

## TEA CREAM—A COMPLEX STORY

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When a hot aqueous extract of black tea cools down, a colloidal complex (tea cream) is formed, which poses technological problems in industrial processes e.g. manufacture of instant tea and tea cordials. Removal of 'tea cream' by centrifugation leaves the residual liquor stripped to a great extent of the desirable characteristics of tea. The studies on the nature of tea cream, the mechanics of its formation and related interactions by other workers have been re-examined in this paper with the objective of planning new approaches to the development of industrial processes. Tea cream is believed to be a H-bonded complex between caffeine and the oxidized tea polyphenols. These interactions are strongest for polyphenol gallates. Operations like, increase of pH, degallation or decaffeination substantially reduces cream formation but simultaneously effects undesirable modification of mouth-feel properties.

This is because the black tea constituents which are chiefly responsible for the desirable characteristics of tea are the very same components which are essentially responsible for cream formation.

### INTRODUCTION

Tea is the most important export commodity for Sri Lanka and earns for us about 60% of our foreign exchange. Tea is usually exported in bulk as black tea.

However, a new development that is assuming greater importance in the food and beverage market is the increasing demand for convenience foods. The thirst for such forms of beverage will have important bearings in marketing strategy. Thus the presentation of tea in a variety of forms to suit a wide range of consumers is an important step in increasing the profitability and image of tea. We are therefore seeking new horizons for tea as a food industry.

Currently, the thrust of research on the biochemical aspects of tea is on product development, i.e. development of new tea based products, e.g. instant teas, tea cordials, tea sherry etc. And it is in this field that one encounters this problem of 'Tea Cream'.

#### The problem

When a strong black tea infusion is allowed to cool, it slowly becomes turbid ; the turbidity thickens with time to form a cloudy precipitate. This phenomenon is known as "creaming" and the deposit formed is called "tea cream".

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Tea cream is a finely divided colloidal precipitate which imparts a distinct opacity to the previously clear liquor. "Creaming" is frequently used as an index of the quality of the tea brew, and generally, the market valuation of teas increase, as the tendency of their infusion to cream, increases. In other words, the constituents of tea cream could be construed as beneficial factors for tea quality. This is one aspect of the question. On the other hand this phenomenon of creaming poses serious technological problems in industrial processes, like the manufacture of instant tea. The tea cream, if not removed, blocks the nozzles of the spray drier and in other instances interferes with the composition of the concentrates. If the tea cream is removed by centrifugation, this leaves the residual liquor stripped to a great extent of the desirable characteristics of tea. Therefore one could ask the question "Is tea cream a hero or a villain". May be a beneficial villain!

The chemical nature of tea cream and the mechanics of its formation and related interactions have been studied by a number of workers. We have re-examined these studies, with the objective of planning new approaches to the industrial process mentioned earlier.

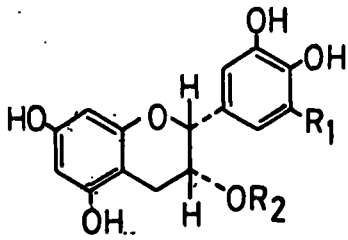
The major components of the tea brew are given in Table 1. It will be seen that extracts of fresh tea material contain about 30% polyphenols and 3 - 4% caffeine (see Fig. 1). In the black tea extracts, the unoxidized or the residual polyphenols are about 5%, the oxidized polyphenols about 25%; the latter are divided into two groups called the theaflavins (TF) and the thearubigins (TR) (see Fig. 2). The structure of the theaflavins contains a benzotropolone ring. Thearubigins are an ill-defined group, believed to be dimeric and sometimes described as polymeric proanthocyanidins. When a gallic acid residue is attached to the theaflavin it forms the theaflavin gallate.

TABLE 1 — *Composition of tea extracts (% dry weight)*

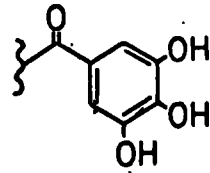
	<i>Tea shoots</i>	<i>Black tea</i>
Flavanols (Catechins)	30	5
Oxidized flavanols	—	20
Caffeine	4	4

#### Physical properties of "Tea Cream"

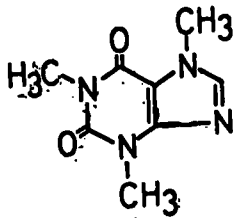
Smith (1968) observed that when a strong tea infusion cools, cream starts to form at 40°C and increases in amount with further decrease in temperature. When the infusion was heated, the cream gradually disappeared and the infusion became clear at about 55°C. Examination under the microscope showed that the cream consisted of spherical globules a few microns in diameter (2–5 $\mu$ ).



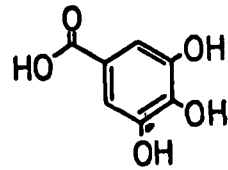
- (-)-Epicatechin;  $R_1=H$ ;  $R_2=H$   
 (-)-Epicatechin-3-gallate;  $R_1=H$ ;  $R_2=V$   
 (-)-Epigallocatechin;  $R_1=OH$ ;  $R_2=H$   
 (-)-Epigallocatechin-3-gallate;  $R_1=OH$ ;  $R_2=V$



Galloyl group - V



Caffeine



Gallic acid

Fig. 1. — Structures of tea polyphenols and caffeine.

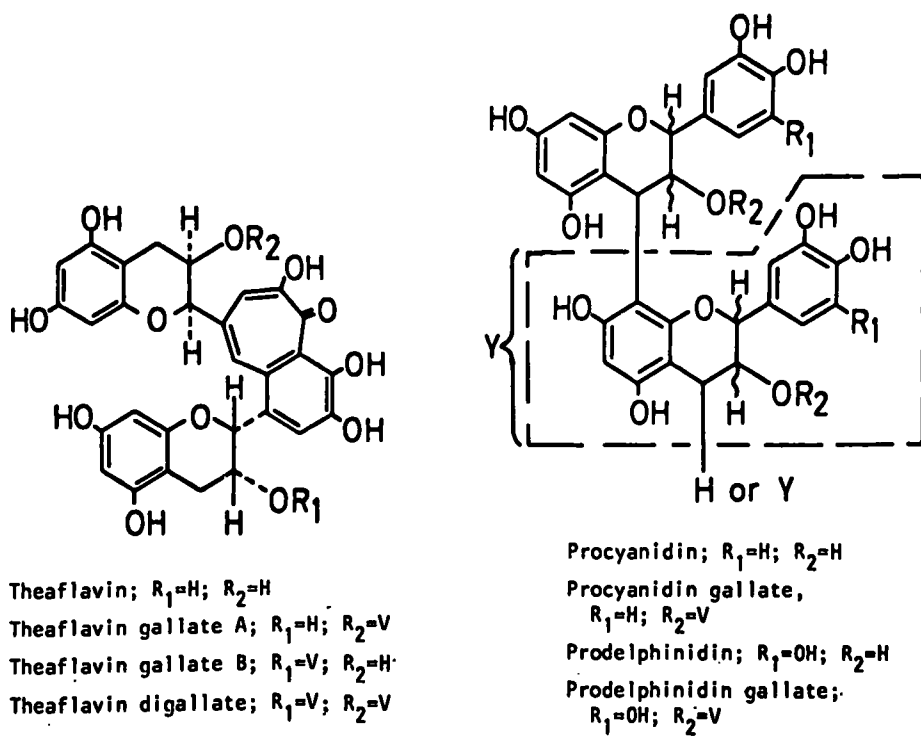


Fig. 2. — Structures of oxidized tea polyphenols — Theaflavins and Thearubigins.

### Composition of tea cream

Roberts (1963) examined the composition of tea cream and found that the major components were theaflavins, thearubigins and caffeine, and that these were present in the approximate ratio of 1 : 4 : 1 (Table 2). The preferential participation of TF in cream formation is indicated by the fact that 62% of the TF present in the original extract has been incorporated into the cream. However, quantitatively the major component of cream is TR.

TABLE 2—*Composition of cream (relative units)*

	<i>Theaflavins</i>	<i>Thearubigins</i>	<i>Caffeine</i>
Tea extract	1.48	12.8	2.78
Decreamed extract	0.56	9.2	1.80
Cream (by difference)	0.92 (62%)	3.6 (28%)	0.98(35%)
%Composition of cream (approx, major constituents)	17	66	17
TF : TR : Caffeine = 1 : 4 : 1			

### Effect of caffeine content on the extent of creaming

Roberts (1963) reported that a qualitative test relying entirely upon visual judgement, showed that addition of pure caffeine to a tea liquor materially increased its powers of creaming down. On the other hand, removal of caffeine from liquor by first shaking with an equal volume of chloroform, resulted in complete inhibition of the creaming down effect. Smith (1968) confirmed these studies by adding increasing amounts of caffeine to a 1 : 40 infusion of tea with a low "creaming powder" and caffeine content. The infusions were allowed to cream down and the percentage of each constituent precipitated determined (Fig. 3). As the caffeine content increased in steps up to double that originally present in tea, the precipitation of soluble solids, thearubigins, theaflavins and caffeine increased.

### Effect of pH on cream formation

The effect of pH of the infusion on cream formation was also investigated by Smith (1968). In general, the amount of cream increased with decrease in pH, which reached a maximum at pH 4 (Fig. 4). There was no cream formed about pH 6.7.

These observations taken together indicated that cream formation was most probably due to H-bonding.

It will thus be evident that interactions between oxidized polyphenols and caffeine appear to be primarily responsible for their precipitation and that these are pH dependent.

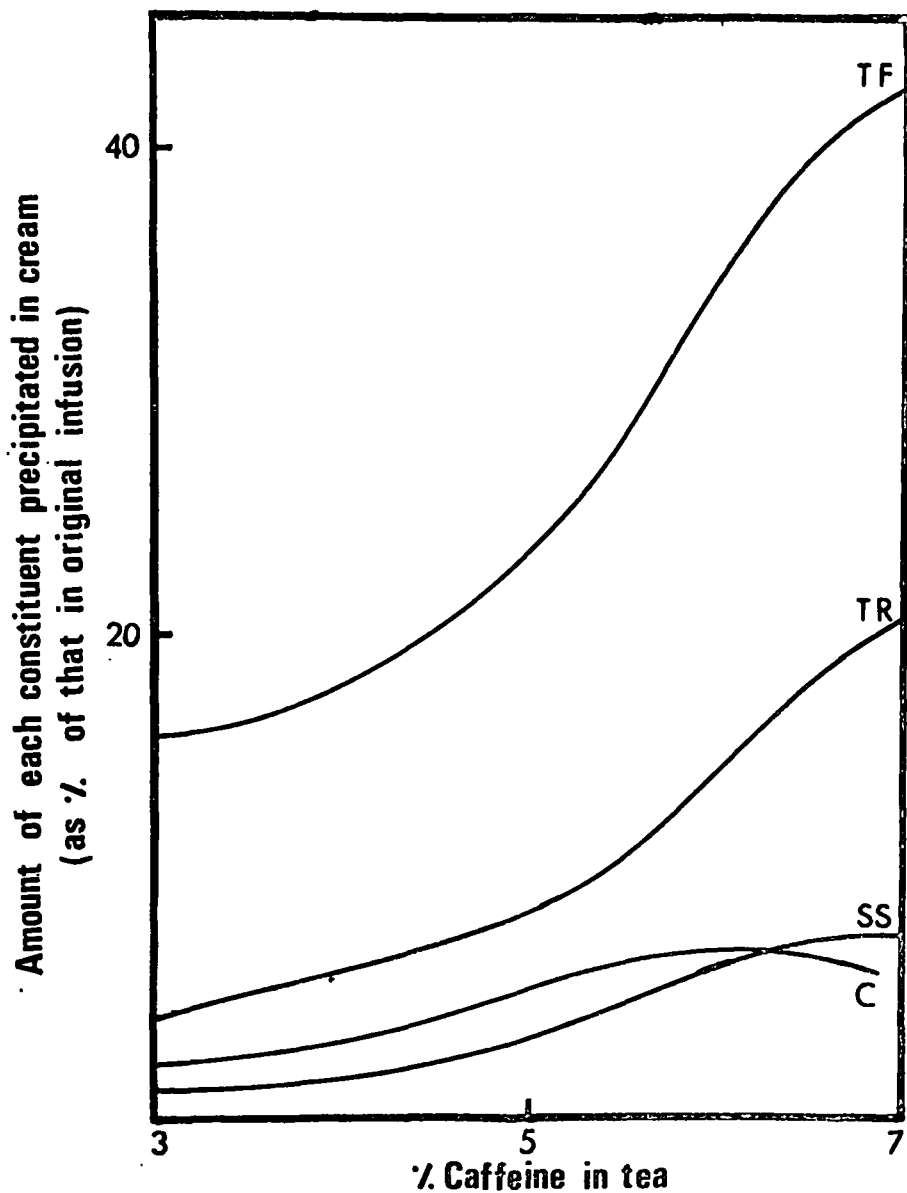


Fig. 3— Effect of caffeine on content of 'cream' constituents  
 TF— theaflavins TR— thearubigins  
 SS— soluble solids C— caffeine

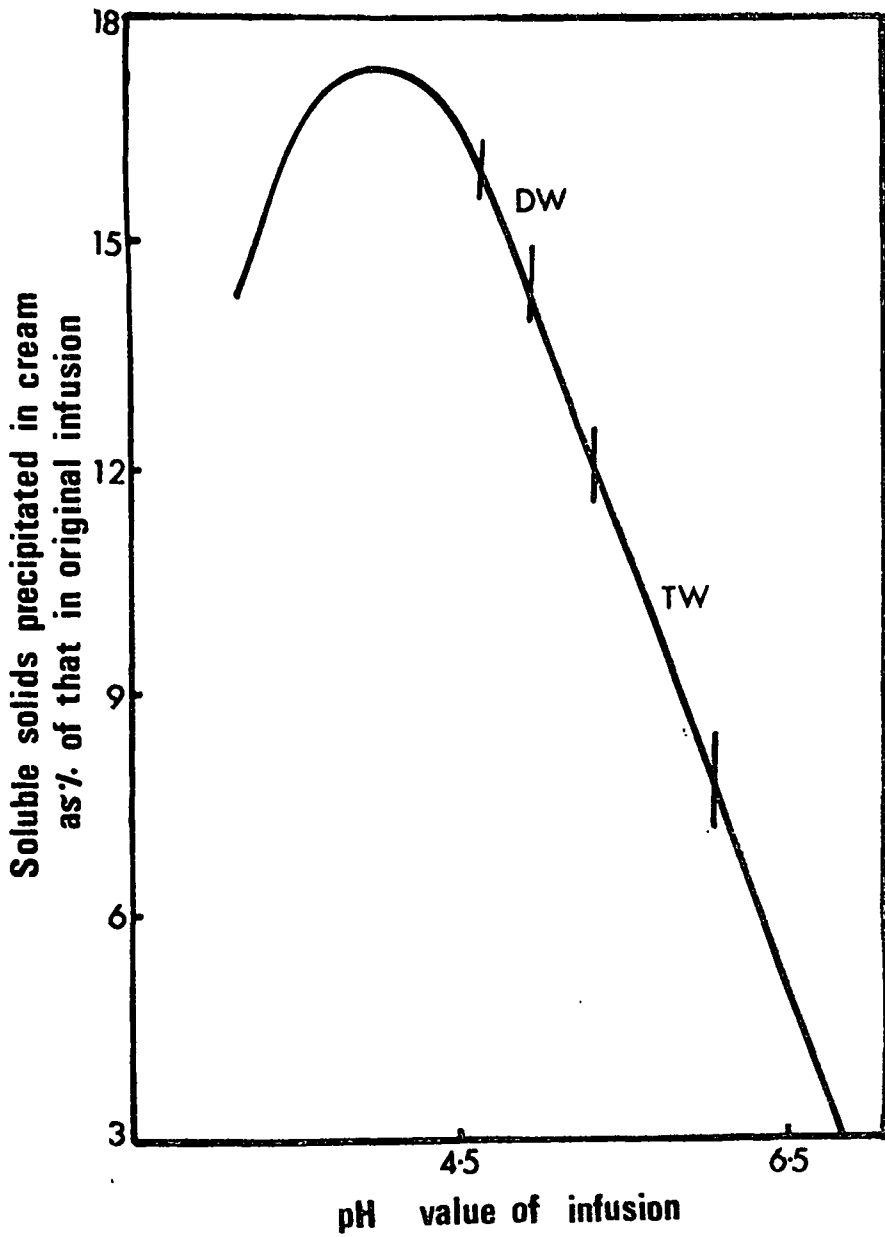


Fig. 4 — Effect of pH on 'cream' formation.

DW — distilled water infusions TW — tap water infusions.

### The importance of galloyl groups in "creaming" reactions

Wickremasinghe and Perera (1966) studied the composition of tea cream and compared it to the composition of decaffeinated extract and indicated that there was some fractionation of tea infusion constituents on decaffeination. The Epicatechin, Epigallocatechin and Theaflavin were found entirely in the decaffeinated extracts while the gallate esters of these compounds were found predominantly in the cream.

These results suggest that polyphenol gallates are more susceptible to interactions with caffeine than the parent polyphenols. Sanderson *et al.* (1976) examined this aspect more closely, and suggested that the galloyl groups on the black tea polyphenols which are important in determining the amounts of astringency of these polyphenols are the specific sites involved in the complex formation with caffeine. In fact observations indicate that degallation of black tea polyphenols will eliminate most of the black tea cream formation. Indeed, this has been the basis of some patents taken out by Tenco Brooke Bond Ltd., (1971), Takimo, New Zealand Patent (1971) and Takimo Canadian Patent (1972).

But Roberts (pers. comm.) is of the opinion that the galloyl groups activate the catechin molecule rather than directly linking up with caffeine. Degallation could be effected by the enzyme tannase which is an esterase acting specifically on the ester bond between the galloyl groups and the gallated tea polyphenols.

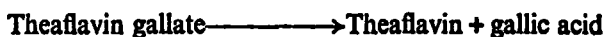


Table 3 shows the effect of decaffeination and tannase treatment on cream formation. It thus appears that cream formation largely involves interactions of caffeine with the gallate groups of tea polyphenols.

TABLE 3 — *Effects of decaffeination and tannase treatment on cream formation*

	% cream
Whole tea extract	26.0
Decaffeinated tea extract	8.7
Tannase treated tea extract	6.8

### Minimizing "cream" formation and effect on taste

It could be inferred from the foregoing that tea cream formation could be inhibited or minimized by one of the following operations :—

1. adjustment of pH to 6.7
2. de-gallation
3. de-caffeination

However, when the pH of tea infusions was increased above 6.5 astringency was reduced considerably and the tea brew is described as "flat". Likewise, degallating an infusion of black tea completely eliminated the "tangy" portion of the astringency of the infusion but had no effect on the non-tangy portion of the astringency (Sanderson *et al.*, 1976). This meant that much of the desirable tea character was lost by degallation.

The effect of decaffeination on the taste of black tea infusions was studied by Sanderson *et al.* (1976). Removal of caffeine resulted in the infusions being characterized as "weak" and was responsible for the bitterness of a tea infusion to increase slightly and also to change the nature of the astringency in the infusion from the tangy type which is characteristic of black tea to a non-tangy type. This is presumably because in the normal tea infusion caffeine complexes with some of the galloyl groups of the galled black tea polyphenols, thereby dampening down any excessively sharp astringency and bitterness.

#### SUMMARY

1. When a hot infusion of tea cools down, we have the process of cream formation ;
2. cream formation is due to the H-bonding between caffeine and essentially the polyphenol gallates ;
3. cream formation could be inhibited by one of the three operations, viz. increase of pH, degallation or de-caffeination ;
4. but, any of these three operations also simultaneously effects undesirable modification of the mouth-feel properties.

Thus it would appear that none of the three operations mentioned above would produce satisfactory results in inhibiting cream formation without detriment to the taste of the tea infusions. This is because the black tea constituents which are chiefly responsible for the desirable characteristics of tea, are the very same components which are responsible for cream formation. A solution to this problem therefore poses a stimulating challenge to food chemists.

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