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Analysis of adulteration in black tea

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Abstract
Adulteration in food has been one of the major concerns since time immemorial, as it not only decreases the quality of food products but also leads to harmful health consequences. Tea is one of the most preferred drinks which is being adulterated with harmful materials like artificial colour, azo dye, coal tar dye and many more either intentionally or unintentionally. The present study was designed to evaluate the quality of black tea available in the markets of Kolkata, West Bengal and to detect adulteration in them. Twelve samples of black tea were analyzed to determine the presence of different adulterants. The products containing adulterants were categorized into high priced and low priced tea samples. Analysis indicated that low cost tea contained more adulterants as compared to high cost tea. The current article attempts to increase the general awareness of the population at large about adulteration of tea in addition to the simple techniques available to detect the same. This may henceforth be beneficial for adequate food choice and selection of appropriate quality of food.

Keywords: adulteration, adulterants, detection methods, tea

1. Introduction
The term adulteration is applied for the deterioration of different food items either by mixing them with cheap and inferior substances or by extracting any valuable ingredients. Food is adulterated to increase the quantity of food and make it more profitable for the manufacturer or retailer [1]. An adulterant is a chemical substance which should not be contained within other substances (e.g. food, beverages, and fuels) for legal or other reasons [2]. The process of the addition of adulterants is called adulteration. The word is appropriate only when the additions are unwanted by the recipient. When a substance is added to food which depreciates or injuriously affects it or any inferior substances are substituted wholly or in part then the food is declared adulterated. Food is also described adulterated if any valuable or necessary constituent or ingredients has been wholly or in part abstracted or if it is imitational, coloured or otherwise treated to improve its appearance [3]. Adulterated food may also contain added substances which may be injurious to health. Foods can be adulterated by different ways which include intentional adulteration, unintentional adulteration and natural adulteration [4]. Consumption of adulterated food can lead to severe health problems in the human body including digestive system disorders, stomach infections liver disorders, cancer of stomach, disorders of blood, epidemic dropsy, glaucoma, cardiac arrest, lathyrism, diarrhoea, carcinogenesis etc. [5]
Tea is regarded as one of the most consumed and preferred aromatic beverages in the world. It is an ancient beverage steeped in history and loved by many. Tea has been shown to provide energy and alertness in the morning. A range of health benefits have been associated with drinking tea [6]. Black tea is a source of caffeine, a methylxanthine that stimulates the central nervous system, relaxes smooth muscles in the airways to the lungs and also acts on kidney as a diuretic. The beneficial effects of tea have been attributed to the presence of flavonoids which improves the immune functioning of the human body. Moreover, tea is used to reduce toxins and to improve resistance against diseases. Tea extract has also been documented to have beneficial effects on fecal microflora balance which includes improving gut health as well as antimicrobial effects in the upper respiratory tract [7]. In present times, food adulteration is a major problem worldwide as it severely affects human health and is associated with food safety. Tea is subjected to many forms of adulteration including artificial coloring and facing, that is, the attachment of heavy bodies to the surface of tea to increase its weight. Tea leaves are frequently dyed with artificial color to conceal damage or inferiority. Sometimes, tea leaves which have been damaged during processing are faced solely to improve their appearance. Adulterants are generally added to reduce manufacturing costs and to deceive the consumers. According to previous reports, tea has been found to be adulterated with different types of azo dyes such as sunset yellow, tartrazine, carmosine, brilliant blue and indigo carmine [8]. Moreover, tea has also been found to be adulterated with starch, sand, china clay, french chalk, iron fillings, chicory, lather flakes, caffeine, used tea leaves and many more [9].
Today tea adulteration is a common practice in the market since tea is the most commonly consumed beverage in the world. The present study was undertaken to analyze presence of adulterants in tea from different areas of Kolkata, West Bengal.

2. Materials and methods
2.1 Collection of raw materials
Black tea samples were used for the study. Two types of tea

i.e. local tea and packaged tea of both high price and low price categories were collected. Tea Samples were collected from different tea dealers from four areas of Kolkata including East Kolkata, North Kolkata, South Kolkata and Central Kolkata. All the samples were procured, sealed in zip lock pouches and stored in card board boxes. The samples were protected from light and air till the completion of study. Tea samples were coded as shown in Table 1. The price range for the different tea samples studied has been mentioned in Table 2.

Table 1: Codes of different tea samples

Area of Kolkata	Price	Code
East Kolkata	Low	E1
East Kolkata	High	E2
North Kolkata	Low	N1
North Kolkata	High	N2
South Kolkata	Low	S1
South Kolkata	High	S2
Central Kolkata	Low	C1
Central Kolkata	High	C2

Table 2: Price range for the different tea samples

Packaged Tea		Local tea		
Brand	Cost/kg	Area	High priced (cost/ kg)	Low priced (cost/ kg)
A	402	South	400 (S2)	180 (S1)
B	350	North	400 (N2)	160 (N1)
C	390	East	400 (E2)	160 (E1)
D	340	Central	500 (C2)	160 (C1)

2.2 Selection of place
The analysis of tea adulteration was conducted in chemical and instrumental laboratory of J.D.Birla Institute, Kolkata.

2.3 Chemical analysis of Tea samples
The tea samples were analyzed for adulterants including artificial color, iron fillings, coal tar dye, catechu, sand, cereal starch, azo dye and chicory.

2.3.1 Test for detection of artificial colour
The tea was spread on the surface of clean glass containing water. Changes in the colour of water indicated that the tea sample was dyed with water soluble colours.

2.3.2 Test for detection Iron fillings
Tea samples were placed in plates and a magnet was held near the plates. If iron filling were present then tea samples were attached to the magnet thereby confirming the presence of the above.

2.3.3 Test for detection of coal tar dye
Tea samples were taken in a test tube and 5 ml of concentrated Hydrochloric acid was added to it. Appearance of pink or crimson colour indicated the presence of coal tar dye in tea samples.

2.3.4 Test for detection of Catechu
Tea samples were taken in a test tube and 5ml water was added to it and followed by few drops of lead acetate solution. The solution was thereafter filtered followed by addition of few drops of silver nitrate. Appearance of grayish cloudiness indicated the presence of catechu.

2.3.5 Test for Sand
Tea samples were taken in test tubes. Then 7ml of water was added and mixed well. Formation of any sedimentation indicated presence of sand in tea samples.

2.3.6 Test for Cereal starch
Small quantity of tea sample was taken in a test tubes and distilled water was added to it. The contents were heated to produce colour. Potassium permanganate solution and diluted Hydrochloric acid (1:1) were added to it to decolorize the mixture. Then 1% aqueous solution of iodine was added. Presence of blue colour indicated adulteration of tea samples with cereal starch.

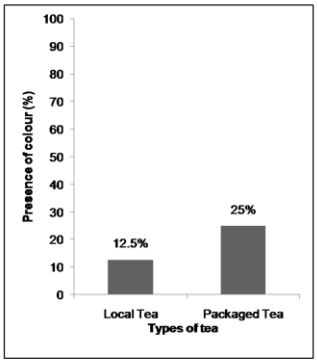
2.3.7 Test for Azo colour
Tea samples were treated with a strong alcohol and the solution was evaporated to dryness. Then it was treated with water. Appearance of characteristic dye colour (red or yellow or orange) indicated adulteration with azo dye.

2.3.8 Test for Chicory
The samples were boiled in a test tube with 2 drops of concentrated Hydrochloric acid. 15 drops of potassium ferrocyanide solution was added and liquid was again boiled till the appearance of dark green colour. The liquid becomes brown and murky, if chicory is present in tea samples, otherwise a precipitate settles at the bottom, leaving a supernatant solution of light yellow colour [10].

2.3.9 Analysis of data
For each test, numbers of adulterated local tea and packaged tea samples were calculated, converted to percentages and graphically represented. In cases where none of the samples showed the presence of a particular adulterant, the data was only represented in a tabular format.

3. Results and Discussion
3.1 Presence of Artificial colour
The results of chemical analysis displayed that Brand F amongst packaged tea samples and local tea coded as N1 were adulterated with artificial colour. All other samples showed the absence of artificial colour as tabulated in Table 3. The overall results showed that 12.5% of local tea and 25% of packaged tea samples were indeed adulterated with artificial colour (Figure 1). Generally, tea leaves can be conceivably adulterated with artificial colour for various reasons which include attracting customers towards the product, increasing profits, and sometimes to sell low cost tea dyed with color at a higher price.

A



B

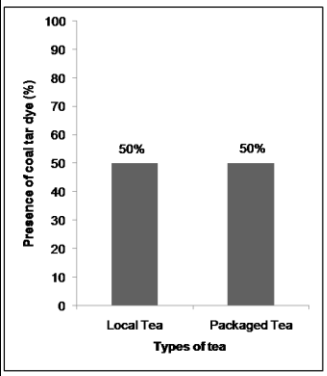
Tea samples (code)	Result
Sample- A	Negative
Sample- B	Negative
Sample- D	Negative
Sample- F	Positive
Sample- E1	Negative
Sample-E2	Negative
Sample-N1	Positive
Sample- N2	Negative
Sample- S1	Negative
Sample- S2	Negative
Sample-C1	Negative
Sample- C2	Negative

Fig 1: Presence of Artificial colour

3.2 Presence of Coal tar dye

Brand B and F among packaged tea and S1, E1, E2 and N1 local tea samples were found to be adulterated with coal tar dye. Therefore, 50% of local tea as well as 50% of packaged tea samples displayed coal tar dye adulteration (Figure 2). Coal tar is a brown-black coloured thick liquid generated during incomplete burning of coal. Coal tar is a complex chemical mixture that also includes a number of suspected and known carcinogens, such as benzene, toluene, naphthalene, anthracene, xylene, creosote oils and benzo[a]pyrene, which is a polycyclic aromatic hydrocarbon (PAH). PAHs are a large class of chemical that are reasonably anticipated to cause cancer. Addition of coal tar dye to tea gives it a dark black colour hence improving its overall appearance for the consumers.

A



B

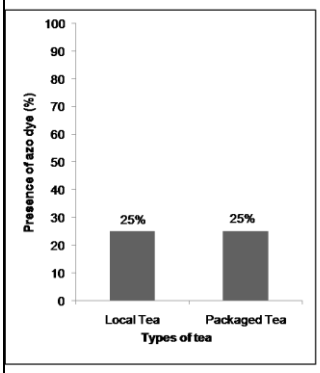
Tea samples (code)	Result
Sample- A	Negative
Sample- B	Positive
Sample- D	Negative
Sample- F	Positive
Sample- E1	Positive
Sample-E2	Positive
Sample-N1	Positive
Sample- N2	Negative
Sample- S1	Positive
Sample- S2	Negative
Sample-C1	Negative
Sample- C2	Negative

Fig 2: Presence of Coal tar dye

3.3 Presence of Azo colors

Chemical analysis of tea samples showed that brand D and samples E2 and N1 displayed the presense of azo colours. Therefore, 25% of both packaged tea as well as local tea samples were found to be adulterated with azo dye (Figure 3). Azo dyes are synthetic colours containing the azo group as part of the structure. Azo dyes are much more stable than most of the natural food dyes. Adulteration with azo dye imparts a strong flavour and colour.

A



B

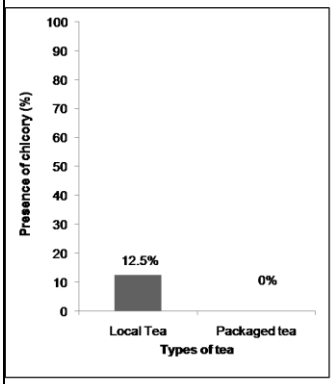
Tea samples (code)	Result
Sample- A	Negative
Sample- B	Negative
Sample- D	Positive
Sample- F	Negative
Sample- E1	Negative
Sample-E2	Positive
Sample-N1	Positive
Sample- N2	Negative
Sample- S1	Negative
Sample- S2	Negative
Sample-C1	Negative
Sample- C2	Negative

Fig 3: Presence of Azo dye

3.4 Presence of Chicory

It was observed that that only C1 was adulterated with chicory (Figure 4). One of the common adulterants of tea is prepared from the root of chicory plant, *Cychorium intybus*. Chicory root gives a pleasant aroma when it is added to tea. However, it acts like a sedative on the central nervous system and could impair reaction time in some individuals.

A



B

Tea samples (code)	Result
Sample- A	Negative
Sample- B	Negative
Sample- D	Negative
Sample- F	Negative
Sample- E1	Negative
Sample-E2	Negative
Sample-N1	Negative
Sample- N2	Negative
Sample- S1	Negative
Sample- S2	Negative
Sample-C1	Positive
Sample- C2	Negative

Fig 4: Presence of Chicory

3.5 Presence of Iron fillings, catechu, sand and cereal starch

The test for iron filings, catechu, sand and cereal starch gave a negative result for all the samples (Table 3). Iron filings may

be added to tea both intentionally and unintentionally. It is intentionally added to increase the weight of the total product enabling the retailer to make greater profits. Unintentionally, iron fillings can be added during the manufacturing process of tea. In our country, most of the machineries used are old and poorly maintained leading to accidental addition of iron from them into the samples. Moreover, improper packaging of tea may also lead to unintentional addition of iron during transportation. Catechu is an extract of acacia trees used variously as a food additive, astringent and dye. Catechu is inodorous, with an astringent and bitter taste, followed by a sense of sweetness. Catechu is often mixed with tea to make it more appealing and attractive. Moreover, sand and cereal starches might be intentionally added to tea to increase the weight of the total product. Sometimes, it could also be added unintentionally during processing, packaging, transportation or sale.

Table 3: Presence of adulterants in tea samples

Adulterants	N1	N2	S1	S2	C1	C2	E1	E2	A	B	D	F
Artificial colour	P	A	A	A	A	A	A	A	A	A	A	P
Iron filling	A	A	A	A	A	A	A	A	A	A	A	A
Coal tar dye	P	A	P	A	A	A	P	P	A	P	A	P
Sand	A	A	A	A	A	A	A	A	A	A	A	A
Cereal starch	A	A	A	A	A	A	A	A	A	A	A	A
Azo dye	P	A	A	A	A	A	P	A	A	A	P	A
Catechu	A	A	A	A	A	A	A	A	A	A	A	A
Chicory	A	A	A	A	P	A	A	A	A	A	A	A

A= Absent, P= Present

3.6 Comparison between packaged tea and local tea

From the chemical analysis of all the tea samples, it was revealed that tea samples were mainly adulterated with different colouring materials which include water soluble artificial colour, coal tar dye, azo dye and chicory. Overall analysis indicated that 50% of the local tea varieties were adulterated compared to 37.5% for the packaged tea samples (Figure 5).

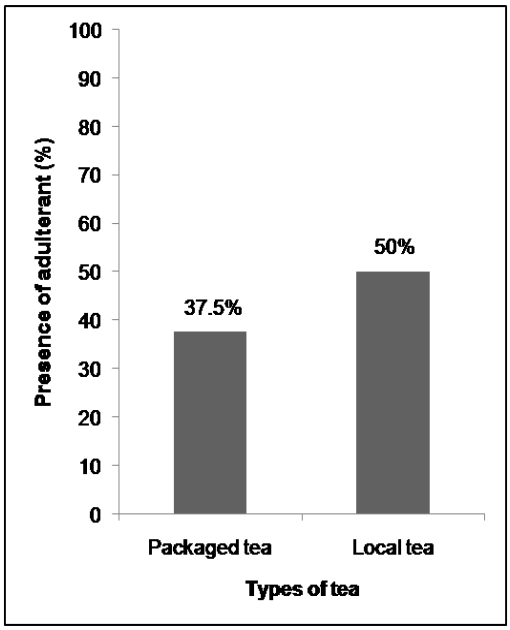


Fig 5: Comparison between packaged tea and local tea

3.7 Comparison between high cost tea and low cost tea

It was observed that low cost tea displayed increased adulteration compared to high cost tea. Analysis of data revealed that 50% of low priced tea samples showed presence of one or more adulterants compared to only 25% for high priced tea samples (Figure 6).

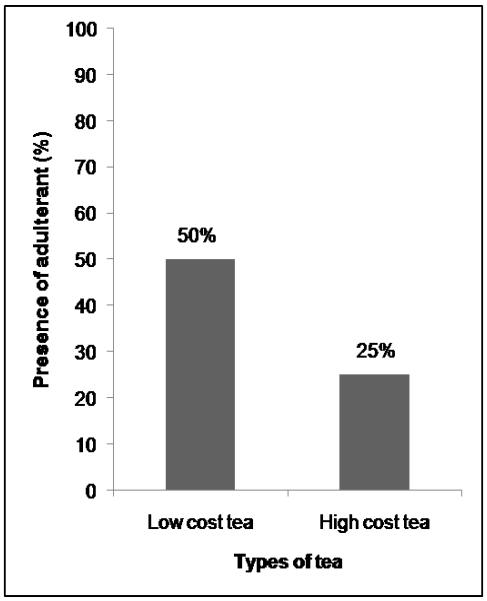


Fig 6: Comparison between high cost and low cost tea

Food adulteration is the process by which the quality of food is depreciated either by the addition of inferior quality material or by extraction of valuable ingredients that adversely affects health conditions. Previous studies have reported that tea has being adulterated with sand, iron fillings, coal tar dye, azo dye, chicory and many more. Results obtained from chemical analysis of tea samples of Kolkata portrayed that these were mainly adulterated with different colouring materials including water soluble artificial colours, coal tar dye, azo dye and chicory. Moreover, it was observed that local tea contained more adulterants as compared to packaged tea as 50% of local tea showed presence of adulterants compared to only 37.5% for packaged tea. This may be because it is almost impossible for the retailer to deteriorate the quality of packaged tea by adding adulterants. On the contrary, the situation is exactly opposite for local tea. Local tea can easily

be adulterated by the shop keeper or manufacturer either intentionally or unintentionally. Additionally, it was also revealed that low cost tea contained more adulterants compared to tea having a higher price per kilogram. The possible reason behind this practice could be an attempt to make the product more appealing to the customer by adding adulterants like artificial colour to tea of inferior quality. Moreover, tea leaves were dyed with artificial colour to increase profits, and sometimes to sell low cost tea dyed with color at a higher price. Analysis of different tea samples would help in generating awareness among people regarding tea adulteration. It may also help individuals to understand the harmful effect of adulterants in the human body. Furthermore, a regular and routine analysis of tea samples may also instigate people to take further steps to prevent food adulteration by reporting in consumer forum or creating awareness in the general population.

4. Conclusion

Adulteration is a common practice in the society which brings about deterioration of food quality leading to harmful effects on human health. In Kolkata, tea is one of the most preferred drinks which are being adulterated with certain harmful material like artificial colour, azo dye, coal tar dye and many more. The study was conducted to chemically analyze various tea samples which were collected from different areas of Kolkata for presence of adulterants. It was observed that local tea contained more adulterants as compared to packaged tea because it was difficult for the retailer to deteriorate the quality of packaged tea by adding adulterants to a completely sealed packet. Additionally, low cost tea contained more adulterants in comparison to high cost tea. The practice of adulteration can be prevented only when the population at large takes a step forward. Moreover, people also need to be more conscious about the quality of product that is been served. Systematic analysis of different tea samples would help in generating awareness about tea adulteration

5. Acknowledgement

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6. Conflict of Interest

There is no conflict of interest in submission of this manuscript

7. References

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