SOME ASPECTS OF TEA MANUFACTURE.

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During the past nine months I have had occasion to visit a large number of tea factories in various parts of the Island to examine the conditions of manufacture. These visits have given me a good opportunity to study variations in factory practice, and it is my intention in what follows to comment on a few of my observations.

It is generally known that the quality of tea is connected with its tannin content. Leaving aside those teas which sell mostly for their flavour, a fairly close relationship is found to exist between tannin content on the one hand and quality on the other. In the present state of our knowledge we are justified in stating that quality is connected more with the tannin than with any other constituent of the tea leaf, although modifying effects are introduced by the non-tannin substances. Chemical analysis shows that the younger the leaf the more tannin it contains. On this basis it is evident that where quality is the prime consideration, the use of coarse and overgrown leaf is detrimental, and the plucking rounds should be adjusted so as to avoid over maturity of the flush. Some of the other factors influencing tannin control have already been discussed in previous publications of the Institute.

It will be sufficient to state here that the amount of tannin present in the pluck varies with the season of the year and the conditions of growth, in other words with the physiological state of the bush. Thus leaf from a freshly pruned field is very poor in tannin and an experiment conducted on an up-country estate indicated that it was not till after the fifteenth round that the leaf regained its normal state. Again, as a general rule, rapid growth is followed by a flush of poor tannin content. Shade is also not without influence and, while moderate shade is beneficial, heavy shade may be detrimental to quality.

It is well to remember that tea manufacture commences from the moment the leaf is plucked and the greatest care is necessary in handling the pluck if serious damage is not to occur before the leaf even reaches the factory. Bruising is the most common fault, being frequently found where wireshoots and ropeways are employed without proper precautions being taken to minimise the force of impact at the receiving station. The importance of avoiding bruising will be appreciated if it be realised that when this occurs, the enzymes or ferments present in the leaf are brought in contact with the other cell constituents and premature fermentation is set up. Such leaf will, therefore, invariably be irregularly fermented with resulting loss of quality. Another far too common fault is overheating, owing to the leaf being packed too tightly in the plucking baskets or allowed to remain in heaps before being spread on the tats. Owing to the fact that respiration is taking place in the leaf, there is a considerable production of heat and the temperatures attained in leaf baskets or leaf heaps is much greater than is usually appreciated, and may be a cause of serious damage.

Carpenter and Harrison have shown that at high temperatures the leaf becomes reddened due probably to chemical changes in the tannin. At a temperature of 138°F. this change may occur in 10 minutes, whereas at 115° more than three hours is required. The importance of keeping the leaf cool is therefore obvious.

WITHERING.

It is not within the scope of this article to deal with the details of withering arrangements but only to discuss certain general considerations. Attention must again be directed to the risk of bruising the leaf while this is being spread on the tats, this often occurs owing to the leaf being trampled on by the coolies or by unnecessarily rough handling.

The two essentials of withering are firstly, to secure conditions which lead to an even and uniform wither and secondly, to turn out from day to day leaf of approximately equal moisture content. Loss

of moisture during withering occurs principally from the leaf surface, moisture from the stalk diffusing through slowly to the leaf. If the loss of moisture be too rapid, as when the atmosphere is too hot or dry, the leaf dries up and may even become black, while the stalk is still insufficiently withered. At the same time the young buds also become dried out, leading to a greying of the tips. Such conditions not infrequently occur when artificial means of withering are used without adequate control. In such cases temperatures in the neighbourhood of 100° may be encountered, particularly round those tats close to the hot air intake. Rapid withering at high temperatures results in mottling of the leaf and is highly detrimental. Provided, however, that proper precautions are taken there is little reason why artificial withering should not give approximately as good results as natural methods. The use of warm air should be restricted if possible to the removal of the surface moisture in the early stages of withering and should not be used to force a wither in the later stages. The latter practice leads to too rapid drying of the leaf surface, leaving the interior still too moist, in other words the condition of the leaf is not homogeneous. Quite frequently it should be possible to secure a wither in a reasonable time by employing the fans without using hot air from the driers. A greater movement of air through the loft is obtained in this way without the disadvantage of high temperatures and it is a practice which might be more frequently utilised.

Owing to the high resistance met with when air has to pass the whole length of a long loft, the fan capacity must be ample and sufficient to replace the air in the loft at least every two minutes. The fan capacity should also be related to the capacity of the drier fans and the bulking arrangements such that proper admixture of hot and cold air in the required proportions can be attained. Very frequently one finds the fan capacity limited by the narrowness of the inlets to the fan chambers and from the fan chambers to the lofts. In such cases pockets of stagnant air will be found and the wither will be uneven. It is needless to say that all lofts should be equipped with hygrometers so that the temperature and humidity of the air being used is known.

In some factories tats are employed with too steep a slope, sometimes as much as 1 in 6. Such tats offer a very high resistance to air movement and are a frequent cause of trouble, particularly when facilities for reversible withering are not available, the air passing through the loft too slowly to secure an even wither at the two ends. Temperature and humidity condition should be as uniform as possible throughout the loft and this is more easily attained if tats with a slope not exceeding 1 in 18 or 20 are employed. The leaf

should be withered down to a definite water content. This is the first step in standardising manufacture, since if this be done rolling, fermentation and drying will take place under definite conditions. The usual system employed is to wither the leaf to a definite loss of moisture after applying a correction for the "wetness" or external moisture on the leaf. This correction will vary within wide limits and, being difficult to assess with any accuracy, this method leads to very varying withers. If no correction for wetness be made and the leaf is withered to a constant moisture content, the degree of wither as conventionally expressed will naturally vary considerably at different seasons and this figure has really little meaning. Thus if a 50% output on made tea to *withered* leaf is aimed at, the degree of wither might be 56% on a dry day or 36% on a wet day, the output of made tea on *green* leaf being 28% and 19% respectively. Although these figures are so different, the condition of the withered leaf on the two days in question would be the same in its relation to rolling, fermentation and drying. It would on all grounds seem preferable to abandon the present system of expressing withers and to control the uniformity of the wither by determining the output of made tea on withered leaf. If withered leaf of constant moisture content is produced from day to day, as is desirable, then this percentage should be constant.

Uniformity of wither has been emphasised above. This, apart from the considerations just discussed, also demands careful attention to plucking so that the green leaf may be as uniform as possible. Tipping leaf should if possible be treated separately.

The principal aim of withering is to reduce the turgid leaf to a flaccid condition suitable for rolling. Physical changes also take place whereby the leaf cells become permeable to the juices. At the same time chemical changes also occur but the nature of these is at present but imperfectly known. In the absence of more precise knowledge it must suffice to say here that there is every reason to believe that the normal withering period of 16-20 hours, which is common practice in Ceylon, permits of these changes taking place in a satisfactory manner. Teas made from unwithered leaf possess no character but there is yet little reliable evidence as to the limiting periods for withering. The conditions under which withering occurs, particularly the temperature, and probably the nature of the leaf, will influence the period in which optimum results will be obtained. Unduly long withers at high temperatures are, however, generally detrimental and may in extreme cases lead to souring of the leaf.

Withered leaf has naturally a higher sap concentration than the fresh leaf and this concentration has some effect on the rate of

fermentation. It is, in fact, possible to control the rate of fermentation, within certain limits by variation of the wither, a soft wither giving a slower fermentation. This could be utilised in the low-country where there is a tendency, owing to the high temperatures, for fermentation to proceed too quickly.

While it is impossible to prescribe a wither suitable to all factories, we can say roughly that the figure for the out-turn of made tea on withered leaf need not be lower than 40% for a low-country nor higher than 50% for an up-country factory.

ROLLING AND FERMENTATION.

The aim of rolling is to to bruise the leaf and mix the cell constituents which on exposure to air undergo a specific chemical change. These changes are responsible for most of the characteristics of black tea. The leaf cells having been rendered permeable during withering, the juices are readily expressed during rolling. At the same time shearing occurs and the leaf becomes broken up and twisted. Excessive shearing is detrimental, it is not conducive to appearance and less juice is expressed by this action than by a good twist which results in rupture of a greater number of cells.

The breaking of the leaf, as also its twist, is controlled by the physical condition of the leaf, by the type of the roller and battens, the speed of rolling and the pressure employed. The extent of sweep of the leaf box has also to be considered. Generally speaking, sharp-edged battens, high pressures, fast rolling and double or triple action rollers tend to cut the leaf excessively. In the earlier rolls twist should be of primary consideration as the leaf juices are thereby better expressed; cutting, however, is required in the latter rolls to deal with the fibrous stalk.

The application of pressure must be adjusted according to the wither. If heavy pressure be applied to soft withered leaf, the leaf yields to the pressure and takes little twist nor is it properly broken up. Light pressure should, therefore, be used as a rule with soft withered leaf, heavier pressures being possible with hard withered leaf. In any case the application of pressure should be graded, otherwise the leaf is broken up in an irregular way.

It is very general to roll in the initial stages without pressure on the ground that the application of pressure is liable to discolour the tips. Although this appears to be true when the pressure is excessive, under light or "quarter" pressure it rarely happens. Moreover, the so-called loss of "tip" is more often apparent than real. Under pressure a large dhool is obtained and the tip may, therefore, not show up so prominently as it would if the dhool were smaller. Pressure, however, is by no means the only factor determining the

size of the dhool. I have seen first dhools amounting to 25% in one case and only 3% in another, the rolling in each case being conducted with the "cap just touching". In the former the roller was a triple action machine with sharp battens, in the latter a plain table was used. The tips in the first instance were broken though no pressure had been employed.

Actually greying and discolouration of the tip would appear to occur more frequently during withering than during rolling.

The application of pressure when hard withers are employed, is not merely optional, but, in my opinion, a distinct necessity in order to squeeze out the sap. When a sample of the fired tea from the first dhool is infused, a thin liquor without quality or strength is obtained whenever the rolling has been conducted without the application of pressure. But when rolling has been carried out under pressure, the first dhool gives liquors having both body and strength. In the usual method of brewing the tea it is the soluble matter from the superficial layers of the leaf that is extracted, and when liquors with body and strength are required it should be the aim of rolling to press out the leaf juices and bathe the twisted leaf in it. As has been said elsewhere pressures cannot be applied on "soft withered" leaf and therefore hard withers and pressure rolling are conducive to strong liquors. The practice obtaining in some factories, of separating the dhools and putting these back again into the rollers—a practice which is believed to give strong liquoring teas—finds its origin in the realisation that a thorough crushing of the cells and smearing of the sap on the surface of the leaf is a factor which ensures strength. This practice is not always advisable, as such leaf is exposed to the high temperature in the roller a second time, and also the chances of staining the tip are great. Just as good results could be obtained by the application of pressure on the leaf during the rolling without the disadvantages of prolonged exposure to higher temperature or loss of tip. This loss of tip is sometimes due to the fact that the small buds get enveloped in a larger leaf during rolling.

In this connection I might refer to rolling for appearance as distinct from rolling for liquors. Rolling without the application of extraneous pressure gives a good twist to the leaf, and this is greatly facilitated when the extent of the sweep of the rolling platform is large. The danger of breaking or discolouring the tips is a minimum and red stalk is not exposed. The appearance of the tea, is therefore, better than it would be under hard rolling. In the latter case, unless the leaf is well withered, the leaf is liable to be irregular and red stalk exposed. However, the tendency of the present day market, is to demand good liquoring teas.

Very little is known about the relative merits of the several types of battens in use. In the initial stages of rolling when twisting is primarily desired in order to wring out the leaf juices, (a greater number of cells are bruised as a result of twisting than by chopping) a rolling platform without any sharp-edged battens is preferable For the final rollings, however, the usual "economic" rollers are admirably suited in order to reduce the size of the stalk by cutting.

The question whether wooden or brass battens should be used is an unsettled point. It is frequently believed that wooden battens turn out teas giving brighter infusions. I have not been able to verify this.

Hard rolling has the same effect as fast rolling. Both give higher percentages of broken grades and tend to expose red stalks, which in extreme cases spoil the general appearance of the teas.

One of the main effects produced during rolling is rise of temperature. This is due to two causes. Firstly, chemical action and secondly, mechanical or frictional action. The intensity of the chemical action drops off with time and the mechanical action too, as the quantity of leaf for rolling gets reduced. Therefore, for equal pressure applied during the rolls, the production of temperature is greatest during the first rolling but steadily drops off with the number of rollings. The usual practice of rolling the leaf for the first 30 minutes without pressure but increasing the pressure for the later rolls, tends to equalise the temperature production during the whole of the rolling period.

The rise in temperature is relatively less important than the actual temperature obtaining within the roller, which to a large extent depends on the room temperature. Thus a rise of temperature of 20°F. in an up-country factory where the room temperature is 65°F may not be serious; but a similar rise in a low-country factory where the room temperature might be 80° is objectionable. As far as possible the temperature should not be allowed to rise beyond 86° and this should be considered a maximum limit. This may appear as a counsel of perfection in a low-country factory, but part of the soluble tannins are rendered insoluble at temperatures above 86°.

There are two ways of minimising the rise in temperature:—(1) cooling down the rolling room by an efficient humidifying device, the cooling effected in this way is considerable during the dry seasons; and (2) controlling the pressure application by repeatedly releasing pressure by raising the pressure cap, thus exposing the leaf to the cool atmosphere of the rolling room. When the pressure is released it may be advisable to break the balls of leaf formed during the rolling. The timing of the application and release of pressure should be adjusted according to the temperature produced.

The rise of temperature when the leaf is soft withered is generally less than the rise when hard withered leaf is being rolled, other conditions being equal.

Efficient roll breaking and sifting is of enormous value in cooling the leaf before the bulk is returned to the roller again. This process often receives very little attention. Particularly for low and mid country factories, not only should the cooling be complete but all chances of the small broken leaf entering the roller again should be avoided. In fact, it is often advantageous to conduct the sifting process twice, the bulk passing over the sifter being sifted a second time; the dhool then will not be uniform but it can be divided into two fractions, the usual dhool and the "Kambi". I have observed this fractionation in a few factories with splendid results. This deserves extended application in mid and low-country factories. The two fractions have to be fermented and dried separately, this will also prove advantageous in the final grading of the teas.

It has already been said that all precautions should be taken to see that the temperature in the rollers is not excessive. Fermentation takes place at an accelerated rate at high temperatures, provided such temperatures are not very high as in the driers, when it will be arrested. If rolling could be conducted without exposing the leaf to high temperatures, as for instance by the use of cooled rollers, it would certainly be an advantage. Extended rolling can normally only result in heating the leaf for protracted periods in the rollers. The effects of rise in temperature are not seriously felt when the rolling room is cool, say 60° or 70°, but such effects are seriously felt in mid and low-country factories where the rolling room temperatures are high. The number of rolls should, therefore, be reduced to a minimum in such cases. Long periods of rolling are popular because these result in a large percentage of broken grades. Further, some planters believe in breaking the leaf as far as possible in the rollers, preferring this to cutting the leaf in the cutters after drying. It is my opinion that both these considerations have been carried too far.

One of the principal, but often ignored, benefits of humidification, lies in the cooling effected thereby. This is perhaps of comparatively greater benefit for a low-country factory than the humidification itself. When humidification is conducted on right lines, without detriment to ventilation, the temperature of the room atmosphere cools down to within a degree of the wet bulb temperature. The latter is usually low when the atmosphere is "dry", and considerable cooling is thereby effected. On the other hand, if ventilation is poor, the wet bulb temperature inside the room rises and stands at a higher level than the corresponding outside temperature and, in extreme cases, it may be just a degree or two below the

dry bulb temperature. It is, therefore, necessary to check the room temperature against the outside, to ascertain whether or not the humidification is conducted on right lines.

Many factories are not provided with the modern systems of humidification. The usual practice is to hang hessian or coir curtains against the room windows, these being maintained wet by a current of cold water. In some cases the effects are satisfactory. The curtains should be hung against the windward side of the room. This statement may appear unnecessary but, unfortunately, I have known several cases where this is not done. The wet curtain arrangement gives reasonably satisfactory results when the blowing of the wind from outside is neither excessive nor too slight. When the blowing is excessive the surface of the fermenting leaf blackens and this results in dull and mixed infusions. This excessive draught may be obviated to a certain extent by the use of double curtains, both maintained wet. When the movement of air outside is slight, air can be drawn in by creating a mild suction in the room by artificial means, such for instance as by fixing up fan blades to the shaftings. I have seen this done in a factory with very good results.

Humidification prevents the loss of moisture from the surface of the fermenting leaf and consequent drying. Dried leaf hardly ferments at all. Stirring the leaf results in the exposure of fresh surfaces to the drying action and should be avoided. Teas fermented under non-humid conditions, with consequent surface drying, give dull infusions.

Any system of humidification resulting in a settlement of water on the surface of the fermenting leaf is faulty. Under this category come the various methods of spraying.

One of the methods employed for preventing surface drying, during the fermentation of the leaf is spraying the leaf with water, or even in rare instances a dilute solution of potassium permanganate. The treatment is repeated at intervals to make sure that drying does not occur. Soft withers are also taken during the dry weather and this is believed to overcome the surface drying. None of these practices appear to be sound. All these involve removal of additional quantities of water during the drying process, thus putting a strain on the drying machinery. When the addition of water is excessive, and this is not rare, fermentation is interfered with, and as all the portions of the fermenting leaf, in the ordinary course of things, are not wetted uniformly, unequal dilution of the leaf juices takes place, thus interfering with the uniformity of fermentation. The use of potassium permanganate is strongly deprecated. It is a powerful oxidising agent and oxidises the tea tannins.

Surface drying is less with a hard-rolled leaf than with a light-rolled leaf, as the former is well smeared with a layer of leaf juices which is not the case with a light-rolled leaf.

It should be remembered that the prevention of surface drying is not the only benefit of adequate humidification. Reference has already been made to the cooling and ventilation.

The rolling and fermenting rooms should be airy; and maintained scrupulously clean. The leaf should be handled as little as possible during the rolling, roll-breaking, or fermentation.

Fermentation is best carried out on cement floors. Experience shows that it is far easier to keep the floor clean than fermenting racks. In the majority of cases where racks are used, old leaf, sometimes putrefying or covered with mouldy growths, accumulates in the crevices or corners and often these are not accessible to scrubbing brushes. The floor, moreover, is usually a degree or two cooler than the room temperature. A comparison of the teas fermented on glass, asbestos, lead, wood and cement surfaces, showed that cement gives the best results.

Leaf should not be spread thickly on the fermenting platform. One of the means adopted to prevent surface drying is to spread the leaf thick. A thick spreading encourages a rise of temperature in the body of the fermenting leaf, and at the same time restricts the access of air to a large portion of the leaf. Fermenting leaf absorbs oxygen and gives out carbon dioxide, it should, therefore, have free access to fresh air. This is one reason why the question of adequate ventilation of the fermenting room is so important. A maximum rise of temperature of 7° was observed in the course of an experiment conducted at St. Coombs when the leaf was spread 3 inches thick and 4° when the thickness was reduced to $2\frac{1}{4}$ inches. No rise was detected when the thickness was $\frac{3}{4}$ inch, and it was only 1° when the leaf was spread to the more usual $1\frac{1}{2}$ inches thickness. The temperatures were recorded about half-an-hour after the leaf was spread on the fermenting floor, and kept steady for about 4 hours during which the readings were taken. In the first case the teas were reported on by tasters as giving dull infusions and disappointing liquors. With a $\frac{3}{4}$ inch spread surface drying was evident and the $1\frac{1}{2}$ inch spread gave the best result.

It is generally observed that later dhools ferment more quickly than the earlier ones, and, therefore, in an attempt to ensure a more or less similar degree of fermentation, the dhools will have to be fired in the reverse order, instead of the more usual regular sequence. If we assume 30 minutes' rolling periods, it is clear that the first dhool, which remained in the roller for the first 30 minutes, will have

fermented at the higher temperature obtaining in the roller for 30 minutes only. The second dhool will be in the roller for 1 hour, the 3rd for 1½ hours and so on. Fermentation is more rapid at the higher temperature within the rollers than on the fermenting platforms, and, therefore, the fermentation of the 3rd dhool when it comes out of the roll breaker will have proceeded to a much greater extent than that of the first dhool. The argument, however, cannot be carried too far, for there is a varying amount of leaf juices squeezed out roll after roll, and as the leaf gets depleted of juices the fermentation slows down. Further it would not be possible to wait until all the dhools are ready before starting firing, for then most of the dhools would have become over-fermented. Generally speaking, where pungent brisk liquors are required, the fourth and subsequent dhools should be fired soon after roll-breaking and the earlier dhools as soon as possible after the fourth. If the room temperature is high, even the third dhool should not be allowed to lie on the fermenting tables, but fired soon after roll-breaking. Longer fermentation may be necessary if coloury teas are required.

Fermentation is followed by diminution in pungency and increase in colour. Long fermentation results in loss of briskness and the liquors become dark and dull. The infusions too become dull. The degree of fermentation to be aimed at depends on the type of tea required. Nosing is a reliable index of fermentation.

Scrupulous cleanliness must be maintained in the rolling and fermenting rooms. After the day's work all the machinery and the floor should be thoroughly washed with water, and proper care should be taken to see that no leaf remains in the corners of the roll-breakers, the crevices in the fermenting racks or the battens of the roller, etc. Once a week or fortnight a thorough wash with a dilute solution of potassium permanganate should be given. Whenever this is done it is necessary to finish off the cleaning with a liberal supply of water. The use of washing soda or soap is deprecated. Where trolleys are used for receiving the rolled leaf from the rollers, these should be thoroughly cleaned after the close of the day's manufacture. It is very unfortunate that these troughs rarely receive attention. If hessian is used for receiving the leaf from the rollers this requires a periodical washing. All oil stains should be removed.

FIRING.

The two principal consequences of firing are the checking, or, as it is more usually called, "fixing" of the fermentation and the reduction of the moisture content of the leaf so as to ensure its keeping qualities.

Sun-drying, practised at some seasons of the year in a few places, results in a black tea which on brewing is liable to give a liquor with a metallic taste. The product fired in the usual way is free from such a taste. Further a sun-dried tea does not appear to keep well although, when fresh, it possesses more flavour than the tea fired in the usual way.

Fermentation is arrested when the leaf is subjected to a temperature of 150°F, but a much lower temperature is sufficient when the leaf is subjected to a blast of air. It appears that a temperature of 120°F is quite sufficient to arrest fermentation under such conditions.

The usual practice is to expose the leaf to a fairly low initial temperature in a blast of air and then to gradually increasing temperatures. It is clear that the initial exposure should be enough to arrest fermentation, or about 120°F. Loss of water also takes place at this stage. This loss is from the surface and is made good by the transference of water from the core. To ensure uniform drying, therefore, the rate of loss of water from the surface should equal the rate of transference from the centre to the surface. If the former is too rapid, as happens when the leaf comes into contact with a blast of unduly hot, dry air, the surface dries up and becomes hardened. This phenomenon is usually referred to as "case hardening." The moisture from the core cannot escape; as the surface has become hard and offers a high resistance, unless the leaf is subjected to a very high temperature, enough to cause a high internal pressure of the water vapour enabling this to overcome the resistance of the hard shell and escape. When this happens tiny blisters appear and are noticeable with some "high fired" teas. This is known as blistering.

If the leaf is initially exposed to too low a temperature, fermentation is not arrested, but continues in the drier in an atmosphere of warm humid air, and "stewing" results.

It is, therefore, clear that the fermented leaf in the *initial* stages should be surrounded with air at a temperature high enough to arrest fermentation, but not so high as to cause "case hardening". Experience shows that this is achieved when the temperature is about 120°F. Loss of moisture from the leaf should be gradual and uniform, and the tea coming out of the drier should contain 3-4 per cent moisture.

Experiments carried out in India and Japan have shown that exposure of leaf to a high temperature is detrimental to the tea and the optimum temperature for firing has been shown to be about 176°F. Higher temperatures spoil both flavour and colour, the soluble substances and tannin decreasing remarkably. According to

Carpenter and Harler high firing results in loss of briskness and strength, and the tips may be destroyed. Teas fired below 140° do not keep.

A proper gradient of temperature and humidity is established when the machine temperature is about 180°-200°, and the exhaust temperature 110°-120°. Under these conditions briskness is maintained and the loss of tannin bodies is a minimum. An exhaust temperature above 120° indicates that firing is not being carried out on economical lines as that only means loss of utilisable heat.

"Case Hardening" appears to be more common than "stewing". The working temperature is often maintained high in order to obtain "brisk" teas and the leaf is spread very thinly on the trays; this is carried too far. A case hardened tea has very poor keeping qualities. The moisture from within the leaf gradually diffuses to the surface and the teas lose their crispness, and appear to all intents and purposes as "underfired" teas. It frequently happens that the machine temperatures are raised in order to overcome this supposed "underfiring", and case hadening becomes worse. By lowering the working temperature, and ensuring correct exhaust temperatures. this case hardening can be avoided.

Fermentation continues in a case hardened tea. I have already mentioned that the moisture content of such teas are high unless they are blistered. When the outer shell has become hard, the inner wet core appears to keep comparatively cool and the enzymes responsible for fermentation are not inactivated. During the period of storage, the fermentation continues and the tea lose briskness and pungency. The infusions as well as liquors become dull.

There are four ways of ensuring the correct exhaust temperature. The first and most obvious way is to raise or lower the machine temperature. This can be done only within limits, as has already been mentioned. The load on the trays can be altered. Cooling is effected by increasing the load as the quantity of leaf in relation to the quantity of air increases and *vice versa*. The third method is to alter the fan speed and increase or decrease the quantity of air drawn through, and lastly the speed of movement of the trays can be altered. Slower movements tend to raise the exhaust temperature.

Even firing is essential to secure a homogeneous product. This is obtained by maintaining an even distribution of the air within the drier. I have examined several driers where this is not the case. More usually the hot air is thrust into the forepart of the drying machine and the temperature in the back portion is very much lower. I have found differences as high as 20° between the front and back portions of the tray which first comes into contact with the heated

air from the drier. This difference is to be attributed to constructive defects in the furnace. The distribution of the air becomes more uniform as the exhaust is approached. Most factories aim at maintaining a more or less uniform working temperature and this is also essential to ensure even firing.

Flavoury teas suffer considerably at high temperature. It should be remembered that the essential oil which is responsible for the flavour is volatile with steam and is therefore, lost on exposure to high temperatures.

Prolonged drying also renders some of the soluble constituents of the leaf insoluble.

Hard firing is desired by some blenders as the teas show more briskness. Briskness is however maintained if the exhaust temperature is about 120° and "stewing" is avoided .

There is another important aspect of firing which has not received much attention. The "stalky" dhools, by which I mean the 4th and 5th dhools, take a slightly longer time—about 2 or 3 minutes—to be properly fired than the more leafy grades. When all the dhools are fired in the same way it is found that the later dhools contain a higher percentage of water.

Final Firing.—From the work carried out in India it appears that teas containing 5-7 per cent moisture undergo a "post fermentation" which is responsible for a "mellowing" which leads to an improvement in the quality. If the moisture content is below 5 per cent, this process does not take place. Teas containing more than about 7 per cent moisture are liable to get mouldy and tainted. Therefore, final firing, unless the moisture content is above 7%, may be definitely harmful, (1) by arresting the post fermentation and (2) by reducing the quantity of saleable tea.

Final firing should be considered a necessary evil during some parts of the year when the teas are liable to contain more than 7% moisture. It is to be regretted that many factories practise final firing as a routine before packing.

Final firing, when necessary, should be carried out at temperatures not exceeding 180°-200°.

PICKING, GRADING, AND STORAGE.

Fired teas usually contain 3-4 per cent moisture when they leave the drier but they absorb considerable quantities of moisture during the picking of red stalk and grading, particularly during the picking out process. This absorption is a minimum if the work is carried out in an atmosphere of 60-65% humidity. Below this teas lose moisture, and if the humidity is greater than 60-65% they gain

moisture. It is, therefore, necessary to carry out these processes in a room maintained at about 60-65 per cent humidity. This should not be difficult in most factories, as a current of warm dry air can be drawn into the room from the drier. Grading rooms should be equipped with hygrometers, properly maintained. The fluff makes the muslin dirty and therefore frequent renewal is necessary and a draught of warm dry air created whenever necessary. The room should be damp-proof.

The storage space should be adequate and the teas should not be allowed to lie about. The bins should have no leaks and should be fully exposed to the atmosphere of the drying room.

Grading depends upon the market requirements and does not come under the scope of the present article. However, the leaf should be handled as little as possible in order to prevent greying. The blackness of the tea is confined only to the superficial layers and when the teas rub against hard surfaces, this layer is rubbed off and teas become grey. It is better to reduce contact with metal as much as possible. Greying is assisted by fast or rotating movement of sifters and the teas should be subjected to as few cuttings as possible.