views on withering. Heated air, correctly used, need not result in the production of a tea inferior to that from natural withering.

47. *Question:*—Should the hygrometric difference increase or decrease while evaporation of moisture is taking place during the withering process?

*Answer:*—Quite obviously it should decrease because of the absorption of moisture by the air.

**NOTE:**—The interrogator, however, was not satisfied with the answer given because whereas Monograph No. 4 also clearly stated that a decrease should occur, he observed an increase and wished to know why. On enquiry it transpired that he was referring to observations made at a particular point in the loft over a period of time. This of course was easily explained by the fact that as withering proceeded there was less moisture evaporation from the leaf. However, if hygrometric differences were observed at two different points *at the same time*, the hygrometric difference would be smaller at the point further away from the other point in the direction of the air flow. It could not be greater. If the hygrometric difference showed no change it meant that no evaporation was taking place.

48. *Question:*—Is it really necessary that one must have a hygrometric difference of 7°F for withering?

*Answer:*—No. Leaf can be withered with smaller hygrometric differences if sufficient air is available and even with bigger hygrometric differences. Two possible dangers however in the case of the latter are—

- (i) uneven withers
- (ii) the risk of the temperatures being too high for the preservation of quality.

49. *Question:*—I get an outturn of about 61% (made tea to withered leaf) at certain times during the dry weather in Uva. Yet the leaf is in a rollable condition. How can this be explained?

## WITHERING

*Answer:*—The figure is certainly abnormal and is equivalent to only about 40% moisture in the leaf. Under normal conditions leaf with such a low moisture content would be partly dry. We cannot give a satisfactory explanation.

50. *Question:*—Shorter withers are preferable for quality. Does this apply to teas in wet weather too?

*Answer:*—Yes. Even in wet weather there is some quality in the leaf.

51. *Question:*—In withering, how does air speed, distribution and volume of air affect the wither?

*Answer:*—Air speed by its relation to the rate of removal of moisture from the leaf; distribution of air by its effect on evenness of wither; and volume of air by its relation to the amount of moisture that it can absorb.

52. *Question:*—Will a small volume of air in association with a slow wither result in greenish liquors?

*Answer:*—On the contrary a slow wither would tend to reduce the degree of greenness of a liquor.

53. *Question:*—Are there any disadvantages in using nylon mesh for withering?

*Answer:*—There are no disadvantages one can think of. (See also answer to question No. 19).

54. *Question:*—Is it correct to use alternate periods of warm air and cold air for withering?

*Answer:*—There is no harm in doing so, but it would be preferable to avoid such a system whenever possible, particularly should it give rise to the use of warm air in the later stages of withering.

55. *Question:*—Is it correct to pass hot air for a period of as long as 4 hours without reversing it at shorter intervals?

*Answer:*—No, because air flowing in one direction for such a long period can bring about uneven withering.

56. *Question:*—Will a higher dry bulb temperature have an adverse effect on quality when compared with a lower dry bulb temperature but with the same hygrometric difference?

*Answer:*—The extent to which quality can be affected depends not only on the dry-bulb temperatures employed but also on the hygrometric difference. The latter is just as important as the former since it governs the wet bulb temperature, which in turn influences the temperature of the leaf. Anyway, under the conditions stated the higher the dry-bulb temperature the worse it is for quality.

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57. *Question:*—The policy is to carry out manufacture early in the mornings. If there is rain in the afternoons, the evening leaf is usually underwithered. Should the wither be delayed for the morning and noon leaf or the wither for the evening leaf accelerated?

*Answer:*—If quality is the main consideration the wither for the evening leaf should be quickened. Otherwise the wither for the morning and evening leaf could be held back.

58. *Question:*—How could hot air be used for withering if the outside temperature is high?

*Answer:*—There is obviously no need to heat air unless the hygrometric difference is so small as to delay the wither. High temperatures and low hygrometric differences are quite unusual however, but should this be the case there is no option but to use hot air however high the temperature may be.

59. *Question:*—Is it advisable to keep loft windows closed in misty weather?

*Answer:*—No. (See answers to questions No. 14, 15, and 25).

60. *Question:*—Is there any harm in employing high temperatures to remove surface moisture? If not, would it be then necessary to open the windows for some time before passing the usual warm air for withering?

*Answer:*—No, it is not necessary to adopt such a measure if the air supply is not stopped. If, however, for some reason or the other it is proposed to use the fans for that particular leaf after an interval it would certainly be advisable to have the windows open in the intervening period, at least a few, for the reasons stated in the answers given to questions Nos. 14 and 25.

61. *Question:*—Is it good practice to partly wither the leaf in the night and completing it in the morning?

*Answer:*—There is nothing wrong with such a practice provided the minimum amount of hot air is used in the later stages.

62. *Question:*—Is it detrimental to quality if surface moisture is not removed quickly?

*Answer:*—Yes, since wet leaf contains more bacteria on its surface than dry leaf, and bacteria are known to be one of the causes of dull liquors.

63. *Question:*—In rainy weather my teas are usually reported on as dull. I am unable to employ high temperatures for removing surface moisture. What should I do?

*Answer:*—It is not necessary that high temperatures should be employed. Use the maximum amount of air, and make the best use of it by spreading first from the end furthest away from the bulking chamber.

## WITHERING

64. *Question*:—If a good wither cannot be obtained, is it correct to manufacture under-withered leaf?

*Answer*:—No. Every attempt should be made to get a proper wither even by extending the period. If the problem is one of inadequate air-supply it can easily be solved by fans of bigger capacity. If the trouble is due to insufficient accommodation replacement of hessian with nylon is a partial solution.

65. *Question*:—A hygrometric difference in the region of 10°F is usually recommended for artificial withering. Does this refer to the point of air entry or exit?

*Answer*:—Air entry, *i.e.* the point where the air leaves the bulking chamber and not behind the first bank of tats or any other position in the loft.

66. *Question*:—On wet days when the withering fans are used, some damp air is drawn into the bulking chamber through the windows opposite the fans. Is this in order?

*Answer*:—It is quite in order but if rain tends to beat in, these windows should be kept closed and more windows opened on the ground floor in order not to starve the fans of air.

67. *Question*:—For artificial withering what should be the hygrometric difference of the air in the bulking chamber and at the first bank of tats?

*Answer*:—(See answer to question No. 65.)

68. *Question*:—In my factory the area of air intake and air exit does not comply with the recommendations of the T.R.I. What should I do?

*Answer*:—Correct this shortcoming at the earliest opportunity. It does not involve much trouble or expense.

69. *Question*:—It has been suggested that good teas can be made from any type of wither? Is this possible?

*Answer*:—No. We do not agree that this is possible. Perhaps the statement refers to different degrees of wither. If so, it is possible to make as good a tea from a soft wither as from a hard wither depending on the circumstances.

70. *Question*:—On a very wet day, if powerful fans are available, is it correct to pass cold air over the leaf for say 2-3 hours?

*Answer*:—However powerful the fans may be, it is pointless passing humid air over leaf.

71. *Question*:—Is it necessary to strengthen tat posts when nylon net is installed?

*Answer*:—It depends on how strong the posts are and how firmly they are fixed to the floor. In any case, the addition of a few horizontal bars to the existing hand and foot rails would be a wise precaution.

## ONE DAY COURSE IN TEA MANUFACTURE

72. *Question*:—When using nylon tats, does the moisture drip from one tat to the other result in uneven withers?

*Answer*:—No. (See answer to question No 22).

73. *Question*:—What are the adverse effects in forcing a wither?

*Answer*:—One adverse effect is an uneven wither. Liquoring properties might also be adversely affected resulting from the employment of too high a temperature, but if the period of withering is short the effect would be negligible. This does not mean that forcing a wither is not a good thing. On the contrary, it would improve quality under the right conditions, namely, large volumes of air and moderate heat.

74. *Question*:—Is it wrong to turn over leaf on the withering tats when leaf is spread thickly?

*Answer*:—It is not the right thing to do since handling could damage the leaf and cause pre-fermentation. But if spreading thickly cannot be avoided because of inadequate withering capacity and the bottom layers of leaf are under-withered there is no option but to turn over the leaf.

75. *Question*:—When reversible withering is in progress is it advisable to pass air, which had already been sent through a loft in which wet leaf was spread, over withered leaf?

*Answer*:—In a well-planned factory such a situation should not arise. However, if the air that has been passed over the wet leaf is still capable of doing useful work it should be used. Otherwise it should be discharged out of the factory.

76. *Question*:—Would the same hygrometric difference at two different dry bulb temperatures give the same results with respect to the rate of wither?

*Answer*:—The higher the dry bulb temperature the greater the evaporative capacity of air, but for the usual range of temperatures employed in withering the small variations in the dry bulb temperature would not affect the rate of wither. That is to say, whether the dry bulb temperature is 75°F or 85°F, if the hygrometric difference is the same in both cases, the evaporative capacity of the air is practically the same. So if rate of withering has to be increased, the thing to remember is that the hygrometric difference should be made greater, but this cannot of course be done without raising the dry bulb temperature unless there are facilities for dehumidifying the air by refrigeration.

77. *Question*:—Is there any harm in having a hygrometric difference of 15°F for withering?

*Answer*:—Not if temperatures are reasonably low. The dry bulb temperature should not be higher than 90°F.

## CHAPTER 7

### ROLLING

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#### Low-country:

78. *Question*:—If a 5 roll-programme is carried out, what would be the ideal dhool outturn for each roll?

*Answer*:—It would depend quite a lot on the roll-breaker meshes used and also on whether a high O.P. outturn is required or not. As a working basis, if 10% dhool is aimed at for each of the first two rolls, and 20% for each of the other three rolls, leaving say about 20% big-bulk, you are not far off the ideal approach, providing rolling of the leaf has been satisfactorily carried out.

79. *Question*:—How could heating of leaf in a roller be prevented, or at least reduced?

*Answer*:—The simple measures that can be adopted are first—avoiding hard withers, second—adopting the lowest charges possible, third—releasing the pressure cap at frequent intervals, fourth—using the right type and size of cone for brisk circulation of the leaf, and last but not least—cooling the rolling room.

80. *Question*:—I use very light pressure in the early rolls. Is there any advantage in raising the pressure cap during rolling?

*Answer*:—If charges are small, rolling periods short, and the circulation of leaf satisfactory under pressure there is no point in releasing pressure. But if there is the slightest indication that some of the leaf at the top is not moving as freely as it should, raising the pressure cap is beneficial.

81. *Question*:—What would be the best method of pressure application in the low-country?

*Answer*:—Many factors have to be considered such as weights of charges, number of rolls, rolling periods, and dhool outturns before any method can be suggested. For the usual 30 minute roll, however, 5 minutes on and 5 minutes off would be suitable.

82. *Question*:—Is it advisable to have short periods for the early rolls and prolong the period for later rolls?

*Answer*:—Yes, since short early rolls help to conserve tip but it is preferable to make the later rolls also short and increase the number of rolls as well if possible, in order to improve appearance.

83. *Question*:—Are large size or small size rollers better for low-country manufacture?

*Answer*:—Large size rollers are generally better because less pressure is required to get the same result on account of the

## ONE DAY COURSE IN TEA MANUFACTURE

larger amount of leaf, which, it should be remembered, exerts a considerable amount of pressure at table level.

84. *Question:*—If a good wither is impossible to obtain, can manufacture be improved by some modification in the roller battens?

*Answer:*—It is very doubtful however much the design of a batten is altered to expect an improvement so long as the wither is not right.

85. *Question:*—If leaf is over-withered, what is the effect of adding a bucket of water into the roller?

*Answer:*—It will assist in bringing some of the leaf into a rollable condition, which otherwise might get easily broken up in rolling.

86. *Question:*—Is it correct to add sandy dust into leaf being rolled in order to improve colour?

*Answer:*—There is no harm in doing so.

87. *Question:*—If withers are soft, would it be advisable to expose the leaf to the sun say after the first roll? Or would it be better to pass the leaf quickly through the drier at a temperature of about 120°F?

*Answer:*—If there are no other means available of getting a suitable wither by prolonging the period or using heated air in the lofts, either of the 2 methods suggested may be carried out, providing too much moisture is not removed from the leaf and brittleness is avoided.

88. *Question:*—What types of roller tables should be used for the various rolls?

*Answer:*—No specific roller tables can be recommended because though one batten may be just as good as another, the critical factor in the performance of a roller is the central fitting. This unfortunately has not been properly standardized in relation to different requirements. It is for this reason the Keegel roller table was developed and it may be used at any elevation to suit one's requirements by merely controlling the pressure applied on the leaf.

89. *Question:*—What is the best charge for a 47" Walkers roller?

*Answer:*—For twist and appearance a charge of about 500 lb. would probably give the best results.

90. *Question:*—Would a roller fitted with 12 battens produce a tea more suited for the London market or the Middle East?

*Answer:*—All other conditions being equal the tea will be more suited for the London market because the greater the number of battens the more breaking up of the leaf.

## ROLLING

91. *Question*:—Would it be advantageous to get some colour to the 'tips' by application of some pressure in rolling?

*Answer*:—Yes, but it should be remembered that the more pressure that is applied the smaller in size is the tip. Therefore, whole tip may be sacrificed in trying to improve the colour of tip. The B.O.P.F. grade would benefit at the expense of the F.B.O.P. The method of rolling to be adopted must accordingly depend on the relative values of these two grades.

92. *Question*:—Twist is good in the first two rolls, but is bad in the later rolls, for which Rettie cones are used. What should I do?

*Answer*:—Try milder types of cones. Perhaps the Rettie cones being used are too large. If this is not the case, smaller charges might rectify the defect.

93. *Question*:—Using different cones I get the same results. How do you explain this?

*Answer*:—It may be that although the cones may be of different shapes and sizes, you are fortunate in having a cone in each roller which is of the correct specification.

94. *Question*:—Should the bulk percentage be always reduced to 20%?

*Answer*:—No, the figure is only a guide for successful rolling. The main criterion should be the appearance of the leaf, which should not be 'open'.

95. *Question*:—What should be the optimum temperature in a roller?

*Answer*:—Between 80 and 90°F according to the evidence so far available on this question.

96. *Question*:—Is night manufacture therefore preferable to avoid high temperatures during rolling?

*Answer*:—Yes. But if a mist chamber is available it might be just as effective in the daytime.

97. *Question*:—If the number of roll-breakers is insufficient, would you recommend that rolling be prolonged?

*Answer*:—It is far better of course to keep the leaf moving in the rollers than piling it up on the floor in such an event. Nevertheless re-planning of the rolling programme should be considered to make the best use of the roll-breakers.

98. *Question*:—Would you recommend a lower charge than the optimum charge of 700 lb. that is recommended for a 47" C.C.C. roller?

*Answer*:—Yes. (See answer to question No. 89).

## ONE DAY COURSE IN TEA MANUFACTURE

99. *Question*:—Is it advisable to add B.M. tea to underwithered leaf for rolling?

*Answer*:—It would probably help in absorbing some of the surplus moisture, but at the same time it will spoil the general appearance of the dhoos. Therefore it would be advisable to carry out such a measure only in the later rolls if any advantage is likely to be gained, but it is very doubtful any worth-while results will be achieved.

100. *Question*:—How best can underwithered leaf be rolled?

*Answer*:—By employing the lightest pressure possible, but however carefully it may be done it would not be possible to get a satisfactory product.

### Mid-Country:

101. *Question*:—What is the maximum permissible dry bulb temperature in the rolling room?

*Answer*:—From the quality stand-point it should not be higher than 70°F. In mid-country factories and even in up-country factories at certain times of the year it would not be possible even with the most efficient humidifying system to maintain lower temperatures in the daytime. It is for this reason night manufacture is gaining more advocates.

102. *Question*:—Is it incorrect to say that the speed of a roller should be lower, the shorter the crank?

*Answer*:—Yes. The shorter the crank the faster the roller should run to get the leaf to circulate properly.

103. *Question*:—Should double action rollers run at a slower speed than single action rollers?

*Answer*:—Here again the answer depends on the length of the crank irrespective of the action. As a rule D.A. rollers are provided with smaller cranks than S.A. rollers; the former should therefore run at a higher speed.

104. *Question*:—Is it right to say that if circulation of leaf is satisfactory, a roller is not over charged? I ask this question because it is not economical for me to undercharge my rollers?

*Answer*:—Yes. We do not know however by what standard you judge circulation but a generally good test is to observe the movement of the leaf under pressure by stopping the roller when under pressure and seeing to what extent the leaf is caked. Under heavy pressure, particularly if the wither happens to be soft, some caking is inevitable however efficient the cone may be, but excessive caking may be regarded as a sign that the roller is overcharged.

## ROLLING

105. *Question*:—Which is the better method—orthodox or continuous? I mean replacing the dhool with withered leaf after each roll and not continuous rolling of the B.B.

*Answer*:—For quality, orthodox rolling is better, but for colour and strength continuous rolling is more suitable. It is possible, however with additional rollers to get the same results from an orthodox system as from continuous rolling.

106. *Question*:—What are the latest types of battens for rollers on the market? What do you think of the Yews battens?

*Answer*:—The only latest type we are aware of is the Keegel battens, which have recently been developed at the T.R.I. As regards the Yews battens we think they are inclined to be rather severe on the leaf. If you find this to be the case, you may be able to reduce the severity of these battens by having only 4 battens on the table instead of the usual eight.

107. *Question*:—What is the best type of battens to match a Keegel cone?

*Answer*:—Keegel battens for the early rolls and M & S battens (broad width) with a special surround for later rolls.

108. *Question*:—I get 20% B.O.P.F. Can I roll the leaf further to get more fannings?

*Answer*:—Yes, you can, if you are prepared to sacrifice some quality, but you may experience some difficulty in that as the leaf gets smaller in size circulation is impeded and throw-out would be excessive. To avoid this or at least minimise it you would have to adopt continuous rolling since the addition of withered leaf at the end of each roll will help to improve circulation.

109. *Question*:—With regard to the figures for speeds of rollers mentioned in one of the papers that were read, were these recently arrived at?

*Answer*:—No. They were published in Monograph No. 4.

110. *Question*:—In drawing up a rolling programme, must it be done on squared paper?

*Answer*:—It is preferable to do so since the details are presented more clearly, and any snags arising from clashing of roll-breaker times and so forth can be easily corrected, which would otherwise be very difficult to adjust from just a mass of figures.

111. *Question*:—What are the relative merits of the Rettie cone and the Fadeaway cone?

*Answer*:—As far as the Fadeaway cone is concerned its main merit is that it induces brisk circulation of the leaf, and being mild in action is more suited for twist than production of dhool.

## ONE DAY COURSE IN TEA MANUFACTURE

In the case of the Rettie cone, it is usually more of a dhool producer but at the same time there is a shallow type of Rettie cone which is even milder than the Fadeaway cone. The shape of the Rettie cone, not ignoring its size, has therefore to be taken into account when discussing its merits. According to our experience, the very shallow type is not suitable for any purpose, the medium type is just as good as the Fadeaway, and the steep type is only meant for the production of more dhool.

112. *Question*:—If there is too much coarse leaf, would the juices from the tender leaf be absorbed by the coarser leaf during rolling and thus result in a poorer tea? I am told, however, that a large percentage of coarse leaf is necessary to obtain colour.

*Answer*:—It is possible that some juices would be absorbed by coarse leaf, but the resultant poorer tea would more likely be due to the presence of the coarser leaf than to the transference of any tea juices, should this happen. As for coarse leaf being essential for colour, it is not the case.

113. *Question*:—Does the Rotorvane eliminate rollers?

*Answer*:—Yes, it is supposed to be capable of doing the job of quite a number of rollers but we believe that for our standards of leaf appearance, conditioning of the leaf in an ordinary roller will still be required before it is passed through a rotorvane.

114. *Question*:—In some factories roller capacity does not match drier capacity. Is it in order to charge all rollers and then reduce the subsequent charges at say 60 minute intervals? Such a procedure would result in the batches having different fermenting periods. If the difference in fermentation between the first batch (rolled in the morning) and the last (rolled in the afternoon) is half an hour, is it satisfactory?

*Answer*:—We recommend such a system only if the weights of charges are carefully planned to avoid over-fermentation of the greater part of the leaf. Haphazardly charging all the rollers initially sometimes up to their maximum capacity without due consideration to drier capacity is not good practice.

A difference of half an hour in the fermentation is permissible under mid-country conditions, assuming the mornings are cool and the afternoons hot.

115. *Question*:—For continuous rolling is night manufacture or day manufacture better?

*Answer*:—Night manufacture. This also applies to normal rolling if no humidifying appliances are available.

116. *Question*:—How would you define drastic fittings on a roller?

*Answer*:—A drastic fitting may be described as one which produces a large amount of dhool without recourse to much pressure. The dhool is also flaky in appearance and consists of a large amount of small sized particles. The general appearance of

## ROLLING

dhool obtained from the use of drastic roller fittings is that of the leaf having been cut as opposed to what leaf looks like when it is broken after having acquired a twist.

117. *Question*:—What should be the usual hygrometric difference in a rolling room?

*Answer*:—About 2°F, but too much importance should not be attached to it. If rolling room temperatures are low no harm would result from a bigger hygrometric difference. The main thing to observe is the actual temperature itself, to which more attention should be paid than the hygrometric difference. When a humidifying device is being used, however, whether it be a mist chamber or the homely wet curtains, the hygrometric difference is a good indicator of the efficiency of cooling. If it exceeds 2°F it would mean that the air is capable of being cooled still further.

118. *Question*:—If the rolling room temperature is low, how will it affect fermentation?

*Answer*:—Provided temperatures are not much below 70°F, fermentation is not likely to be retarded since the temperature of the leaf attained during rolling will be very much higher.

119. *Question*:—Is it advisable to direct hot air from the driers to the rolling room, if the rolling room temperature is below 65°F?

*Answer*:—Yes, if fermentation is carried out in the rolling room and it is desired to improve the colour of the liquors—not otherwise.

120. *Question*:—When 'steam' issues from a roller is it a sign of over-heating?

*Answer*:—Not necessarily, because if the rolling room is cold and humid the moisture from the leaf condenses and gives the misleading impression that the leaf is overheated. Anyway the best check is to take the temperature of the leaf.

121. *Question*:—Is it possible to get thick liquors without losing leaf appearance?

*Answer*:—Appearance of the tea will have to be sacrificed to some extent to gain this objective.

### Up-Country:

122. *Question*:—Is it correct to say that if the wither is hard, a greater weight of leaf can be charged into a roller?

*Answer*:—No. Weight should not be confused with quantity. Because of leaf shrinkage in the case of a harder wither a roller would probably be able to accommodate more leaf, but because of the lower moisture content of the leaf its weight would be less than that of the same volume of softer-withered leaf. That

## ONE DAY COURSE IN TEA MANUFACTURE

is why when the wither is hard difficulty is experienced in charging a weight in excess of the normal capacity of a roller.

123. *Question*:—If temperatures do not rise above 85°F would any harm result from increasing the pressure?

*Answer*:—No, because the temperature is below the maximum we consider harmful for quality.

124. *Question*:—What are the merits of E.P. rolling? What effect has this type of rolling on quality and flavour? What periods are recommended?

*Answer*:—From our experience, the results from E.P. rolling are no different from those obtained with batten/pressure cap rolling, except in the appearance of the teas. If the right fittings are used, the teas turned out by both methods may be almost indistinguishable. Compared with batten/pressure cap rolling, E.P. rolling, has the following main advantages:—

- (i) unrestricted circulation of the leaf,
- (ii) bigger charges and shorter rolls, and
- (iii) higher dhool production.

For best results we recommend 4 × 15 minute rolls or 3 × 20 minute rolls.

125. *Question*:—What are the advantages and disadvantages of wooden tables as compared to metal tables?

*Answer*:—Wooden tables do not last as long as metal tables, but one advantage which appears to be in their favour is that they are supposed to give a better twist to the leaf. Otherwise metal tables are more advantageous, because rolling conditions are cooler.

126. *Question*:—If the speed of a roller is too high, what would happen to the leaf?

*Answer*:—It would break up the leaf without producing a satisfactory twist.

127. *Question*:—For the initial charge, I use two rollers of the same size but of different speeds. What is the remedy?

*Answer*:—The only remedy is obviously to correct the speeds. But if the difference in speed is small it is not worth bothering about.

128. *Question*:—If there is good circulation of leaf under pressure, is it necessary to raise the pressure cap at all?

*Answer*:—Leaf may appear to circulate very well with the pressure cap lowered. Yet it is possible, particularly in the later rolls, that some leaf may get caked at the top, which will not be apparent unless the roller is stopped while the leaf is under pressure. For this reason alone short periods of “no pressure” rolling are recommended. Release of pressure also helps to cool the leaf to some extent and to break up some of the lumps.

## ROLLING

129. *Question*:—If the hygrometric difference in the rolling room is over 5°F, should the windows be kept open?

*Answer*:—No; the mist chamber should be used and all but two or three windows kept closed.

130. *Question*:—It is said that by using rollers fitted with severe battens and cones, liquors would be light. Please explain this statement.

*Answer*:—The explanation for such a result is that the leaf is unduly broken up without much expression of juice. The action of a severe batten or for that matter any severe fitting on a roller table would not be dissimilar to say that of a pair of scissors. The leaf is merely reduced in size without the required amount of juice on the surface to bring about proper fermentation. For best results juice has to be wrung out of the leaf and the wringing action cannot be applied to small particles of leaf in an orthodox roller. Early stages of rolling must therefore twist, rather than cut, the leaf.

131. *Question*:—Is it wrong to generate heat by rupturing leaf cells during rolling?

*Answer*:—No. The important thing is to get fermentation started as soon as possible for which some heat is advantageous. Excessive heat is of course bad because of its adverse effect on the activity of the enzymes and also on the desirable properties of tea.

132. *Question*:—Is it correct to add orange peel during rolling and permanganate solution to fermenting dhools? I get good results.

*Answer*:—Though you may be getting good results it does not follow that worse results would be obtained by omitting such substances. In any case, addition of foreign matter to tea is not lawful.

133. *Question*:—If a roller runs clockwise in one roll and the subsequent roll is carried out in an anti-clockwise direction, is the twist of the leaf affected?

*Answer*:—No, for the simple reason that the twist acquired by leaf in the process of rolling is mainly brought about by a stirring motion and friction between leaf and leaf. The action of rolling cannot be compared to the manner or degree in which a thing is twisted by rubbing it between two plain surfaces.

134. *Question*:—What are the ideal speeds for rollers?

*Answer*:—35 to 40 r.p.m. for single action rollers and 40 to 45 r.p.m. for double action rollers. (See also answer to question No. 103).

135. *Question*:—My factory is situated in a valley and the difference between the wet and dry bulb temperatures in the rolling room is 7°F. How could this be rectified?

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*Answer:*—If temperatures are reasonably low there is no need to go to much expense and trouble in rectifying the conditions. Otherwise, the installation of a proper humidifying chamber is the only answer.

136. *Question:*—When must a mist chamber be used?

*Answer:*—When the temperature in the rolling room exceeds 65-70°F. In rainy weather, whatever the temperature, it is not necessary to use a mist chamber.

CHAPTER 8  
**ROLL-BREAKING**

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**Low-country:**

137. *Question:*—What is the best size of mesh for a roll-breaker in the low-country?

*Answer:*—Generally speaking, No. 4 for the early rolls and No. 5 for the later rolls.

138. *Question:*—For what rolls do you recommend double roll-breaking of the bulk?

*Answer:*—For only the first 3 rolls, primarily with a view to recovering tip and increasing the outturn of the leafy grades. This must not be taken as a hard and fast rule since a lot will depend on the roll breaker mesh and the efficiency of the machine.

139. *Question:*—What is the normal speed of an oscillatory type of roll-breaker?

*Answer:*—About 300 r.p.m.

140. *Question:*—What is the gauge of the wire for different mesh sizes for normal use?

*Answer:*—No. 15 for No. 4 mesh; No. 16 for No. 5; and No. 18 for No. 6.

141. *Question:*—With regard to double roll-breaking of leaf, whether it be dhool or bulk, cannot it be eliminated by altering the slope?

*Answer:*—It can, depending on the speed, rate of feed, size of mesh employed and so on. There are so many factors involved, which would necessitate much experimentation to get the desired results, that most estates adopt the easiest course, namely double roll-breaking.

**Mid-country:**

142. *Question:*—Does double roll-breaking of the dhool affect the quality of the tea?

*Answer:*—Yes, if overdone. Further rolling of leaf which would normally be regarded as dhool could lead to some loss of quality because of the higher temperature it would be subjected to in the rollers. Double roll-breaking should therefore be carried out with discretion and avoided whenever possible unless the main objective is improvement in colour and strength.

143. *Question:*—Why should double roll-breaking be avoided?

*Answer:*—Because it involves more time and labour, and in some cases an additional machine. The danger of quality being impaired is also present. In any case, why go to the trouble of double roll-breaking when the same results could be obtained in a single operation by the employment of suitable mesh.

## ONE DAY COURSE IN TEA MANUFACTURE

144. *Question*:—When two different sizes of mesh are used on a roll-breaker, where should the smaller size be fitted?

*Answer*:—At the lower end, because in the downward passage of the leaf the dhool tends to be larger in size than at the feeding end.

145. *Question*:—Is there any fixed combination of mesh size that should be used on a roll-breaker?

*Answer*:—No. (See also answer to question No. 141).

146. *Question*:—Should the roll-breaking of the last roll be carried out in a special manner, or should single roll-breaking be carried out irrespective of the unevenness of the dhool?

*Answer*:—The 4th dhool or for that matter any other dhool requires no special treatment unless the dhools are very uneven or it is desired to separate wiry leaf from the broken leaf in order to facilitate sifting of the made tea. In the case of the last dhool it may sometimes be an advantage to double roll-break it for the sake of the O.P. grade it may contain.

147. *Question*:—If roll-breaker mesh sizes of Nos. 5, 6, 7 and 8 are used and a B.B. outturn of 18% obtained, would it be better to reduce the percentage of big-bulk by using larger mesh instead, say Nos. 4, 5 and 6?

*Answer*:—It makes no difference to the tea what mesh is used for a last-roll. All that different sizes of mesh would do is to alter the percentage of big-bulk. Whatever figure is obtained it should be related to mesh size. Accordingly, a lower B.B. outturn from the use of normal sized mesh corresponds to a larger outturn from smaller mesh. The overall result is the same.

### Up-country:

148. *Question*:—You say that the use of a brush during the operation of roll-breaking should not be encouraged, but when mesh gets clogged on account of soft withers, what is one to do?

*Answer*:—The statement we made was with respect to the indiscriminate use of the brush, sometimes with a view to increasing the dhool outturn. This of course we strongly disapprove of.

149. *Question*:—Does double roll-breaking affect fermentation?

*Answer*:—It can, since the dhool is cooled. If only a small part of the dhool is put over the roll-breaker, however, the effect may be negligible.

150. *Question*:—Is it advantageous to use conveyor belts for roll-breakers or rely on feeding with baskets or basins?

*Answer*:—Most certainly it is of great advantage to use a conveyor not only because more even spreading is obtained but because a constant rate of feed is also achieved. Under such conditions the performance of the machine is improved.

## ROLL-BREAKING

151. *Question*:—Can dhools be varied in size, appearance, and outturn by alterations to roll-breaker speeds and crank-throw?

*Answer*:—Yes, far more than what one would expect. We are now investigating this question, which has not received sufficient attention by the makers of roll-breakers.

152. *Question*:—In general, what mesh size would you recommend to get 80% of main grades.

*Answer*:—No. 5 and 6, or No. 6 only depending on the size of the grades required.

153. *Question*:—Does the T.R.I. recommend stainless steel in preference to G.I. mesh?

*Answer*:—We have not sufficient evidence yet to make a firm recommendation.

154. *Question*:—I have a roll-breaker fitted with No. 6 mesh. Despite double roll-breaking, the dhools are still large in size. What should I do to correct it?

*Answer*:—Perhaps the gauge is not right or the defect can be due to a number of causes, such as slow feeding, sagging mesh, rubbing leaf over the mesh, retarding the passage of leaf by battens, too slow a speed, slope not steep enough, and too long a tray.

**NOTE**:—The question of double roll-breaking of dhools was raised on numerous occasions and our views on this matter are liable to be misunderstood. We do not deny that even dhools are obtained, thus enabling larger particles to be re-rolled. Double roll-breaking also reduces the amount of cutting of made tea, which is another advantage in its favour. But what we maintain is that the same results can be obtained by a suitable combination of mesh in a single operation, thus saving time, labour and machines.

## CHAPTER 9

### FERMENTATION

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#### Low-country:

155. *Question*:—What are the effects of thick spreading?

*Answer*:—One quite definite effect is that it keeps the leaf warm, which would naturally promote the development of colour. It would also help to keep the leaf in a moist condition and also minimize surface drying.

156. *Question*:—If extending the period of fermentation results in more colour and less briskness, how can I maintain both features?

*Answer*:—It is an axiom in tea manufacture that one characteristic is developed at the expense of another, unless they happen to be two characteristics of similar properties. Since colour and briskness are strongly opposed it is not possible, whatever you do, to get the maximum amount of potential colour and briskness at the same time. But with a suitable period of fermentation it is possible to get a tea possessing both these characteristics to a fairly high degree, provided temperature conditions have not been unfavourable to the preservation of briskness.

157. *Question*:—If colour cannot be obtained in 3 hours is it correct to ferment for 4 hours?

*Answer*:—No, since the tea is likely to get soft. Of course if colour is the only consideration, extending the fermentation is permissible. However, it would be far better to improve the rolling conditions rather than unduly lengthen the fermentation in a case like this.

158. *Question*:—In the first and second roll-breaking of the bulk, the dhools obtained have different rates of fermentation. What can be done about it?

*Answer*:—Fire the two fractions at separate times if it is feasible. There is no other way of offsetting this difference.

159. *Question*:—Please explain further enzymic and non-enzymic fermentation.

*Answer*:—Enzymic fermentation means that part of the process in which the oxidizable matter in the leaf is oxidized by the enzymes, and non-enzymic fermentation refers to the subsequent changes that take place in the compounds formed by enzymic oxidation. So whereas the first part of the process depends on the activity of the enzymes, the second reaction depends on temperature only. Both reactions can take place almost simultaneously, depending on the temperature—the higher the temperature the faster the conversion of those compounds from enzymic oxidation (called theaflavins) to those resulting from

## FERMENTTION

temperature alone (called thearubigins). The theaflavins give the desirable character to the liquors, whilst the thearubigins primarily produce colour.

160. *Question*:—What do you consider to be the minimum and maximum periods of fermentation that are permissible in the low-country?

*Answer*:—Approximately 2 and 3 hours respectively.

161. *Question*:—Is the degree of blackness of fired tea associated with the period of fermentation?

*Answer*:—Yes. An underfermented tea would not be as black as a fully fermented tea.

162. *Question*:—Is not the fermentation produced from rolling alone sufficient, without having to extend it on the fermenting racks?

*Answer*:—No, because a considerable proportion of the leaf would not be long enough in the rollers for the necessary reactions to take place.

163. *Question*:—Which is the preferable surface for fermenting—cement or aluminium?

*Answer*:—According to experimental evidence there is no difference between the two.

164. *Question*:—What should be the thickness of spread for fermenting dhools on a dry day and on a wet day? (Note:—this same question was asked in almost every district).

*Answer*:—It is a complicated question to answer because there are 3 things to consider, namely, period, temperature and humidity. On a dry day, for example, a thick spread would be beneficial in order to reduce surface drying. At the same time there is the danger of a rise in temperature of the leaf if the ambient temperature is high. It would therefore not be advisable to unduly thicken the spread in hot, dry weather unless the period is shortened.

In wet weather under low-country conditions, temperatures experienced are not low enough to justify a thickening of the spread as in most up-country areas.

In general we do not advise altering the thickness of spread according to weather, and if there is any doubt about the most suitable thickness, a spread of about 2" could be adopted all the year round without any misgivings.

165. *Question*:—Is it advisable to turn over the leaf during fermenting?

*Answer*:—Only in very exceptional circumstances is it advisable to do so, and that is when there is an undue development of heat.

166. *Question*:—What is the thickest spread you would recommend?

*Answer*:—About 3".

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167. *Question*:—In a bought leaf factory, will not the fermentation be affected as a result of different types of leaf being received having different enzymic and catechin contents?

*Answer*:—Most certainly it will. Even estate leaf will have these properties, but perhaps not to such a variable extent. The effect of these differences is however not so adverse as one would expect, because in the rolling process the juices get mixed.

168. *Question*:—In the absence of a mist chamber, is it satisfactory to spray water on the floors and walls, avoiding the fermenting dhools, but keeping the windows closed?

*Answer*:—Yes, but we do not advise keeping all the windows closed. A little ventilation is necessary.

### Mid-country:

169. *Question*:—Do the fermentation temperatures you mention in your paper refer to room temperature or temperature of the leaf?

*Answer*:—Temperature of the leaf. The best time to note this, in order to get a fair idea of the heat developed, is after the leaf has fermented for about half the period on the racks.

170. *Question*:—Is there any harm in extending the fermentation in the rush period?

*Answer*:—Generally speaking, no.

171. *Question*:—Can I prevent over-fermentation on the fermenting racks by keeping the leaf longer in the rollers without pressure?

*Answer*:—No. In fact it will be much worse since conditions in a roller are hotter than on the racks. The sooner the leaf is discharged the better for cooling, unless due to roll-breaking delays discharge of leaf necessitates the leaf remaining in a heap for some time.

The simplest solution is to shorten the fermentation.

172. *Question*:—Does a thin spread and faster fermentation improve quality?

*Answer*:—Since both factors are conducive to the preservation of quality, an improvement in quality can be expected, but the liquors may lack 'body'.

173. *Question*:—Is it wrong to spread leaf on wet floors?

*Answer*:—Yes, we think so for the only reason that a part of the juices in contact with the floor would probably get diluted.

## FERMENTATION

174. *Question*:—Should the temperature in the fermenting room be higher than in the rolling room?

*Answer*:—No. The heat generated in the rolling process is more than sufficient to provide the necessary warmth for fermentation to proceed normally on the fermenting racks. Specially heated fermenting rooms might prove helpful only in the case of those factories, where conditions are really cold.

### Up-country:

175. *Question*:—How do teas become soft when they are over-fermented?

*Answer*:—The soft character is due to excessive oxidation of the oxidizable matter in the leaf. When there is an excess of oxidized juice tea loses its briskness.

176. *Question*:—What is the effect of a big hygrometric difference in the fermenting room on the characteristics of the tea?

*Answer*:—It slows down fermentation and would probably result in a greener infusion and lighter liquor. Quality is not likely to be affected.

177. *Question*:—You recommend that all the big-bulk should be fired at the end of the day? Would this not result in dullness?

*Answer*:—The recommendation was made for those estates with inadequate drier capacity. It is better to do this than over-ferment the dhools.

178. *Question*:—Why do you say that turning over of leaf during fermenting is bad?

*Answer*:—Because it results in unnecessary cooling of the leaf. Furthermore, in dry weather, a fresh surface is exposed to the drying effect of the air. (See also answer to question No. 165).

179. *Question*:—But does not the adoption of such a measure bring about more even fermentation?

*Answer*:—We do not think so, judging from our observations of the colour of the leaf of the top, middle and bottom layers. For normal spreads of  $1\frac{1}{2}$  to  $2\frac{1}{2}$ " there is no significant difference, but for thicker spreads or in the case of leaf packed closely some improvement might possibly result from turning leaf over.

180. *Question*:—Do you recommend daily washing of fermenting racks.

*Answer*:—Most certainly. We attach great importance to cleanliness, whatever may be the views held by some on the washing of fermenting surfaces.

181. *Question*:—What is the effect of period of fermentation on quality and flavour?

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*Answer:—*It is now an established fact that the shorter the period the better quality and flavour would result but the fact must not be lost sight of that it takes some time for these characteristics to be developed. The optimum period varies according to a number of factors, such as wither, method of rolling and the rise in temperature of the leaf.

182. *Question:—*Does it follow then that if these characteristics are to be preserved the early dhools should be fired first?

*Answer:—*Yes, but since the later dhools also possess some quality and flavour the shortest possible charging interval should be adopted.

183. *Question:—*Is a period of fermentation of 1 hr. 50 mins. satisfactory for preservation of flavour? I carry out short rolls with hard pressure.

*Answer:—*Quite satisfactory. We are aware of even shorter periods of fermentation being adopted for the conservation of flavour.

184. *Question:—*Do you consider a thickness of spread of  $1\frac{1}{2}$ " satisfactory for a dry bulb temperature of  $68^{\circ}\text{F}$ ?

*Answer:—*Yes, quite satisfactory.

185. *Question:—*Does the use of a metal roller table retard fermentation, as opposed to a wooden table which would keep the leaf naturally warmer?

*Answer:—*There is a possibility of this happening only in the early rolls, if light rolling is adopted.

186. *Question:—*Despite a hygrometric difference of only  $2-3^{\circ}\text{F}$ , drying takes place during fermentation. What is the reason?

*Answer:—*The only possible explanation is that the drying is brought about by excessive draughts. (On enquiry it was learnt that this was the case).

## FIRING

**Low-country:**

187. *Question*:—Should the exhaust temperature vary with inlet temperature, and what would be the effect of having an exhaust temperature of 135°F?

*Answer*:—Whatever may be the inlet temperature, the exhaust temperature should be constant. We recommend 120–130°F, assuming a drier is functioning normally and that the temperature registered above the top tray has not been affected by leakages of hot air or any similar defect. In any case, we attach more importance to the moisture content of the fired teas. Exhaust temperatures are meant to serve as a guide only.

An exhaust temperature of 135° is wasteful of heat. It does not harm the tea but it is possible that it would result in reducing the moisture content of the tea to such a low figure as to interfere with its maturing.

188. *Question*:—Do you recommend slow or fast firing?

*Answer*:—Neither, because of the risk of over-firing or under-firing the teas. A firing period of 18–21 minutes is always safe to adopt.

189. *Question*:—What would be the ideal inlet temperature for the low-country?

*Answer*:—About 200°F.

190. *Question*:—Does a high inlet temperature affect the 'bloom of tea'? A temperature of 185°F has been suggested in order to retain the 'bloom'.

*Answer*:—We have no evidence of the effect of temperature on the 'bloom'.

191. *Question*:—What are the minimum and maximum periods of firing permissible?

*Answer*:—15 and 24 minutes.

192. *Question*:—If moisture contents of teas are in the region of 7% how will they affect liquors and infusions? I ask this question because my teas are reported on as being bright and brisk despite being fired to a very high moisture content.

*Answer*:—It is quite impossible to get such satisfactory results from so much moisture in the teas, since they will be underfired, and instead of brightness and briskness the teas will be dull and soft. (Note:—On investigation it was found that the teas were actually being fired to a normal moisture content; the figure of 7% was entirely wrong).

## ONE DAY COURSE IN TEA MANUFACTURE

193. *Question*:—There are many practical difficulties in boxing teas after 30 minutes of cooling. What will happen if the teas are heaped up till the following morning?

*Answer*:—The teas would never get a chance of being cooled to a satisfactory degree, since continuously hot teas will be placed on partially cooled teas. Most of the teas in the heap would therefore remain in a heated condition even till the following day. The teas might very well acquire an over-fired character.

194. *Question*:—Is there a difference in the teas from the use of two types of driers—suction and pressure?

*Answer*:—There can be a difference if high firing temperatures are employed for the reason that the temperature of the air in the middle of a suction drier is generally higher than on the two sides, whereas in the case of a pressure drier the temperatures are more uniform. The distribution of air in the latter type of machine is also more even.

### Mid-country:

195. *Question*:—For how long do you recommend fired teas should be cooled, and what should be the temperature?

*Answer*:—Length of time would depend of course on how thinly the teas are spread, but half-an-hour should be the maximum, if excessive absorption of moisture is to be avoided. It is not necessary that the teas should be stone-cold; they could be boxed when they are just warm to the touch, which corresponds to a temperature of about 85–90°F.

196. *Question*:—How could a drier thermometer be checked for accuracy?

*Answer*:—If no standard thermometer is available, the methods described in the paper on “Thermometry and Hygrometry” can be used.

(Note:—No reference was made to this matter in the initial addresses and was introduced later because of the interest shown).

197. *Question*:—What is the best firing temperature for the preservation of quality?

*Answer*:—180–190°F, but if the lower temperature is used particular care must be taken to see that the moisture content of the fired teas does not exceed 3%.

198. *Question*:—Should not the maximum moisture content of fired teas be less than 3%? I feel that 3% is too high.

*Answer*:—It would be preferable of course to fire to a lower moisture content, but 3% is considered quite normal. It is a safe limit.

## FIRING

199. *Question*:—What is the fan speed of a modern E.C.P. drier?

*Answer*:—Usually about 500 r.p.m. but some drier fans work at slower speeds and others at higher speeds, depending mainly on the size of the fan and the resistance offered to the flow of air. A simple test to know whether a drier fan is running too fast or too slow is to observe the disturbance of the leaf on the trays and also to check the blow-out.

200. *Question*:—What do you consider to be a reasonable amount of blow out?

*Answer*:—About 2–3%, but this figure can be much higher if the leaf is coarse and flaky. A narrow exhaust duct can also increase the blow-out, because it brings about a higher speed of air at the exhaust. If good tea is found in the blow-out there is something seriously wrong with a drier, otherwise there is nothing to worry about.

201. *Question*:—Is the removing of a cowl over a drier advantageous?

*Answer*:—Most certainly it is from the firing standpoint. But sometimes it is found necessary to have a cowl because of the situation of a drier, in which case it is absolutely essential to see that the area of the opening of the cowl is not smaller than that of the drier exhaust. If this precaution is ignored, drier performance is impaired.

202. *Question*:—Is there a simple method of checking the speeds of trays in an E.C.P. drier?

*Answer*:—Yes, but since the three pairs of trays run at different speeds, the bottom pair being the slowest, each pair has to be checked separately. All that has to be done is to note how long leaf takes to travel on each row of trays from the time it falls on the row to the time it is discharged to the next. The time taken for any particular tray to travel the whole length of the tray circuit does not give the required information.

203. *Question*:—Despite the exhaust temperatures being the same on two driers, the moisture contents are not the same. Why is this?

*Answer*:—Because no two driers are alike. (See also answer to question No. 187).

204. *Question*:—What do you consider to be a suitable inlet firing temperature for a mid-country estate (elevation 3,500')?

*Answer*:—190–195°F. We recommend this temperature for all elevations except in two special cases; one is when flavour is present, for which a lower firing temperature of say 180–185°F may be preferable, and the other concerns the low-country where a higher temperature may be employed without any ill-effects.

## ONE DAY COURSE IN TEA MANUFACTURE

205. *Question*:—Is sun-firing advocated for quality and flavour for teas sold in London?

*Answer*:—No, because the keeping properties of such teas are rather poor.

206. *Question*:—I sun-fire my teas and notice that though the top layer dries, the lower section is coppery. Would this have any effect on the teas?

*Answer*:—It would because of uneven drying. One part of your teas would probably be under-fermented and another part over-fermented. If this effect is to be minimized spreading should be as thin as possible.

207. *Question*:—What progress has been made on D.F. heaters?

*Answer*:—None. Because of tat deterioration, damage to roofing sheets, and no likelihood of a continuous supply of low sulphur content oil being guaranteed, the future prospects of D.F. heaters are not bright.

208. *Question*:—Furnace fuel is cheaper than liquid fuel. Yet my experience is that in the long run the latter is more economical because of the greater deterioration of tubes brought about by the use of furnace oil. Do you agree?

*Answer*:—We do not have a sufficiently wide experience of furnace fuel to confirm this point. Perhaps you are right.

209. *Question*:—When ground floor windows are kept open in wet weather damp air comes into contact with hot tea. Is this satisfactory?

*Answer*:—Not at all. (See answer to question No. 220). If windows have to be kept open for supplying the fans with air, most of the fans' requirements could be met from the windows opposite the bulking chamber and only the minimum number opened on the ground floor. Teas should be kept away from the vicinity of windows.

### Up-country:

210. *Question*:—Does quick firing improve quality?

*Answer*:—Theoretically it should, all other conditions being equal, but we have not been able to prove this from the experiments that we have conducted on different periods of firing varying from 15 to 24 minutes.

211. *Question*:—What would be a suitable firing temperature for improving colour?

*Answer*:—We are not aware of any particular temperature tending to improve colour, and the evidence of different firing temperatures has shown that the only effect is on quality.

## FIRING

212. *Question*:—What should be the moisture contents of teas discharged from the drier?

*Answer*:—For correct firing it should be from 2 to 3%.

213. *Question*:—In case fired teas do not cool within 30 minutes, what is your recommendation?

*Answer*:—In such a case there is no option but to extend the period of cooling, but a consequent possible increase in the moisture content of the teas must be expected. All due precautions must then be taken to see that the teas are kept away from draughts. (See also answer to question No. 195).

214. *Question*:—Is it advisable to cool teas on zinc topped tables?

*Answer*:—Yes, these are quite satisfactory.

215. *Question*:—How much moisture do teas absorb when they are cooled, assuming the period of cooling is short and the teas are not subject to draughts?

*Answer*:—Teas during cooling under these conditions will rarely pick up more than half per cent moisture.

216. *Question*:—Which is the best surface for spreading fired teas for cooling—cement, canvas, wood or metal?

*Answer*:—We have not investigated this question, but we imagine there is little to choose between them.

217. *Question*:—What is a reasonable thickness of spread for cooling of fired teas?

*Answer*:—About half an inch. The thinner the spread the better of course because cooling will take place quicker and transference to boxes can be done before the teas gain too much of moisture.

218. *Question*:—Is not a temperature of 190–195°F too high for flavoury teas?

*Answer*:—We would not say it is too high but lower temperatures would be preferable. (See also answers to questions No. 197 and No. 204).

219. *Question*:—What should be the correct distance between the exhaust thermometer bulb and the top tray of an E.C.P. drier?

*Answer*:—About 6".

220. *Question*:—If loft fans are working, and windows left open in the firing room, is it advisable to cool fired teas?

*Answer*:—It would of course not be advisable to expose the teas in a position subject to draughts. They have to be cooled however, and by closing a few windows a place in the firing room can surely be found where it would be safe to expose the teas.

## ONE DAY COURSE IN TEA MANUFACTURE

221: *Question*:—Is there any ruling on the drying periods for infra-red moisture testers?

*Answer*:—No. They vary from instrument to instrument because of variations in voltage and in the height of the lamp above the pan. In view of this inconsistency, of which we are aware, it is an obligation on the part of the supplier to state exactly the conditions under which each instrument should be operated. The instrument should also be calibrated for a fixed position of the lamp and for a fixed drying period. Varying the latter according to the first visible signs of smoke from the sample, which is done in some factories, is a most unreliable method for moisture content determination. Misleading conclusions could be drawn from incorrect use of moisture testers (see question No. 192).

## GRADING AND STORAGE

**Low-country:**

222. *Question:*—Is tip essential in small B.O.P. grades?

*Answer:*—We would not say that it is essential but if such grades are destined for the Middle East Market the presence of tip would enhance their value.

223. *Question:*—Could good clean grades, free of stalk and fibre and of a satisfactory standard, be obtained from coarse leaf, without increasing the outturn of off-grades?

*Answer:*—Quite impossible. Not only will a higher percentage of off grades be obtained but the amount of refuse will increase as well.

224. *Question:*—What is the effect of passing 'tippy' teas through an electro-static stalk extractor?

*Answer:*—In the first place we see no point in passing a tippy tea through a stalk extractor for the sake of an odd stalk or two that it may contain, when the job can be done much more efficiently by hand-picking. Furthermore, some tip might find its way in the tailings, recovery of which would be more laborious and time consuming than picking of the stalk from the untreated tea.

If on the other hand, such tea contains a fair amount of stalk, say as the result of hard rolling, and hand picking is not feasible, some tip may have to be sacrificed if the tea is treated in an electro-static stalk extractor.

225. *Question:*—The F.B.O.P.F. grade made in my factory contains a lot of stalk. What should I do?

*Answer:*—If there is no hope of the standard of plucking being improved, lighter rolling and shorter periods may help. The implementation of this recommendation means that the number of rolls will have to be increased.

226. *Question:*—Are there any detrimental effects on the teas when they are passed through an electrostatic stalk extractor?

*Answer:*—None that we are aware of. At one time it was thought that the keeping properties were impaired, but this was disproved by experiments carried out at the Institute. Another effect that was supposed to take place was greying, but this was found to be due to a defect in the feeding arrangement of the bigger machines, which has now been rectified by the manufacturers.

227. *Question:*—What are the effects of excessive winnowing?

*Answer:*—Some possible loss in colour and strength of the liquors. The same effect is produced if stalk extraction in the electro-static separator is carried out to excess, and this has given rise to an unfavourable opinion of the machine.

## ONE DAY COURSE IN TEA MANUFACTURE

228. *Question*:—Would you recommend continuous rolling of withered leaf to obtain more flowery grades?

*Answer*:—We would not, because tip is easily destroyed. Even if great care in rolling is taken, there is one serious shortcoming in this method of rolling. The dhools will not be free of stalk and the problem of separating the stalk from the tip will arise.

229. *Question*:—Is it correct to final fire off-grades?

*Answer*:—It is the correct thing to final fire any grade only if it has absorbed excessive moisture, otherwise it is just a waste of time and money.

230. *Question*:—I have observed that separation of stalk in an electrostatic stalk extractor is better with teas re-fired after storage than with freshly fired teas. Any comments?

*Answer*:—We agree that the degree of separation improves after re-firing, but as to why it should give a better result than freshly fired teas it is difficult to give a satisfactory explanation.

231. *Question*:—Why should not the electrostatic stalk extractor be used for early dhools?

*Answer*:—See answer to question No. 224.

232. *Question*:—My teas gain  $\frac{3}{4}\%$  moisture after grading. Is this too much?

*Answer*:—No, It is a normal increase.

233. *Question*:—Is a moisture absorption of 3% too much?

*Answer*:—Most certainly. If teas gain more than 2% moisture after firing, something is obviously wrong. Sifting room conditions may not be right or the fault may be due to over-exposure of the teas.

### **Mid-country:**

234. *Question*:—What is the advice you give for making more fannings? Can I also improve liquors by making more of this grade?

*Answer*:—If by improvement of liquors you mean an improvement of colour and strength, you can get this and more fannings at the same time by harder rolling and smaller roll-breaker mesh.

235. *Question*:—For more fannings is it better to re-roll the dhool or use a Tarry Nipper breaker?

*Answer*:—If liquoring properties are not to be sacrificed, our opinion is that re-rolling of the dhool is the better method.

236. *Question*:—Why should grading of teas not be carried out on the same day they are manufactured? Would not teas stored overnight absorb more moisture than if they were graded immediately after firing?

## GRADING AND STORAGE

*Answer:*—Our views on this matter have evidently been misunderstood. We do not say that teas should be sifted the following day. If they could be sifted on the same day of manufacture so much the better, but what we advise against is the sifting of teas while they are hot.

237. *Question:*—Do teas stored in bins, absorb or lose moisture?

*Answer:*—They generally absorb moisture, however air-tight the bins may be, because each time a bin is opened fresh air is introduced.

238. *Question:*—But would not some loss of moisture take place during the very dry weather experienced in Uva?

*Answer:*—This is possible, but it would be very small indeed.

239. *Question:*—What should be the temperature in a bin?

*Answer:*—The temperature varies with the room temperature and can at times be rather excessive if the bins are too close to the driers. All measures should be taken to see that teas are stored under the coolest conditions possible.

240. *Question:*—Please elaborate on the use of the Tarry Nipper in conjunction with the Electrostatic stalk extractor.

*Answer:*—Since the latter machine does not appear to be ideally suited for the separation of heavy stalk, we recommend that the Tarry Nipper be used instead when dealing with teas of this type. One way of using the two machines in conjunction with each other is for example as follows:—

Remove the maximum amount of stalk possible by first using the electrostatic stalk extractor. Some good tea is bound to be removed with the stalk. This fraction could then be dealt with in the Tarry Nipper breaker. In this way only a part of the original tea would be subject to the crushing effect of the breaker, which would otherwise have to be used for the whole of the tea.

241. *Question:*—Does the use of the Tarry Nipper affect quality?

*Answer:*—We expect it would since abrasion occurs.

242. *Question:*—How much of cut leaf is permissible in the B.O.P. grade?

*Answer:*—It depends on the size of the grade, and also the outturn. For a normal sized B.O.P. grade, say of 60% outturn, it would not be unreasonable if it contains up to 10% cut leaf.

243. *Question:*—What is the maximum percentage of refuse tea permissible?

*Answer:*—If plucking is very coarse, refuse tea may be as high as 4% and even 5%. For normal standards of plucking the figure is in the region of 2%.

## ONE DAY COURSE IN TEA MANUFACTURE

244. *Question*:—Do you favour the practice of using the connecting door between the sifting room and firing room for winnowing of teas?

*Answer*:—There is no objection to such a practice if no winnower is available and the air is drawn into the sifting room from the firing room.

245. *Question*:—To what extent can grading of the dhool be carried out in a green state?

*Answer*:—From our experience pre-firing grading is impracticable and not at all desirable. The biggest problem is the firing of dhools of different sizes, which require different conditions. Handling of small amounts of leaf and firing them separately adds to the problem.

246. *Question*:—Do you recommend stamped aluminium in preference to brass mesh for sifting?

*Answer*:—Yes, we quite definitely prefer stamped aluminium, because it has a smoother surface and therefore reduces the greying effect.

247. *Question*:—Is it desirable to extract all the fluff from graded teas?

*Answer*:—From the marketing standpoint it is desirable, although some loss in colour and strength may result.

248. *Question*:—Could the electrostatic stalk separator be used for hot teas, straight from the drier?

*Answer*:—Freshly fired dhools may be passed through this machine, but we have not observed any particular advantage in doing so. Some estates have apparently got good results, whilst others have not. This inconsistency in the performance of the machine is probably connected with type and size of tea, moisture content of the tea, and ambient conditions.

249. *Question*:—Does final firing improve quality?

*Answer*:—No. All that it does is to check deterioration that has started in a tea, and thus improve its keeping properties.

250. *Question*:—Has final firing any effect on colour and strength? I regularly final fire my teas even though the moisture content is below 4%.

*Answer*:—We have not observed any significant effect on these two characters, but if teas with a low moisture content, as in your case, are final fired a slight deleterious effect may take place, but this effect may disappear after storage. Whatever the case may be, we are of the opinion that no benefit is derived from final firing teas containing less than 4% moisture. There is the additional cost to consider as well, and also the possible abrasion of the teas in their passage through the drier.

## GRADING AND STORAGE

251. *Question*:—What should be the period and ideal temperature for final firing?

*Answer*:—12 to 15 minutes and 140 to 160°F.

252. *Question*:—Dust grades absorb a large amount of moisture. How do I final fire these?

*Answer*:—The only feasible method is to cover the drier trays with hessian or material of similar texture, and spread the teas on it. The trays will have to be stationary of course.

253. *Question*:—What is the ideal moisture content for packed teas? If I pack my teas with 5% moisture, what would be their moisture content on arrival in London?

*Answer*:—According to our investigations an ideal moisture content would be in the region of 4%.

If teas are properly packed for shipment, the gain in moisture on their arrival in London should not be more than half-per-cent, so that means that a tea packed in Ceylon with 5% moisture will on arrival in London probably have 5½% moisture, providing all suitable precautions are taken initially to see that linings are in good order and the chest is not loosely packed.

254. *Question*:—During the flavoury season is it correct to delay grading?

*Answer*:—We do not advise the delaying of the grading process in any weather. If grading can be done on the same day teas are fired, so much the better, but the teas should be cooled before they are sifted. Some factories, however, find it more convenient to sift the following day. We need hardly emphasize that in such cases the teas should be stored in covered boxes.

255. *Question*:—What should be the gain in moisture between firing and grading?

*Answer*:—Not more than 1%.

256. *Question*:—You have stated that a high outturn of off-grades is due to faults in manufacture. What about a low standard of plucking?

*Answer*:—A poor standard of leaf can very well be a major contributory factor to the increase in off-grades.

257. *Question*:—Should there be an increase in weight in the total quantity of tea after grading, compared to the weight of fired tea?

*Answer*:—If the weight of refuse tea is included, there should be an increase in weight. Otherwise, the total weight of grades would not normally be more than that of the fired tea.

## ONE DAY COURSE IN TEA MANUFACTURE

258. *Question*:—Does the figure of 5% mentioned in one of your papers refer to the moisture content of tea leaving the factory or that at destination?

*Answer*:—Leaving the factory. Although 5% was mentioned we advise teas to be packed at a lower moisture content.

### Up-country:

259. *Question*:—Is 5% a suitable figure to reduce the moisture content to, after final firing?

*Answer*:—Since packed teas should not contain more than 5% moisture, a moisture content of 5% in the final fired teas may seem to be in order. But in view of the possibility of some gain in moisture in the process of bulking and cooling prior to packing, we advise that the moisture content be reduced to 4%.

260. *Question*:—Would there be a loss in weight during grading?

*Answer*:—Any losses that occur in grading would not be the result of teas losing moisture but due to waste tea, pickings, fluff etc. If the weight of refuse tea is not excluded, there should be no loss in weight during grading.

261. *Question*:—What is the loss of fluff which is taken out by the dust fan and not recovered?

*Answer*:—We do not deny that some such loss occurs, but we do not think it can be very much. We have not measured it.

262. *Question*:—What is the disadvantage in sifting hot teas?

*Answer*:—Hot tea is very brittle and in this condition the slightest rubbing of the surface tends to cause greyness.

263. *Question*:—How soon after firing do you consider it advisable to start sifting?

*Answer*:—Sifting can commence as soon as the teas are cooled. The period of cooling will vary according to the methods adopted. Under favourable conditions teas will be ready for sifting within a few minutes after being discharged from the drier.

264. *Question*:—What grades would you recommend to be put through the Electro-static Stalk Extractor?

*Answer*:—All grades except perhaps the O.P. However, it would be a waste of time passing the whole of each grade through the machine, unless it happens to be very stalky.

265. *Question*:—Is it in order to winnow teas before sifting?

*Answer*:—Indiscriminate winnowing of dhools is not the right thing to do since the grades will be winnowed in any case, and excessive winnowing is harmful. The later dhools and big

## GRADING AND STORAGE

bulk would, however, benefit from a preliminary winnowing prior to the commencement of sifting operations.

266. *Question:*—Are zinc topped tables suitable for red-leaf picking?

*Answer:*—We have nothing against any smooth surface for picking over of teas, but if the surface is dark as well it will be an aid to better picking because it will show up the red stalk more clearly.

267. *Question:*—Is it possible to have an even B.O.P. grade without having a B.P. grade?

*Answer:*—It is rather difficult but by the employment of a suitable cutter an even sized grade can be obtained.

268. *Question:*—I find that by adding only 5% cut leaf to the B.O.P. grade, I cannot overcome unevenness. What should I do?

*Answer:*—Use smaller cutter cells.

269. *Question:*—Is it true that quality and flavour are adversely affected when teas are passed through an Electro-static Stalk Separator?

*Answer:*—No. There is no evidence of this happening.

## MISCELLANEOUS

**Low-country:**

270. *Question*:—Do you recommend the use of detergents or caustic soda for washing the rolling room and its equipment, including fermenting tables?

*Answer*:—An occasional use of such compounds is permissible, but it should be followed by copious washing with water. Condy's fluid is safer to use, but the use of all these chemical agents is not at all necessary, if daily washing with water is carried out and the room opened at the end of the day's work.

271. *Question*:—What causes good creaming down of liquors?

*Answer*:—It is believed to be caused by a high concentration of red condensation compounds in the liquor. These are soluble in hot water, but separate out on cooling of liquors as 'cream'.

272. *Question*:—In a factory where different types of leaf are received, what should a teamaker do to produce the best possible tea?

*Answer*:—If it is feasible to treat each type of leaf separately on its own merits or demerits, a better tea can result than from mixing the leaf prior to rolling and grading. But it is not a simple matter to do this if several types are involved. There is no other way out of the problem.

273. *Question*:—Is it better to pick coarse leaf from green leaf or after withering?

*Answer*:—It is really simpler to pick out coarse leaf from withered leaf as the former is more conspicuous, but the only danger is that leaf may have to be heaped up for a considerable length of time and heating would take place in such circumstances. To eliminate this risk, picking can be done while the leaf is on the tats, and the operation repeated if necessary after the first roll when the leaf is being passed over the roll breaker.

274. *Question*:—What causes 'plain' teas? Can the type of roller table used be associated with this defect?

*Answer*:—It is most unlikely that any change in rolling equipment can bring about plain liquors. The primary causes are coarse leaf and poor withers. The defect need not in fact be due to any of these factors and can very well be caused by seasonal changes.

275. *Question*:—Can foul air affect the quality of tea?

*Answer*:—Yes, because of the presence of undesirable organisms.

## MISCELLANEOUS

276. *Question*:—Can good teas be produced from leaf of a newly pruned field?

*Answer*:—No. The only satisfactory feature such teas will possess is a good appearance.

277. *Question*:—If liquors from teas made from day manufacture are described as 'strong', would the same results be obtained from night manufacture?

*Answer*:—From the results of our experiments we expect a small loss in strength by the adoption of night manufacture because of the shorter withers. This will be offset by a gain in briskness.

### Mid-country:

278. *Question*:—Do you recommend the use of gunnies for transport of leaf? Which is better—coir bags or leaf baskets?

*Answer*:—Gunnies should on no account be used, for the simple reason that the leaf is still living and giving out heat energy. If the heat generated by the leaf is not allowed to escape, undesirable effects will result.

Leaf baskets are of course preferable to coir bags because of less damage to the leaf during transport, but whatever method is adopted, close packing of the leaf should be avoided.

279. *Question*:—I have observed a temperature of 125°F in a leaf bag and the leaf discoloured. Is this bad?

*Answer*:—Most certainly. When leaf is in this condition a chemical change somewhat similar to fermentation takes place, and will give rise to soft liquors.

280. *Question*:—I find that there is no agreement in Tasters' reports on my teas between London and Colombo. Could you please clarify?

*Answer*:—One probable explanation for this discrepancy is that requirements of the two markets differ. Whereas London would be placing more emphasis on colour and strength, and also briskness, Colombo would be more concerned with quality. Whatever the case may be, a difference in tasting opinion might very well arise from the fact that the samples are not examined at the same time. The type of water used can also affect the issue, and so can an error in sampling.

It is for these reasons we obtain as many opinions as possible on our experimental samples before drawing a conclusion. It is too much to expect unanimous agreement from different tea tasters.

281. *Question*:—What would you understand by the following report:—Strength improved, briskness improved but liquors plain?

*Answer*:—That the teas lack character.

## ONE DAY COURSE IN TEA MANUFACTURE

282. *Question*:—London requires a coppery infusion. How can I get this?

*Answer*:—For some unaccountable reason the infusions of Ceylon teas have tended to be greener in recent years. Whether it is due to heavier manuring or the cumulative effect of copper spraying, extra shade, or some other factor we do not know. If an infusion is greenish we cannot make it coppery by orthodox methods of manufacture but we can reduce the degree of greenness by more rolling and a longer period of fermentation. A softer wither also helps. In attempting to achieve this objective some loss of quality may result. So our advice in this respect is that if, with a greenish infusion, quality is maintained, it would not be worthwhile to risk quality for the sake of improving the infusion.

283. *Question*:—If low jat leaf and high jat leaf are manufactured under the same conditions which tea would fetch a higher price?

*Answer*:—We suppose the latter teas would command a better price, because of the extra colour and strength they would possess when compared to the liquors generally produced by low jat leaf.

284. *Question*:—What modifications in manufacture would you suggest for blister infected leaf?

*Answer*:—Shorter and softer withers and also a shorter period of fermentation.

285. *Question*:—Do tortrix caterpillars affect quality?

*Answer*:—There is no evidence to suggest this according to the results of some experiments we have carried out. We deliberately introduced the grubs into a roller to test this point because of a suspicion that they caused a taint. In practice, it is not likely that they will be present in large numbers, since they are inclined to crawl away from the leaf when it is plucked off the bush.

286. *Question*:—Can a greenish infusion be due to coarse leaf?

*Answer*:—Yes, but tender flush can also produce the same result.

287. *Question*:—Due to an excess amount of leaf for the evening weighing, would not it be better to have 4 weighings instead of the customary three?

*Answer*:—Yes, the sooner leaf is delivered to the factory the better. Most estates however do not favour the idea of sending too many batches of leaf because of the extra cost and inconvenience. But if it can be done we would strongly advocate it.

**Up-country:**

288. *Question:*—Is there any possibility of inducing flavour artificially?

*Answer:*—We are not aware of any agent that can successfully do this. Some time ago we came across an essence, which was claimed to produce such an effect, but on investigation we found that the flavour it introduced to tea was foreign to tea flavour, so much so that some tasters called it a taint.

289. *Question:*—The Brokers frequently report on my liquors being thin, but do not comment on quality. What should I do, as such reports appear misleading?

*Answer:*—There is no reason for any wrong impression being created. Thinness of a liquor has no connection with quality and refers to lack of strength. The only remedy is harder rolling and better expression of juices.

290. *Question:*—What is your recommendation for a factory that has to deal with a crop almost twice its maximum capacity?

*Answer:*—Substitute the hessian tats with nylon, increasing fan capacity at the same time, and work on a double shift.

291. *Question:*—Is softness of a liquor attributed to moisture content alone?

*Answer:*—No. It can also be caused by excessive heat in withering and rolling, and over-fermenting.

292. *Question:*—Can a soft liquor be detected by the infusion?

*Answer:*—Yes, if the infusion happens to be dull, but this is not an infallible test. If softness has been brought about by too high a moisture content, the infusion need not be dull.

293. *Question:*—Could soft liquors be brought about by tipping leaf?

*Answer:*—Yes, since such teas are without point or briskness,

294. *Question:*—Why are teas manufactured during the early morning period generally better than those made later in the day?

*Answer:*—Mainly because of the lower temperatures experienced in the rolling room.

295. *Question:*—It has been my experience to find that liquors are greener in the wet weather. When the weather is fine the greenish character disappears. Could you explain why?

*Answer:*—We must honestly admit that the cause of greenish liquors is still obscure. This applies to greenish infusions as well, and we are inclined to the view that greenness arises mostly from an inherent property of the leaf, and not from any manufacturing fault, unless leaf is purposely under-fermented.

## ONE DAY COURSE IN TEA MANUFACTURE

296. *Question*:—If teas are reported on as 'choppy', what is the fault in manufacture?

*Answer*:—This expression is used to describe a grade that contains too much of cut tea, obtained by the use of a cutter or breaker. These cut pieces of tea are easily distinguishable and should not be confused with leaf cut or broken up in the rollers, which is not so easy to recognize. The fault in manufacture therefore is that the dhools are too large in size.

The expression 'choppy' may also apply to a grade such as B.P., which consists chiefly of cut tea.

297. *Question*:—At high temperatures the enzymes are destroyed. What is the duration of time for this to take place?

*Answer*:—The survival of enzymes is limited at temperatures above 120°F and at a temperature of 190°F they are destroyed in a few minutes. At temperatures below 120°F and above 90°F, they are not destroyed but their activity is considerably reduced.

298. *Question*:—What effect has a short pruning cycle on quality?

*Answer*:—An adverse effect, particularly when weather conditions are favourable to the development of this characteristic.

299. *Question*:—What effect has the pruning cycle on colour?

*Answer*:—There is a tendency for colour to decline with the extension of the pruning cycle.

300. *Question*:—What is the effect of heavy shade on the characteristics of tea?

*Answer*:—A loss of quality with an accompanying improvement in colour. Flavour is also adversely affected by heavy shade. (Note:—The last 3 questions are discussed in detail in the Annual Report of the Technologist for the year 1962.)

301. *Question*:—When standards of plucking are low, is there anything a tea-maker can do to improve the standard of tea?

*Answer*:—One cannot expect to make a good tea from poor leaf, whatever is done in manufacture, but picking of the coarse leaf will assist in improving the standard. (See answer to question No. 273). Careful sifting to eliminate some of the coarser tea in the later dhools from the main grades will also help, but this cannot be done without increasing the outturn of off-grades considerably.