STUDIES ON THE FIRING OF TEA.—I

J. LAMB

INTRODUCTION

Since the inception of *The Tea Quarterly* various articles dealing with the different aspects of the firing of tea have been published.

The general principles of drying were dealt with at some length by the writer at the Fourth Conference.[1] A series of articles dealing with Fuels for Tea Dryers [2] followed, and the relative costs of firing with various fuels, calculated from the results of exact experiments, were presented in the form of a "Ready Reckoner" in the fourth article.[3] Under wartime conditions the value of these experiments may be greatly enhanced and attention is drawn again to these articles.

At various times references have been made to the fundamental problems connected with the drying operation [4] and to our efforts in connection with the construction of apparatus for exact experiments [5, 6] on firing. This apparatus was finally completed about eighteen months ago and has since been employed in the elucidation of firing problems with a degree of accuracy hitherto unattainable.

Since the apparatus has already been described in the articles quoted above it is unnecessary to do more than give a brief outline of its main features.

1. Steam heating which allows exact control of temperature over the range normally employed for firing tea.

   A steam trap allows a measure of the heat used in any operation to be made.

2. A variable speed fan which allows a wide variation of air flow.

3. A drying chamber with six trays of circular cross section. Each tray is divided by aluminium partitions into four sections of equal area and each section is spread with from six to eight ounces of leaf thus ensuring even distribution of leaf in each tray. A plenum chamber with tubular orifices is embodied in the drying chamber to ensure evenness of air distribution.

4. As a further precaution to ensure stability of the conditions being studied the leaf from the centre section only of each tray is taken for bulking and subsequent report. At least twelve trays are loaded and passed through the machine before an experiment commences. This ensures stabilised conditions throughout any experiment.

OBJECTS OF THE EXPERIMENTS

In the tea drying operation there are a number of variable factors which may affect the quality of the finished product.

1. Moisture content of leaf to be dried.
2. Nature, (*i.e.*, coarse, fine, etc.) of leaf to be dried.
3. Temperature of the air employed.
4. Volume of air employed. The air drawn into the drying machine may also vary in temperature and humidity.
5. Load of leaf, *i.e.*, thick spreading or thin spreading.
6. The period of the drying operation.
7. The moisture content of the product.

In general practice these variables are all subject to some degree of control and the aim of the experiments is to study the methods of control with a view to producing the highest quality of the finished product.

EXPERIMENTAL METHOD

The general principle of the approach to firing problems has been to investigate one factor at a time, keeping all other factors constant as far as practicable.

The ultimate application of the results to general commercial practice has been borne in mind throughout and conditions which are impossible to achieve in full scale dryers have therefore been avoided.

Seven factors have been mentioned above; if each of these factors had only two levels of variation, *e.g.*, high and low temperature, long and short period, thick and thin spreading, etc., there would be in all $2\times2\times2\times2\times2\times2\times2=128$ different investigations to be carried out.

As already stated, however, results of practical value are the immediate object and in view of the fact that modern dryers are designed and constructed to deal with normal variations in the green dhools and are capable of maintaining a constant relation between the rate of air flow and the rate of loading, the most important points for immediate investigation are temperature, moisture content and period.

Accordingly, temperature investigations have now been proceeding for some time and the results form the basis of the first article of this series.

Three levels of temperature were chosen for the experiment. High (210°F.), Medium (190°F.) and Low (180°F.). Since the time factor is a practical consideration in temperature experiments and also a problem in commercial practice when firing temperature is varied (drying is naturally a quicker process at high temperatures than at 160°F. when it becomes exceedingly slow), the experiments were divided into two series to embrace consideration of firing period.

The conditions of all experiments were fixed so that the moisture content of fired teas was of the order 3 to 4 per cent. In one series the constants were time and air flow and the load variable, while in the other series load and air flow remained constant and time was varied.

The supply of leaf was arranged with the aid of the experimental rollers. Well bulked leaf from the same field was withered in three different lots and the charging times staggered so that on each day three experiments, each at a different temperature, could be carried out with the same leaf. The experiments were carried out in groups,

each group covering three days so that the order could be changed as follows:—

1st Day	2nd Day	3rd Day
1st Experiment at 160	1st Experiment at 190	1st Experiment at 210
2nd „ „ 190	2nd „ „ 210	2nd „ „ 160
3rd „ „ 210	3rd „ „ 160	3rd „ „ 190

At the end of each three-day period the experimental leaf fired at each temperature was bulked and graded before the final sampling.

Fermentation times were standardized and the samples were drawn from leaf fired over a set period so that the length of firing did not affect the length of fermentation.

By these various devices the teas from each comparative group varied only in the temperature of firing.

RESULTS

The results now available cover two complete periods, namely the North-East Monsoon 1938 and the Inter-Monsoon Period (April-May) 1939. Some results are available from a South-West Monsoon period (1939) but are not complete owing to the disorganisation consequent upon the outbreak of the war. The South-West Monsoon and the Dry Weather — Flavour Season — are to be covered by future investigations.

Series I.—Load and air flow constant.

Time of firing 160° 42 minutes.
190° 21 ,,
210° 15 ,,

(a). Season — North-East Monsoon.

Temperature °F	Valuations		Analysis						Keeping Quality
	Colombo Cts.	London Pence	Appearance	Colour	Strength	Pungency	Quality	Flavour*	Valuation in Colombo after storage for six weeks Cents
160	+ 0.2	+ 0.5	0	0	0	+1	+1	+1	+ 1.3
190			Taken as standard for comparison						
210	- 3.0	- 0.6	0	0	0	- 2	- 2	- 4	- 1.5

* Flavour only reported in one sample.

(b). Season — Inter-Monsoon (April-May).

Temperature °F	Valuations		Analysis						Keeping Quality
	Colombo Cts.	London Pence	Appearance	Colour	Strength	Pungency	Quality	Flavour*	Valuation in Colombo after storage for six week Cents
160	+ 2.5	0	0	0	0	0	+1	-	+ 0.25
190			Taken as standard for comparison						
210	- 1.0	- 0.3	0	0	0	-1	-1	-	- 2.0

* Flavour absent.

(c). Season — South-West Monsoon.

Temperature °F	Valuations		Analysis						Keeping Quality
	Colombo Cts.	London Pence	Appearance	Colour	Strength	Pungency	Quality	Flavour*	Valuation in Colombo after storage for six weeks Cents
160	+ 3.0	+ 0.4	0	0	+1	+1	+1	-	+ 2.5
190			Taken as standard for comparison						
210	- 1.0	0	0	0	0	-1	0	-	- 1.5

* Flavour absent.

Series II.—Time and air flow constant.

Time of firing was 21 minutes in each case.

The comparative loads were:—

160° $\frac{3}{4}$ lb. per tray.

190° $1\frac{1}{2}$ lb. per tray.

210° $2\frac{1}{4}$ lb. per tray.

Thus at 160° the rate of loading was half that at 190° and $\frac{1}{3}$ that at 210°F.

(a).—Season — North-East Monsoon.

Temperature °F	Valuations		Analysis						Keeping Quality
	Colombo Cts.	London Pence	Appearance	Colour	Strenght	Pungency	Quality	Flavour*	Valuation in Colombo after storage for six weeks Cents
160	+ 1.2	+ 0.5	0	0	0	0	+ 1	+ 1	+ 0.6
190			Taken as standard for comparison						
210	- 2.0	- 0.9	0	+ 1	0	- 3	- 2	- 4	- 1.5

* Flavour only reported in one sample.

(b). Season — Inter-Monsoon (April-May).

Temperature °F	Valuations		Analysis						Keeping Quality
	Colombo Cts.	London Pence	Appearance	Colour	Strenght	Pungency	Quality	Flavour*	Valuation in Colombo after storage for six weeks Cents
160	+ 2.0	- 0.2	0	0	0	0	0	-	+ 2.0
190			Taken as standard for comparison						
210	- 0.5	- 0.26	0	0	0	- 1	- 2	-	- 1.5

* Flavour absent.

DISCUSSION OF RESULTS

Throughout the experiments the teas fired at 190°F. were taken as standard when tasted by teams of Tasters in Colombo and London. As the samples were sent to London by post a further check on keeping quality was provided by storing duplicate samples for six weeks and sending them to Colombo for a second opinion.

The figures given are the averages of a large number of experiments conducted over the entire periods stated. In the course of normal market fluctuations the actual valuations varied considerably and so the average differences are presented with plus and minus signs affixed, the plus sign indicating that teas were valued higher than the standard and the minus sign indicating a lower valuation.

The system of analytical specification has been described in previous articles [7] and in brief it may be said that the standard sample is given an arbitrary ten marks and the characteristics of the other samples are marked up or down on this basis. Thus +1 under Pungency indicates that samples received on the average 11 marks for pungency as against 10 for the degree of pungency in the standard. The sign "0" indicates that there was not any reported clear deviation, on the average, from the standard.

There is a clear indication that Tasters prefer teas fired at 160°F to teas fired at 190°F. and that those fired at 190°F. are preferred to teas fired at 210°F.

On the different bulked lots sent for report the order of preference is expressed in the following figures:—

160°F.	preferred to	190 and 210	on 18	occasions.
190°F.	,,	160 and 210	on 5	,,
210°F.	,,	160 and 190	on 0	,,

The reason for the preference is also shown quite clearly in the above tables and is that pungency, quality, and flavour when present, depreciate with rise of temperature employed by firing. Appearance, colour and strength are not affected to any marked extent.

Both Colombo and London Tasters are in very close agreement over the characteristics of these teas and this, from a scientific point of view, affords more satisfactory evidence than the valuations. Despite market fluctuations in values and requirements the actual valuations however show clearly enough that the effect of firing temperatures is sufficient to affect commercial values and that the differences are not merely academic.

These considerations raise the question of the economic firing temperature. The evidence so far obtained is practically sufficient to condemn firing temperatures above 190°F. The capacity of a firing machine working at 160°F. and turning out leaf fired to 3-4 per cent moisture content is however only about half the capacity at 190°F. Excluding the cost of heating up the dryer, this practically doubles the cost of firing and the enhanced value of the product may not always be commensurate with this additional expense even if the drying equipment is capacious enough to deal with the whole crop at the lower temperature.

Further investigations are necessary to clear up these points as far as is possible with the market value of pungency, quality and flavour ruling at the time of the experiments.

The indications are at present that firing at temperatures as low as 160°F. may only be worth while when quality is in demand and although it is not intended at the present juncture to make hard and fast recommendations these considerations are offered as food for thought. It is of considerable interest to record that substantially similar conclusions have been reached at the Tocklai Experimental Station.[8]

SUMMARY

1. The first results of a series of accurate experiments upon the control of the firing process are described.

2. In two different seasons and over part of a third, it has been found that pungency, quality and flavour when present, depreciate as the firing temperature employed is raised.

3. Appearance, colour and strength are not affected by the normal range of firing temperatures to any marked extent.

4. Similar results were obtained when either load or firing period were varied to compensate for the temperature differences.

5. The differences found were sufficient to affect the market values of the teas and to such an extent that the indications are that firing temperatures above 190°F. are to be condemned. Firing at 160°F. may be economic when quality teas are in demand. Further experiments are proceeding.

REFERENCES

1. *The Tea Quarterly*, VIII, 43.
2. „ IX, 17-24, 48-59, 110-123, 163-177.
3. „ IX, 172.
4. „ X, 65, XI, 95.
5. „ X, 65.
6. T.R.I. Bulletin No. 12, p. 60.
   13, p. 71.
   17, p. 81.
   18, p. 79.
   19, p. 71.
7. *The Tea Quarterly*, X, 57.
8. Indian Tea Association, Scientific Department, Tocklai Experimental Station, Annual Report, Chemical Branch, 1935, p. 37.