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THE TEA INDUSTRY IN THE EAST AFRICAN SUB-REGION

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I. THE TEA INDUSTRY IN THE EAST AFRICAN SUB-REGION

1. The tea plant, Camellia sinensis, has been known and its leaf used as a b verage in China for between two thousand and three thousand years. It has been cultivated on plantation scale only during the last one and a half centuries. Cultivation started in India in 1818, in Java around 1830, and in Ceylon in 1867. The tea plant was introduced into Africa as early as 1877 and plantations established in Natal have subsequently gone out of cultivation.

2. The oldest continuing industry in Africa is that of Malawi. The first plantation was established in 1891 on the slopes of Mlange Mountain. By 1914, Malawi was exporting over 100,000 pounds of tea, and its present output from 32,000 acres in the Cholo and Mlange districts is around 30 million pounds.

3. It was not until 1920 that tea planting on a commercial basis was undertaken in Kenya. It is grown today at altitudes varying from 6,000 feet to 7,500 feet in the Kericho and Limuru areas. The total area planted in Kenya is 52,000 acres, and small holdings development sponsored by the Kenya Tea Development Authority is to add another 23,250 acres by 1971. The output of made tea in 1963 was 40 million pounds and this is expected to increase to 55 million pounds by 1970/71.

4. In Uganda, the first tea plantations were established in 1916, but the significant advance in cultivation was delayed until the early thirties. Tea is grown at altitudes varying from 4,000 feet in the Mengo district to 5,500 feet in Toro. In 1963, Uganda had 23,564 acres under tea and produced 13.6 million pounds of made tea. It has been increasing the acreage of Ugandan small producers and planted acreage is expected to reach 30,000 by 1967.

5. Planting on a commercial scale stated in Tanzania only in the twenties. Tea is grown in both Eastern and Western Usambaras, in the Mufindi and Njombe districts of the Southern Highlands, and in the Rungwe districts. The elevation varies from 3,500 feet to 6,700 feet. The area

under planting in 1963 was 20,793 acres and its output for that year, 11 million pounds of made tea. The development plan envisages increase of acreage under tea through peasant development to 30,000 by 1970 and the annual production to 15.8 million pounds.

6. Besides these four major tea countries in this sub-region, others - Rhodesia and Mauritius - also grow tea. Recently, Ethiopia has begun exploring possibilities of growing tea on commercial scales. The total acreage under tea in the countries of the sub-region in 1962, 1963 and 1964 and their output are shown in Table 1.

Table 1: Area Planted with Tea and Production

Country	Acreage		Production in '000 lbs.		
	1962	1963	1962	1963	1964
Kenya	49,156	52,998	36,217	39,864	44,622
Uganda	21,049	23,564	13,932	13,602	16,789
Tanzania	20,031	20,793	9,503	11,064	10,609
Malawi	30,906	31,639	29,410	26,268	27,293
Rhodesia	5,644	5,940	2,836	2,697	n.a.
Mauritius	4,506	5,320	2,799	3,257	n.a.
Total	131,292	140,254	94,697	96,752	

7. With the rate of planting planned in Kenya, Uganda and Tanzania and the expansion of tea production on irrigated land near Nkata Bay in Malawi, and Chipinga district in Rhodesia, the total area under tea in the sub-region might well reach 200,000 acres by 1970, and its output of made tea might soar to 150 million pounds.

8. The total area under tea, which includes the major tea-growing countries of India, Ceylon, Indonesia, Formosa, USSR, Japan, Pakistan and East Africa, but excluding China and Indo-China, for which figures are not available, is 2.5 million acres. The total exports of tea from the above-mentioned countries in 1963 was 1,300 million pounds.

9. For the East African sub-region and principally for Malawi, Kenya, Uganda and Tanzania, tea is therefore a major economic crop. The total export earnings from this industry in 1963 were as follows:

Table 2: Average Price and Export Value

Country	Average price		Export value in £
	Nairobi (E.A.sh.)	London (pence)	1963
Kenya	3.27	48.77	5,665,409
Uganda	3.31	44.14	2,041,000
Tanzania	2.86	46.04	1,552,145
Malawi	2.35	35.17	3,267,855

The average price is lower than that of tea from Ceylon and North India, which obtained during 1963 the prices of 52.33 and 55.70 pence, respectively.

10. The increase in the value of exports of tea from this sub-region may be obtained by increased output through extension of the area under tea, and higher yield per acre. This is being actively pursued through intensified agricultural methods. The present paper deals with another approach, that of enhancing quality and the average price, by improved techniques in conventional black tea manufacture, and the manufacture of other new forms, such as instant tea or soluble tea.

11. The tea industry has been known to be extremely conservative in all countries of the world and this sub-region is no different in this respect. While, however, India and Ceylon have in recent years freely exchanged information and shared research results, similar exchange, particularly on estate or manufacturing practices, is lacking in the East African sub-region. While a Tea Research Institute, financially supported by the industry exists, particular companies have spent large sums in research on the development of instant tea manufacture, and the results of this work are kept closely guarded secrets, even from their own research institute. Similar evasion or lack of collaboration is evident in the field of processing techniques in black tea manufacture. Consequently, little or

no scientific work has been carried out on the effects on quality characteristics of the variation in processes or techniques of manufacture in East Africa. What literature is available emanates from machinery and equipment manufacturers and these are subjective results.

12. This study reviews traditional methods of manufacture of black tea and of modifications made in withering, bruising and fermentation in recent years. In the light of present knowledge of the chemistry of tea, it suggests avenues for further research and investigation in determining optimum conditions of manufacture. It further details processes involved in instant tea manufacture and emphasizes the necessity to have a deeper knowledge of the biochemistry of tea before further advances in quality of instant tea directly from green leaf can be obtained.

II. MANUFACTURE OF BLACK TEA - A REVIEW OF TRADITIONAL, NOVEL AND NEW METHODS AND PRACTICES

13. Tea, as it is known in commerce and in the home, is largely the black tea [1] which has been processed in the estate factories from fresh leaf. This degree of processing is necessary to preserve it from deterioration during the long periods of storage, transport and distribution to consuming countries, and also to impart certain desirable quality and flavour characteristics.

14. The processing in the factory can be simply stated. The traditional two leaves and a bud plucked from the tea bush, are sorted and more mature leaves are eliminated in the sorting. The next step is withering, the physical conditioning of the leaf, to a flaccid state, through reduction of moisture either by natural air ventilation or by artificial methods.

15. When withering has been completed, the leaf is subjected to bruising by rolls and this operation squeezes the juices, exposes these to the action of enzymes and then initiates what is termed in tea parlance "fermentation", besides imparting to the leaf a twist. The rolled leaf is then heaped on trays to a height of two inches and left to "ferment" for a predetermined period of time, usually $2\frac{1}{2}$ - 3 hours, at the end of which it is fired. The last operation is done in a drier and it involves the drying of the twisted leaf to a moisture content of 3 per cent and at the same time killing the enzymes so that no further fermentation can take place. From the drier comes the black tea, which is sorted, graded and packed for consumption and/or export.

16. The characteristics of the leaf are different in different countries and variations in quality may exist within one country or even within a district. The African leaf is of a harder texture than the Indian or Ceylon leaf and would therefore require harder rolling and perhaps other modification of the processes involved in manufacture, in addition to care in plucking and sorting. These various processes will be reviewed as practised in Asia and in Africa.

1/ Also green tea, which is made principally in China from fresh leaf which has been steamed to kill enzymes and subsequently rolled and fired.

Withering

"Tat" Wither

17. This in its simplest form is carried out under atmospheric conditions with the leaf spread thinly on "tats" made of tightly-stretched jute. More recently, the jute is being replaced by nylon netting. The rate of wither can only be adjusted by the thickness of the spread.

18. A modification of the above natural withering is to provide for air movements in the lofts by means of large fans. The air is blown over the tats and on particularly wet days, a mixture of hot air from the driers and fresh cold air is admitted to the fans. As against "tats" fitted into lofts, mobile tats containing a bank of tats on a wheeled trolley device are also used and this permits greater control of the degree of withering, as representative tats can be checked by weighing.

Drum Wither

19. On the assumption that withering is undertaken largely to reduce the moisture content and to bring the leaf to a flaccid state for rolling, several other methods of accelerated moisture reduction were attempted. Drum withering is done in large perforated revolving drums through which hot air at around 130°F is blown. This has the advantage of saving both space taken by tats and lofts, and time. The drum usually holds 1,500 pounds of fresh leaf and the withering time is three hours, compared with tat withering of 18 - 20 hours. The possible disadvantage is, however, the bruising of the leaf in the drum, and drum withering has therefore been largely abandoned both in Asia and in Africa.

Trough Wither

20. A consideration of the merits of trough wither, where the leaf is withered in troughs by a controlled humidity air system can only be made in relation to existing knowledge of the chemical and biochemical reactions that the leaf undergoes during withering. Keegel 1/ suggested that the prime object of wither is to condition the leaf into a flaccid state

1/ Tea Manufacturers in Ceylon - Monograph No. 4, by E.L. Keegel.

for rolling, and to make the leaf permeable to the juices that the rolling will squeeze out and thereby spread such juices evenly over the surface. He concluded that ideal wither required low heat bulb temperatures, ample supply of moving air and high hygrometric differences. Leaf is generally considered to be withered if it has lost its springiness when squeezed in the hand.

21. During wither, the leaf is alive, and respiration and other bio-chemical changes occur. The type of reactions involved are little known, although there is definite evidence of increase in enzyme activity and caffeine content. Also noted is a substantial loss of carbohydrate and breakdown of protein.

22. Because of our imperfect knowledge of the bio-reactions involved, tea planters have often held views and beliefs unsupported by scientific evidence. In Ceylon, several planters resited their factories at highest points on the estate and this new siting they claimed gave a higher quality tea. During the early periods when drum wither was introduced, claims were made that when fresh leaf was stored in bulk for several hours prior to drum wither, the resultant manufactured leaf was of a higher quality than that immediately processed. There is no direct evidence even for the contention that withering increases enzyme activity. Child and Todd in 1954 kept the stalk of fresh leaf immersed in water for two days and demonstrated that this leaf had higher fermentation rate than the normal withered leaf. The time factor seems, therefore, to have an important effect on changes in the leaf of which little is known.

23. In spite of the lack of more definite scientific information, two factors of importance can still be discerned. The wither has to be slow, using cold dry air of controlled humidity. The leaf should not be bruised in the wither process. These two conditions are satisfied in trough withering. The method was first developed in the Congo and consists of leaf being placed in a trough with a wire floor through which air can be blown or drawn. Later modifications allowed for cold air and control of humidity. The wither takes 14 to 20 hours. East African leaf requires a slow light wither and this is widely practiced. While more scientific

investigation into the reactions involved in wither and controlled trials on the time factor, rate of moisture removal, optimum temperature and humidity, etc., is required, there is a growing awareness that in trough wither is an advance which has great potentials in quality development. This, we hope, will form the basis of further research in East Africa and in other tea-producing countries.

Rolling

24. Originally, the Chinese rolled the withered leaf between the palms of the hand. The rollers which emerged when tea became a plantation commodity simulated this action of compressing and twisting the leaf while keeping it in continuous motion. The rolling operation is repetitive and is carried out in spells lasting half an hour. Light withered leaf is rolled for three to five periods. The modifications made to the conventional tea roller are in the mechanism of applying pressure, the design of battens, and in the device for continuous feed.

25. In conventional manufacture, the first rolling is done in an open roller without pressure, followed by four or five subsequent rolls with graded increase in pressure.

26. Two other devices have become popular in recent years. The C.T.C. system of passing the leaf through serated rolls fitted one on top of the other and the McTear rotorvane which consists of a screw working in a chamber. In the latter, leaf is squeezed and bruised by its passage through the chamber while being forced by the screw worm. The C.T.C. machine was introduced into East Africa by Mr. Britten many years ago, and his comments at that time are of significance. He stated, "We found out what I had expected would happen, that with the African leaf being of a harder texture than the Indian we had to be far more severe with it to rupture the cells correctly. As soon as we put leaf of a reasonable quality through a C.T.C. machine, we had a bright, coppery infusion and a brisk bright liquour." Both the C.T.C. and the rotorvane have become popular in Ceylon and in India in spite of the softer leaf and hard wither practices prevailing in those countries.

27. The twist and non-flaky characteristics in made tea, which have for decades been thought of by the trade as a mark of quality, still have an influence on rolling. While many planters in East Africa considered that C.T.C. machines gave better quality and product, convention and trade have connived against its exclusive use. The conventional roller is still used along with either the C.T.C. or the rotorvane, or both.

28. In one factory visited, the withered leaf is sent through conventional rollers for 45 minutes and later passed to the C.T.C. machine or, alternatively, sent through conventional roller for 25 minutes and then through the rotorvane. It establishes that the iniquitous conventional roller is used in some way or other and the tea industry has still not accepted the C.T.C. or the rotorvane as complete systems. Full acceptance can only come through scientific proof of their superiority over the conventional tea roller and the abandonment by the trade of the idea that twist implies quality. If twist is not essential and bruising and spreading the juice evenly over the leaf is the desired effect, how effectively do the C.T.C. and rotorvane machines achieve this, and what are the settings and time required to obtain optimum treatment? To our mind, this has not been answered, and controlled experiments varying only one factor at a time with correlation of end quality as estimated by tasters have either not been made or, if made, are a guarded secret.

No Wither and No Roll

29. This discussion brings us to another aspect of tea manufacture where the leaf is not withered and because the leaf will not be in a flaccid state for rolling, the leaf is cut in a machine similar to a cigarette cutter, e.g. Legg cutter, and further shredding and squeezing obtained on the C.T.C. machine. The additional water content inherent in this type of processing makes the firing a complex operation requiring careful control. It could, however, be partly overcome by centrifuging the leaf in a basket-centrifuge, thereby removing up to 20-30 per cent moisture before it is passed to the Legg cutter. The centrifuging would, while avoiding the loss of juice during maceration, provide sufficient juice for even spreading over the leaf mass.

30. The fermentation that results is rapid and even and these teas are characterized by their bright and homogenous infusions. The reported brassy metallic flavour is a disadvantage, but no evidence is available as to the cause - the non-wither or the non-roll. The answer to this may provide a clue to the more effective use of the rolling systems and intensive research in this field would pay ample dividends both in increasing export revenue, and in reducing capital expenditure on unwanted machinery and building space.

Fermentation

31. In the undamaged tea shoots, the polyphenolic substrates are in the vacuole and the enzymes associated with the chloroplasts. No oxidation of polyphenols can take place until the leaf is bruised and the substrate and enzymes are brought in contact with each other in the presence of oxygen. This process of oxidation and the subsequent reactions which follow are referred to as "fermentation". Dr. T. Eden in his book on tea 1/ states that the reactions involved in fermentation are little known and investigations into this subject are far from complete. He describes the reactions as follows:

> "The essential chemical processes in tea manufacture consist in the oxidation by a specific enzyme or enzymes, secreted in the living tissues of the leaf, of catechins or gallo catechins having hydroxyl groups in the ortho-position. The primary oxidation products are o-quinones which polymerize to produce an extended series of coloured astringent condensation products of varying solubility, which are partially extracted in the domestic process of brewing tea. The extent of the oxidation and the range of condensation products depends partly on the initial status of the leaf in regard to both polyphenol content and enzyme, and partly on the routine of manufacture to which leaf is subjected in factory operations. Both these factors affect materially the elusive characteristic of quality in the finished product."

Later sources summarized the probable chemical changes, inter alia, during fermentation as:

(a) the enzyme oxidation of the catechins followed by polymerization;

(b) enzymic breakdown of pectinic acid to pectic acid and methanol, and

(c) production of the characteristic tea aroma.

1/ Tea, by T. Eden, Longmans, Green and Company.

The most favoured degree of oxidation and polymerization and means of arresting polymerization at the desired stage are not known. It has been known that tea leaf from certain areas and/or a particular bush or field would exhibit slow fermenting characteristics because of low enzyme activity. The activators of enzyme oxidizes have not been studied. The fermentation process consists of a series of complex reactions in which the enzymes and the various mineral and other constituents of the leaf are involved. Although considerable research has been carried out during the last decade, insufficient attention has been paid to this important subject in tea-producing countries. What passes as an hypothesis is largely empirical and it can be stated that the mechanism of reactions involved and its relation to quality characteristics is imperfectly understood.

32. Fermentation is still largely done on trays, both in Africa and elsewhere. The use of the fermentation trough is rapidly becoming popular.

> "In this system, air at controlled temperature and humidity is fed into the base of the trough containing fermenting leaf and circulates upward through the leaf. The design of the trough ensures an even flow of air through the whole bulk of the leaf which can be loaded into the troughs to a depth of 12 inches. Each trough contains four cubic feet of fermenting leaf and is mobile, so that it can be wheeled from the point where it is charged with leaf to its place of attachment to the source of conditioned air." 1/

33. A further advance is the drum fermenter, where the leaf travels slowly along the drum, being turned over and over all the time. Fermentation in this system is completed in three hours.

1/ "Trends in Processing of East African Tea", by E. Hainsworth (unpublished paper).

III. THE MANUFACTURE OF INSTANT TEA 1/

34. Instant tea, an extract of tea freely soluble in hot water, is a recent development, but instant coffee has been known for many years. It has been reported that over 65 per cent of all coffee is in this form and that instant coffee development not only increased the consumption of coffee but, because of the economy of use and the acquired new flavour, made considerable inroads into the traditional tea markets of the world. It was therefore logical for tea interests to think in terms of a similar development and instant tea appeared on the European and American markets as early as 1955. Because the instant coffee was a development of the major consuming countries of the West and America, these same interests developed instant tea not from fresh green leaf, but from the blended black tea of commerce.

35. When instant tea is made from black tea, there occurs a double loss of tea characteristics, such as flavour and quality. The first loss occurs in the tea estate factory when the fermented leaf is fired to produce black tea. Visitors to tea areas will have noticed the smell of tea discernible from almost a mile away and would therefore appreciate the extent of the loss of aroma which this smell signifies. The second loss takes place when the black tea is extracted with hot water, and the water extract which is low in total solids is dried to a powder or granular form. Because of this double loss, the instant teas produced from black tea lacked the qualities associated with black tea. The powders dissolved in hot water gave a liquour which was characterized as dull, flat and lacking in briskness and had none of the taste characteristics or the aroma associated with a tea brew made from black tea. In spite of this, instant tea was becoming popular in America, in particular for iced tea.

36. Tea-producing countries, and particularly, Ceylon, rightly argued that if instant tea was made directly from green leaf, there would be only one loss of those characteristics referred to earlier, and consequently

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1/ Development of Instant Tea, by A. Sundralingam, Times of Ceylon, July 1963.

the quality would approach that of black tea. There were other advantages for a tea-producing country. Processing directly from green leaf would retain non-extractable refuse within the country, provide additional value by-products, such as caffeine, from such waste, besides reducing the freight charge as the extract is only one-fifth of the weight of black tea. Instant tea from fresh leaf could only be made in a producing country, and if instant coffee is an analogy, may rightly be expected to yield a higher value and consequently increase the export income. A further thought was the increasing production of tea and it was felt that instant tea might find the new markets for the new production.

37. Instant tea is a manufactured product and the consumer will expect uniform quality and good keeping properties from such a product. In the process of manufacture, therefore, each step requires careful and strict quality control. This, however, entails a precise knowledge of the mechanism of the reactions involved in each of the processes - withering, bruising and fermentation.

38. In simple terms, instant tea can be made by following traditional processing methods of withering, rolling and fermentation, extracting the fermented leaf, and reducing the extract to powder form. It will be noted that withering, rolling and fermentation are common to both types of manufacture and that while in black tea the fermented leaf is fired, in instant tea the leaf is extracted and the solution dried to powder.

39. In instant tea, which is in powder form, the shape of the bruised and fermented leaf is of little interest. It can therefore be argued whether the conventional rolling is necessary or essential, and other methods of bruising, such as the C.T.C. and rotorvane or the Legg cutter combined with non-wither, will be of equal value. Each step or process has to be re-examined and re-studied and modifications effected in order to obtain the desired colour, taste and flavour in instant tea. Experimental development in Asia has shown that colour could be greatly increased by suitable conditions of wither, fermentation and drying. Several qualities have been imparted by freezing the leaf, centrifuging, cutting and macerating the leaf.

40. As the fermented leaf is extracted, the moisture content of the leaf at stage of bruising is therefore not critical. This might suggest elimination of the wither, which on the conventional method takes considerable factory space and time. But, as has been indicated earlier, there is a time factor during which certain desirable characteristics are evidently developed, and what is attained by wither is not only a reduction of moisture and the flaccid state. This is borne out by leaf-freeze experiments referred to, and the quality attainable in non-wither teas.

41. A detailed study of the mechanism of reactions involved in withering and fermentation will not only lead to better quality black tea, but to the manufacture of instant tea of greatly improved quality.

42. Instant tea manufacture entails efficient extraction of the tea substances in the fermented leaf, at the highest possible concentration, and the conversion of this liquour into a powder. While in black tea the fermented leaf is fired, during which period further fermenting action is arrested, in instant tea manufacture the fermented mass is extracted. Consequently, the stage of fermentation is likely to be different for the two types. The methods available for extraction are percolation, batch pressure extraction, and continuous counter-current and step-wise counter-current extraction. Water is the preferred extraction medium, preferably at elevated temperatures. The main factors influencing extraction are:

(a) the ratio of fermented leaf to water;
(b) temperature of water;
(c) time of extraction, and
(d) design of extraction equipment.

Over-extraction leads to bitterness and is not desirable. A balance has to be attained between extraction efficiency and quality. A further balance is needed for instant tea for use in iced tea, as this variety would require higher solubility properties in cold water.

43. The final physical characteristics of instant tea - flakes, powder, spheres - will determine the type of drying. There is reason to believe that certain flavour characteristics are imparted in the drying and that to obtain these, the liquour should be instantaneously converted into powder or spheres. Drying in vacuum shelf driers and drum driers gave poor results and freeze drying, for the reason given above, may also not be applicable, although this is used in drying black tea liquour into instant tea.

44. The instant tea developed in Ceylon and produced now at one million pounds per year is the result of scientific choice of the many alternatives which each stage of the process offered. It involved hundreds of experiments and painstaking development on pilot scale before full production was possible. It did, however, prove that high quality is attainable. In Uganda, Solutea is already in production and its products are being sold to vending machines in the UK. Two other companies in East Africa, Brooke-Bond and James Finlay, are in advanced stages of development. India has tooled a factory and is expected to be in production this year.

45. The market for instant tea of quality is good, principally in the traditional coffee-drinking countries and the demand is estimated at 10 million pounds. East Africa, and in particular Malawi and Tanzania, should explore the feasibility of the manufacture and export in bulk form of instant tea. Such efforts should be pooled in the common economic interests of the tea-producing countries in East Africa. Attempts to be selfish and secretive are likely to delay the acquisition of that detailed scientific knowledge required for quality attainment and, consequently, the development of this industry. It is further suggested that work in this field be shared by the East African Tea Research Institute and the Malawi Tea Research Institute and part of the cost be met by those firms who have already shown an active interest in this development.

IV. CONCLUSIONS AND RECOMMENDATIONS

46. The reactions involved in withering, fermentation and firing are imperfectly understood and there is need to mount research programmes in both the East African Tea Research Institute and the Malawi Tea Research Institute so as to elucidate and build basic knowledge.

47. The trough wither appears prima facie to be a development which could improve quality.

48. The comparative efficiency of the C.T.C. and rotorvane machines as against the conventional tea roller should be further investigated by the research institutes, and factory information available on these machines shared between the East African countries.

49. Sufficient market exists for instant tea and it is recommended that Malawi and Tanzania explore the feasibility of the early establishment of instant tea factories on a scale of 500,000 pounds of instant tea per year.

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