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STORAGE OF BLACK TEA — A REVIEW

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Black tea may deteriorate under prolonged storage, resulting in loss of quality and character. This result has been ascribed to the decrease in theaflavins. The principal agent catalysing these changes has been identified as moisture.

The relative humidity of the storage surroundings on moisture absorption patterns during the stages of grading and packing are also examined, and the use of humidity-controlled rooms for these operations is suggested.

INTRODUCTION

Sri Lanka teas are subject to a 3-6 month period of storage during their transit to the different sale centres in the world. During this time the teas often lose much of their astringency and may acquire undesirable characteristics which sometimes render them unsaleable.

This review examines a few of the recent studies on this subject with a view to identifying the possible causes and suggesting remedial measures to arrest tea deterioration during storage.

Maturing of tea

The last stage in the manufacture of black tea is the process of 'drying' or 'firing' which is designed to convert fermented leaf to a stable product.

Since during drying the enzymes responsible for 'fermentation' are believed to be inactivated, further changes taking place in dried teas are ascribed to slow oxidation reactions. However a number of workers have clearly shown a residual activity of enzymes in dried tea. Deys (1937) found that the activity of peroxidase, which is a heat-resistant enzyme, in dry tea is 1.5% of that in fermented leaf, while Roberts (1962) also established a peroxidase enzyme activity of 1.5% in dried tea. The recent results obtained by Cloughley (1981) confirm the presence of active polyphenol oxidase and also peroxidase in black tea. It is well known that freshly-made black tea has a 'raw' or 'green taste' and that this 'matures' on storage for a few weeks. *ie* the initial rawness of the liquor gives way to smoothness. Wickremasinghe & Perera (1972) ascibed this to the possibility of the combination of the astringent polyphenols with proteins, a reaction which they also felt may be promoted by moisture. Recently, Cloughley (1981) reported an increased valuation in teas during the first few weeks of storage which corresponded to the putative post-manufacture maturation phase.

Prolonged storage

As mentioned above, tea tends to improve in quality under optimum conditions of storage, but when this process induced by high moisture and temperature continues too long, its effect on tea quality could be detrimental. A number of workers have examined the effect of some environmental factors, on the keeping qualities of black tea.

Wickremasinghe and Perera (1972) studied the relative effects of light and moisture on the changes occurring during storage of black tea. Black tea samples from the same invoice were stored on the bench, in:

(a) a tightly closed clear glass bottle; and

(b) a loosely covered wooden box

The samples were analysed at fortnightly intervals and simultaneously evaluated by the tea taster. Their results revealed that although the tea stored in the box had almost twice as much moisture as that stored in the bottle (4% moisture) the valuations of the two samples did not show a great divergence in the market prices. This was interpreted to mean that high moisture content *per se* does not lead to deterioration of stored teas and that other factors contribute to the 'softening' of teas on storage. A net decline of theaflavins was also reported.

At this stage it is relevant to recall the findings of Labuza *et al* (1970) who showed that it is the 'water activity' which determines the rates of various reactions involved in food deterioration. Lipid oxidation, leading to rancidity, is most rapid at low water activities, whereas non-enzymic browning reactions show a peak rate when the water activity increases to an intermediate level. Enzyme activity is also maximal at intermediate levels, whilst growth of micro-organism occurs only at higher water activities. It will be evident that all these reactions will be favoured at various stages of storage of tea, and that after prolonged storage it will be the growth of micro-organisms which will have the most profound effect (Wickremasinghe and Perera, 1972). In the particular investigation of Wickremasinghe and Perera (1972) described above, the valuations of the tea stored in the clear glass bottles were similar or lower, than those of the tea stored in the wooden box, although the latter has a higher moisture content. The authors argue that this finding suggests that lipid oxidation and non-enzymic browning reactions are mainly responsible for the deterioration of the tea stored in the clear glass bottle, possibly due to photo-chemical effects, and that these reactions are initially more detrimental to the valuation of a tea sample than those due to increased moisture alone.

The chemical changes occurring during storage of black tea was also studied by Stagg (1974) who found that deterioration of black tea was characterised by a loss of flavour and astringency and sometimes by the acquisition of undesirable "taints". These changes in quality characteristics were accompanied by lipid hydrolysis and by auto-oxidative reactions that caused losses of theaflavins, amino acids, sugars, photosynthetic pigments and some volatile aliphatic constituents, and increases in non-dialysable pigments and some volatile phenolic components. These reactions were accelerated by moisture and heat. The hydrolysis of lipids during storage liberates free fatty acids, and these could undergo oxidation during the 'brewing process' and this in turn may lead to a type of rancidity that detracts from 'quality'.

The changes occurring in black tea during storage was examined extensively by Dougan *et al* (1978). Black tea was stored under varying conditions of temperature and humidity and samples taken for evaluation and analysis over a period of 26 weeks. The results revealed that undesirable changes took place under all the sets of conditions studied but the rate of deterioration increased with increasing temperature and moisture. The following conclusions were significant:

1. The decline in the value of tea during storage over a period of about six months, was attributable to the effect of moisture, and to a smaller extent, to temperature.

2. About half of the loss in value could be attributed to the decrease in theaflavin content. The rate of loss of theaflavins was affected about equally by moisture and temperature.

3. The sensory qualities of briskness, strength, infused leaf and flavour all declined during storage and all contributed to the loss of value. Their rate of decline was highly dependent upon moisture and to a small extent upon temperature.

4. Changes in the composition of head space vapours were correlated to a small but significant extent with changes in the value of tea and to a similar extent with the taster's score for flavour.

The recent work of Cloughley (1981) throws fresh light on the possible causes of storage deterioration of black teas. This worker found that black tea retained considerable polyphenol oxidase and peroxidase activities and that both enzymes were reactivated to some considerable extent by absorption of moisture during storage. He also found that levels of thearubigins and caffeine increased during storage,while flavanols and soluble solids decreased. The theaflavin content (TF), except for an initial increase during the brief maturation period, decreased as a linear function of time during the 5-month storage period. The loss of TF was the major factor responsible for the deterioration in quality and reduction in the valuation of black tea.

In seeking to explain these changes, Cloughley (1981) points out that the two enzymes, polyphenol oxidase and peroxidase, possess unusually high thermal stability, and have been implicated in many deterioration processes, and that problems associated with the regeneration of their enzymic activity, even after drastic heat treatment and also widely encountered in the food industry (Reed, 1966; Coleman and Whitaker, 1974; Sevensons, 1977). According to Cloughley (1981) therefore, many of the chemical changes observed, may be related to the enzyme activity retained in black tea, and its subsequent reactivation by water absorbed during storage.

Moisture content

The above studies clearly establish the relationship between the moisture content of made tea, quality of tea and its keeping properties.

Tea is a markedly hygroscopic body. It conforms to well known physical laws, the amount of vapour taken up tending to establish an equilibrium with the water vapour in the atmosphere. Tea can absorb moisture under all prevailing conditions beginning with the discharge at the dryer and ending with the presentation in some form to the consumer. The amount of moisture absorption will depend on the actual moisture content and the conditions of humidity to which it is exposed. After the freshly dried tea has been left to cool and has been sorted on the next day the moisture content may have risen from some 3% to 4% or even higher.

The effect of relative humidity and temperature on the moisture sorption by black tea was studied by Jayaratnam and Kirtisinghe (1974 a), and they reported that the moisture sorption patterns were sigmoid as has been previously found for other foods. Their data also showed that the moisture level of tea cannot be kept under the 6% level (that is deemed necessary to keep a tea from undergoing rapid change), unless it is stored in an atmosphere whose relative humidity is under 45%, a figure not easily attained under storage conditions in the tropics. This would therefore emphasize the importance of storage under airtight conditions.

Jayaratnam and Kirtisinghe (1974 b) also examined the effect of relative humidity on the storage life of made tea and they found that:

(i) the rate of deterioration on storage increased with relative humidity and that;

(ii) for low humidities in the region of 32.3%, teas could be stored for a period of 300 days without loss of tea character, whereas;

(iii) for a relative humidity of 100% teas were reported as flat after 15 days of storage.

In view of the above considerations, it would appear useful to re-examine the post-drying operations in the factory in relation to moisture sorption.

Dried tea

The tea is discharged from the dryer at a temperature approaching that of the inlet air and when this heat is retained the period of firing is almost continued giving the tea a bakey character and also causing loss of quality. Therefore after discharge from the dryer tea, containing some 3% moisture should be cooled off quickly. It is usually recommended to spread the tea discharge from the dryer on a suitable surface and allow it to cool to about 35° C before temporary storage prior to grading. The latter normally takes place the following day. Teas cannot be cooled without picking up some moisture; the harmful effects of excessive gain of moisture have already been stressed. Since freshly dried teas absorb moisture rapidly they should not remain exposed for too long, and be covered during the night thus, protecting from further moisture absorption.

Grading

Freshly dried tea graded directly after firing would become greyish as the brittle outer parts would break off. Therefore, the tea should be allowed to obtain a uniform moisture content in every particle before grading. However, during the process of grading, the sifting operation provides some opportunity for further moisture pick-up, if the humidity of the grading room is high. This should be avoided.

Bulking and bin storage

The graded teas are bulked daily and stored in bins, till sufficient quantity of teas have been collected to make a 'break'. This would take on an average between 2-5 days, after which the entire lot is bulked again. Moisture absorption by the stored teas during this transient period of storage especially in open bins could be considerably high. The bulking operations also provide opportunity for moisture absorption, dependent mainly on the relative humidity of the surrounding. It would appear therefore that the bulking operations, the bin-storage and the grading should be best done in humidity-controlled rooms. Dehumidifiers are not expensive, but choking of the equipment by tea fluff may be a problem. This has to be overcome by recourse to fine cloth sieves or filters.

Packing

The modern tea chest, properly made still provides the best medium for packing and despatching tea, but compared with aluminium foil there are nowadays attractive alternative lining materials. Pliofilm, polythene and saran all were found to give equal protection against moisture uptake as the normally used aluminium. One point about polythene should be realized, whereas it is highly resistant and impermeable to water and moisture vapour *ie* when it is sufficiently thick, it is permeable to many organic vapours. Therefore taints may be more readily picked up by polythene packed tea than by tea packed in normal aluminium foil (Werkhoven, 1974).

Moisture absorption during transit

The teas that have been packed in tea chests according to the above recommendations could be expected to have a moisture content of 3-4%. When the tea chests are correctly lined with aluminium foil, further absorption of moisture would be minimal. Further, if damp warehouses are avoided during storage of these tea chests in Colombo as well as during transit by ship, it is quite possible that the teas would reach the overseas destination in fairly good condition.

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