TEA MANUFACTURE*

J. LAMB

I am going to make this address short and to confine myself to broad principles rather than to details. To deal with details of any of our main lines of research would take a very long time and would also usurp the function of our journal the *Tea Quarterly*. Furthermore, I am sure that the most important thing about this personal contact is to afford an opportunity for the asking of questions. To stimulate questions, I think the best thing to do is to give a general account of our work, but in doing this I want to preserve a sense of perspective. It must be difficult for you to see our work in its true perspective when you are only able to form impressions from reports, probably read at long intervals, and perhaps from an occasional rocket let off by the press, about some particular aspect of our work.

With this end in view I shall divide my report into three sections. The first will deal with pure scientific research which is too technical for publication in

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the *Tea Quarterly* and is published in scientific journals. This work makes a contribution to science as a whole and I shall make only a brief mention of it so that my account shall be balanced. The second section will deal with applied science ; that is science applied to present methods of manufacture with the object of improving existing methods and machines. The third section will deal with what may loosely be termed invention and deals with long term projects which may not bear fruits for some years to come.

Firstly, then, our activities in pure scientific research. Our principal contribution has been the discovery that the enzyme concerned in tea fermentation is a copper protein compound. We have also been able to indicate something of the mechanism by which the constituents of green leaf are converted into the coloured aromatic compounds which we drink. This work has been of some general scientific interest and the *Biochemical Journal* has accepted seven lengthy papers on this subject.

We also interest ourselves in all analytical methods pertaining to tea, and keep a routine check on conformity to the Food and Drug regulations of the principal consuming countries. Some years ago we had to undertake a lengthy investigation of lead contamination. We also make it our business to keep informed on the biochemical aspects of human nutrition and on the consideration of tea from this angle. Tea contains valuable stimulants, vitamins and elements essential to modern diet. The occurrence of fluorine, which has recently been found to play a vital role in the prevention of dental decay is of special interest to us at the present moment. I have brought all our analytical figures on the occurrence of this element *in* Ceylon tea with me to London for discussion with Mr. Huxley. I believe that much could be done by closer co-operation between the research and propaganda organisations attached to the tea industry.

I now propose to deal with the second section and our attempt to improve existing methods. On this matter I have the most to say, because it concerns the greater part of our work. I will take the various stages of manufacture in their proper order :—

Firstly, therefore, I will deal with withering. Our chief object has really been to dispense with the process in its present form. Withering is responsible for an entirely disproportionate part of our building and working costs, and is directly responsible for our factory fire problem. We now know that withering is little more than a means for making rolling possible and that it has little inherent virtue. Freezing and thawing will, under certain conditions, render leaf flaccid and capable of taking a twist without going through the ordinary withering process. We are in touch with a British firm of refrigeration engineers and hope to get suitable machinery for semi-commercial scale tests. It is feared, however, that treatment of this nature will prove too expensive, and there is very little practical scope for methods which increase our cost of production. At the moment it is not possible to be certain what the cost of this particular type of treatment would be, and we must carry out further tests before the point can be settled. We have also investigated techniques employed in the dehydration of vegetables with the hope of simplifying and speeding up the withering process. The basic difficulty is to kill the leaf and to destroy its resistance to withering without destroying the enzymes responsible for fermentation. Whilst the leaf is still living, it has a high natural resistance to loss of fluid, but once dead it dries more like wet cloth, and

a comparatively small amount of dry air will wither it down to the requisite degree, in a short space of time. We have found a method for doing this, but unfortunately it requires a high degree of technical control, and is not suitable for operation by our present labour.

In all our research we have to take into account the fact that we have little or no technically skilled labour available in tea factories and that many possible approaches are barred by this obstacle. I shall deal with more radical solutions to the withering problem in the last section of my address.

The next operation, namely rolling, is the one on which we are doing most work and is the principal subject of my address. I have repeatedly emphasised in our publications that present rolling methods are little more, in effect, than the original hand rolling process carried out with a certain amount of mechanical aid. Development of more economical methods is severely limited by the necessity for maintaining a traditional appearance of product, and is a handicap from which most other industries have escaped.

The basic object of rolling is to express the sap or juices from the cells of tea leaf, and to enable the enzymes or ferments to obtain oxygen from the air so that they are able to oxidise the substances which then give rise to the pleasant colour, flavour, and aroma, which are associated with a cup of of tea. Present methods of rolling achieve this object by wringing the juices from the leaf with a twisting action. Little more than 50 to 60 per cent. of the juice is actually extracted and fermented. The rest of the juice stays in the cells and is thrown away with the spent leaf, unless the tea is stewed for long periods in the teapot, and even then, being unfermented, it gives an unpleasant bitter taste to the liquor. There is therefore plenty of room for improvement in rolling methods, but we must bear in mind that the trade at present insists on the traditional black, twisted appearance of the final product, and still views with suspicion any change of grading percentages. Our grades have not for many years past, borne any relation to the fine or coarse parts of the flush. The only approximately true grades are orange pekoe or rather nowadays, broken pekoe, which is made by cutting what would have become mainly orange pekoe. This grade consists almost entirely of stalk. Any part of the bud and two leaves may appear in any other grade. Grading percentages are therefore no more than mere mechanical sizes and I have recently been very surprised to find how much misunderstanding there is on this point.

Shortly after I first joined the Institute we commenced a long and detailed study of the mechanism of rolling and the functions of the many various types of battens employed on roller tables. It really was surprising how little was known about the reasons for all the complicated shapes and sizes, but the explanation has proved to be a simple one. Only those portions of battens which cover the centre of the table, that is to say, the parts usually fixed on the door, have any real effect. In other words the greater part of the old types of batten are virtually useless. Much more effective rolling action may be obtained by accentuating the fittings on the door and removing the battens from the table iteself. Devices based on this principle are being introduced by engineering firms in Ceylon and although they appear simple in shape, their dimensions are very critical and their method of construction and fitting of the highest importance. The optimum dimensions vary with the size and type of roller. Much trial and error experimentation is necessary before they can be made available

for all sizes and types of rollers, and we are of the opinion that conversions should be left entirely to reputable engineering firms rather than to estate carpenters. Errors in dimensions and construction may prove disastrous, and we strongly recommend that estates should not be in too much a hurry to convert rollers.

Another interesting result of this investigation has been the unmasking of the pressure cap as an imposter. Far from helping the rolling process it impedes the vital action which, as I have mentioned, is the twisting or wringing action. The wringing action of the circular tea roller is entirely dependent on the circulation of leaf. As the leaf turns over and over in the jacket, the drag between the units (that is to say, the pieces of flush comprising two leaves and a bud) twists up the leaf and imparts the wringing action. In other words the leaf rolls itself, once set into motion and kept churning over. As soon as dhool separates, the wringing action is finished because the dhool particles are too small to grip each other with any force. In fact dhool separation is the result of the units adjusting themselves in such a way as to offer the least resistance to the motion of the roller. I have always suspected the pressure cap, because it obviously arrests circulation of leaf, and therefore must impede the twisting process.

When the cap is screwed down tightly it induces another type of dhool formation. The leaf compressed in the jacket by the pressure cap is dragged round and round over the battens and torn to pieces by sheer abrasive action. Thus dhool may be torn off from leaf which is not properly twisted and poor liquoring qualities will result from this type of action. In practice we have of course adopted a compromise and have raised and lowered the cap at frequent intervals as well as varying the degree of pressure applied. The so-called light pressure rolling will allow a certain amount of circulation to take place in the jacket provided the centre battens are reasonably efficient. In the newer, so-called cone-rolling method the projection or boss attached to the centre of the table, stirs the leaf like a gigantic spoon and intensifies circulation and the resultant twisting action. Also in addition to the twisting action, the leaf caught between the projection and the jacket is given a hard nip which greatly assists the extraction of juice and the formation of dhool, but here again if the gap between the projection and the jacket be too small the leaf is smashed rather than twisted into dhool. The most critical feature in the design of this type of roller is the dimension of this gap between the projection and the jacket in relation to the diameter of the jacket and the crank throw. If the dimensions are wrong, leaf will be smashed and torn and severe damage may be done to the roller, and that is why we strongly recommend that conversions should be carried out by engineers with experience of the method.

It is most important to realise that once leaf is reduced in size, the wringing action is much more difficult to apply. Dhool of a sort could be produced by a cutting action alone, but only the cells along the cuts would be ruptured. To apply the twisting action to the rest of the cells in the small strips of cut tissue becomes infinitely more difficult than it is in entire pieces of flush. For this reason it is undoubtedly best to take small first dhool percentages so that the whole flush is thoroughly wrung out before it is reduced to dhool. Even with the new types of fitting it is best to concentrate on twisting in one type of roller and to use another type of roller for reduction to dhool. This, in practice means a large gap between jacket and projection for first rolls, and a smaller gap for later rolls. Once leaf is well twisted it can be reduced

to any desirable size very quickly, and this size should logically be governed by the size of leaf required by the various markets rather than by any conventional or traditional percentages of so-called grades.

By employing these newer methods three twenty-minute rolls may do all and more than four thirty-minute rolls on the older types of table: that is to say sixty minutes' rolling time, in place of one hundred and twenty minutes' rolling time. This pratically doubles the output per roller and per cooly. In addition, owing to the ease of charging into an open top jacket and the elimination of the necessity for constant pressure cap manipulation, labour is further reduced. Throw-out of leaf is also done away with because the plain table allows the jacket to be lowered to within a very small clearance of the table. I should like to point out that two engineering firms have done a great deal of work in Ceylon on this type of rolling and that we are not claiming any exclusive credit for its development. It has been our happy privilege to work in close touch with most of the engineers in Ceylon and freely acknowledge that we have gained as much as we have given by co-operation.

In 1938 whilst we were in the earlier stages of unravelling the complications of ordinary rolling, we were fortunate in coming into contact with Mr. Clive Meares who brought a new type of rolling machine to Ceylon. After seeing some of his earlier results we were unable to ignore the fact that the machine was capable of producing teas of outstanding liquoring quality, although the appearance of the teas made by this method was at this stage very poor. We suggested that further experiments should be carried out at St. Coombs and Mr. Meares worked with us for over a month, in which time we together succeeded in making teas of orthodox appearance without any serious diminution of the fine liquoring quality. Experiments passed on to a fully commercial scale of working and we sold invoices of these teas on the London market. We carried out normal and Clivemeare manufacture on alternative days during both monsoon and dry weather periods and in both cases the Clivemeare roller produced teas which actually sold at a penny to threepence better than the normal teas. When I came home at the end of 1938 I was able to discuss these invoices with blenders, and they were quite definite about their usefulness and quality. Only a few weeks ago, one of the principal London blenders commented on the good quality of these invoices which he had remembered from 1938.

If it had not been for our contract with the M.O.F. which precluded the alteration of our grading percentages we should have continued Clivemeare manufacture at St. Coombs. The process increases the percentages of fannings and dust at the expense of leafy pekoes. The B.O.P. percentage is unchanged.

I have previously referred to misunderstanding about grade percentages and have been astonished during recent visits to blenders, by the amount of cutting and even grinding which is applied to teas before blending. The production of small teas in tea factories themselves has, of course, increased enormously during the past decade, but it appears to me that we shall be asked for much more smaller tea in the future and I must say that it is much better for everyone concerned to carry out this reduction in the rolling room rather than to cut and grind dry leaf. The Clivemeare roller therefore fits in with a current trend and we recommend it for earnest consideration, along with cone rolling.

Having given some indication of the practical promise of these particular experiments, I want to explain how the underlying theory of this method of rolling has influenced our lines of thought.

I have said that the expression of juice and exposure of juice to air and constant enzymic activity is the basic requirement of rolling. I have also explained how the circular tea roller depends upon a twisting or wringing action to achieve this purpose. Now I want to put it to you that there must be quicker and more efficient ways of getting juice out of the leaf than by twisting or wringing and I am quite certain that there are.

The Clivemeare roller is a precision machine consisting essentially of two stainless steel cylindrical rollers like a rubber roller or domestic mangle. In Clivemeare manufacture the gap between these rollers is adjusted to 10/1000th. inch and withered leaf is passed through this gap to give it an intense nip and disrupt as many cells as possible without breaking the leaf up entirely. After this, a single roll in an ordinary roller is enough to complete the rolling process, and impart an orthodox appearance to the finished product. The method is therefore simple and economical as well as effective. Here I must leave rolling although I shall follow up the same line of thought in the final section.

The next stage in normal manufacture is fermentation, and with regard to this stage I may say that our laboratory investigations have shewn that fermentation is made or marred by rolling, and all that can be done after rolling is to provide an ample supply of humid air.

With regard to drying, I have only to say that all the results of a long and intensive series of experiments on tea drying were published sometime ago. We have specified the best drying conditions for Ceylon manufacture and have taken into account all factors, including keeping quality which I think is really the most important. We have no cause to change our recommendations and believe that the present method of drying tea is efficient and that it will remain unchanged for a considerable time. We are considering modern high frequency electrical methods but fear that they will anyway prove too expensive to apply to tea drying.

I now come to the final section in which I intend to deal with the more inventive side of our work which is concerned with future requirements and prospects. Our costs of production in Ceylon have already risen to alarming heights and it is difficult to be optimistic about long term prospects. I am sure that much will depend on our ability to reduce or even maintain levels in view of rising labour costs and generally difficult labour conditions. We have to face up to problems which have confronted many or most other industries during some period of their history and much will depend on our adaptability in the fairly near future.

Such operations as withering will have to be modified or eliminated. Withering takes practically half the present factory labour and also necessitates our large inflammable factories. Acreage per factory is limited because of transport problems raised by the care required in the handling of leaf which has to undergo a withering process. A fire in a large factory also causes more serious disorganisation than a fire in a small one, apart from the fact that capital loss is greater. Rolling is another tiresome process at present involving much handling which could only be eliminated by the most complicated conveyor systems and being a batch process is altogether uneconomical compared to continuous or line processes employed by most modern industries.

I have already inferred, when dealing with our rolling experiments, that rolling in a circular type roller is only necessary because of the traditional appearance of the twisted leaf, and that withering is only necessary because of the fact that the wringing action can only be applied to withered leaf. Fresh leaf merely breaks up into fragments when rolled in an ordinary roller. If we can make a good liquoring product by cheaper and simpler means why should we remain for ever bound to a particular style of product? Flour, sugar, houses, motor cars, clothes all change their appearances during the course of the years and there is no reason why the appearance of tea should not change. The majority of tea consumers are certainly not enraptured by the beauties of black, well twisted leaf but are undoubtedly shrewed judges of a pungent, aromatic liquor which has a pleasant bright red colour after milk is added. Such changes cannot take place overnight, but even now the appearance of the leaf is slowly changing and all popular brands are at least much smaller in size than they were even a few years ago.

Instead of wringing juice out of cells on to the surface of leaf, where it can ferment, leaf can be instantly reduced to a mass of broken cells and this mass can be aerated so as to produce a complete fermentation, of almost all the contained juice, instead of a fraction of it as at present. We have done this by passing green leaf through the Clivemeare roller with the rollers touching, that is through a gap of less than 1/1000th inch as against the 10/1000th in use for Clivemeare manufacture. At first, after drying the mass, we compressed it into cakes which could be broken down, blended and re-compressed into tablets. In these particular experiments we did not aerate the leaf sufficiently during fermentation and a slightly bitter character resulted in the liquors. As you know, the idea of tablets was not received at all well, although the matter was distorted by the most unfortunate publicity which we regretted even more than you did.

Our most recent experiments have been devoted to complete aeration during fermentation, and to the production of imitation B.O.P. fannings and dust. We can produce dry leaf which is passable in colour and appearance within two hours of the arrival of the green leaf at the factory by what is still an extremely simple process, although not quite so simple as the first process. I have recently taken samples to Messrs. Brooke Bond, English and Scottish C.W.S., Liptons, and Lyons and all have agreed that the liquoring qualities are good, and I think I could justifiably say exceptionally good, especially when the teas are milked. The difference between normal teas and new process teas made from the same batch of well-bulked leaf is really very remarkable when milk is added. I have also been assured that we have not lost any Ceylon character or flavour. One blender told me that they are accentuated and that one chest of this tea would give as much Ceylon character and flavour to a blend as two or three chests of normal tea.

This all sounds very promising, which I think it is, but of course, there is a catch in it, and that is the leaf is lacking in weight. A ½ lb. of this leaf will not go into a standard ½ lb. packet. Blenders are not, at least at the moment, prepared to entertain the idea of increasing the size of their packets and would find great difficulty in using the leaf. However, when I return to Ceylon I shall try to overcome what we hope will be the last obstacle, and I hope that when I next come home on leave perhaps I shall be able to report considerable progress along these lines.

DISCUSSION

In reply to an enquiry from Mr. W. Coombe as to the reason why ½-lb. of the

new process teas would not go into a standard ½-lb. packet, Mr. Lamb said that they were too light and flaky, but supplementary methods are now being employed to increase the density. It was possible already to produce a shotty form of pekoe of which 120 lb. could be packed in a full chest, the minimum quantity required by blenders being 110 lb. He assured Mr. Coombe that not a single drop of juice was lost in the new process of rolling unwithered leaf.

Mr. Horner expressed the hope that, in all their experiments and research, the Institute would keep before them the consideration that standardised methods of manufacture might be disastrous to Ceylon. Many estates depended upon their own particular methods of manufacture for their market and had everything to lose by the present craze for large-scale planning and bulk buying. Those in London were no less receptive to new ideas than planters in Ceylon, but the Institute, which had deservedly acquired considerable prestige during the first 20 years of its existence, should continue to be the servant rather than the leader of the Industry and should attempt nothing which would tend to destroy the individuality of each estate and its superintendent : the Ceylon tea producing industry was vitally dependent upon the special characteristics of its teas.

Mr. Lamb said that, as a result of sending samples to different parts of the world, the Institute was fully alive to these factors. At present they were rightly endeavouring to find out what the requirements of blenders were and the first obstacle to be overcome was that of filling the ½-lb. packet. Dealers' teas would continue to be manufactured by the old method : general standardisation was not an objective. It was a fact, however, that the special characteristics of individual estates still came through the new method of manufacture, and it was still possible for a taster to pick out teas made from old and young leaf and to detect seasonal variations. Any inherent quality was fully maintained.

Mr. A. A. Prideaux referred to an address given by Dr. Carpenter some years previously, in which it had been stated that withering was as much a chemical as a mechanical process but that less was known about the former aspect, and enquired whether the Tea Research Institute ignored the chemical side.

Mr. Lamb said that, so far as Ceylon conditions were concerned, there was no chemical change that a chemist could detect, apart from certain slight changes due to bacteria.

Lt.-Col. Agar enquired whether the new methods had only been tried in the St. Coombs Factory.

Mr. Lamb replied that the Institute had tried to meet this difficulty by bringing low-country teas to St. Coombs for manufacture there with the minimum possible delay in transit. Low-country teas, however, did not benefit so much from the new process as those from up-country estates because the quality was not there. It was hoped to establish a separate Research Station in the low-country in the near future but considerable expense would be involved.

In reply to Mr. George Brown, who enquired whether experiments on dehydration such as had been applied to vegetables had been carried out by the Institute, Mr. Lamb said that the difficulty had been to kill the leaf in such a way that it withered quickly and this had been overcome by a high temperature blast of 10 or 20 seconds' duration. In dehydration the objective was to kill everything, including the

enzymes and to avoid the change of colour that was necessary in the case of tea.

In reply to an enquiry from Mr. Cooke, Mr. Lamb said that there had been very little Legge Cutter manufacture in Ceylon and that he knew very little about this process. Mr. Napier Ford had recently shewn him some quite black normal looking teas but he imagined that similar difficulties with density occurred with this process.

Mr. Snelling, referring to the shotty pekoe which Mr. Lamb had mentioned, asked whether this was black or red in colour, and whether the liquor was similar to that of B.O.P. Mr. Lamb replied that the liquor was similar and that the colour of the leaf, though not entirely black, was blacker than many North Indian teas or teas from Uva and Maturata and not sufficiently red for any housewife to detect. These teas only contained a small percentage of dust.

Mr. Coombe suggested that the higher the specific gravity of the leaf the better so far as quality and keeping properties were concerned and that possibly some quality was lost in the new process, as a flaky tea would not keep so well as one with a greater density.

Mr. Lamb agreed that efficiency of manufacture could be assessed by the weight of the resultant teas, but this test was not applicable to teas manufactured by the new process. The loss of weight was purely a physical matter and, as in the case of paper cut into large or small strips, the amount which could be packed in a chest depended upon the size of the particles. The object of rolling the leaf smaller was to increase the density and to satisfy the trade demands.

The President concluded the discussion with a cordial expression of thanks to Mr. Lamb for his interesting lecture and for the replies which he had so readily given to the enquiries addressed to him.