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Food Forensics: Detection of Hidden Toxins Present in Common Household Consumables

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Abstract

Food forensics is an emerging branch of forensic chemistry which comes to rescue when food is contaminated or adulterated. It helps to check food safety and quality amongst others. Food fraud in terms of adulteration is a growing problem in India. Every possible food item either raw or processed are often prone to adulteration. The present study was to identify common adulterant found in most common household consumables using simple chemical tests prescribed in the manual of Food Safety and Standards Authority of India (FSSAI). The 114 samples of 10 different food products both branded and locally available items were collected. The samples of ten different food items, i.e. Milk, Red chili powder, Tea leaves, Turmeric powder, Ghee, Honey, Pulse (yellow toor dal), Jaggery, Sugar and Asafoetida were tested. It was observed that locally available items that could be loosely purchased were particularly vulnerable to adulteration.

Keywords: Forensic Chemistry; Food Forensics; Adulterants; Presumptive test

Introduction

Forensic Chemistry uses the principles of chemical techniques to aid investigation agencies and law enforcement. In one such application, food forensics is a field of study under the forensic chemistry division and deals with the identification and analysis of illegalities in relation to food products or items of local consumption[]. Food being an important necessity for every living entity to obtain desired nourishment, is required for the sustenance of life. Adulteration can be defined as "An act of deliberately contaminating food material with inferior quality or cheap and inedible or toxic substances"[1,2]. Food adulteration may lead to chronic poisoning, various kinds of diseases and even fatality. Forensic studies with regards to food have not been a widely popular especially in India, where most of the cases of adulteration and testing are routinely carried out by the Food and Drug Administration [3-5]. Since the topic has a significance in the forensic field as well, this study was carried out to determine whether the current practice in place needs to be amended to elicit the criminal intentions of a few vendors or distributors and the rules if flouted by locally available items which finds its way into many homes across India[6].

The present study was conducted with the objective of detecting the presence of adulterants in commonly consumed household food items inclusive of both, packaged or branded and locally available or loosely sold items by presumptive color tests[7,8]. A total of 114 samples were studied which comprised of ten different food products i.e. ten samples of Milk, fourteen of Red Chili powder, ten of Tea Leaves, twelve of Turmeric powder, fourteen of Ghee, twelve of Honey, ten of a Pulse - Toor Dal (yellow), ten of Jaggery, twelve of Sugar and ten of Asafoetida (Hing). The potential toxins in each of them were detected by observation of color changes in the samples on performing prescribed tests as per the manual of Food Safety and Standards Authority of India (FSSAI).

Materials and Methods

a. Glassware: Test tubes, Test tube stands, Droppers and Glass rods.

b. Chemicals: Conc. HCl, Distilled water, Iodine solution, Conc. H_2SO_4, Ether, N-Hexane, Acetonitrile and Ethanol.

c. Miscellaneous: Lactometer, Red Litmus paper, Bunsen burner, Filter paper and Magnet.

The positive control samples for each adulterant was run side by side with the unknown samples. The unknown/test samples were randomly selected from both branded and local items. Minimum of 10 varieties of each ten different items were collected and tested using the appropriate chemical test methods[9].

Methodology/ Experiment/ Procedure

Each sample was measured and 5ml quantities were taken in each test tube[10]. The tests performed for the chemical examination of different adulterants have been illustrated in the tabular column given below Table 1.

Table 1: Vanaspati - an Indian food product obtained through the process of saponification of vegetable oils rather than animal fat. It is generally consumed as a vegetarian item in the Indian cuisine.

Sl. No.	Food item	Adulterant	Test performed	Observation (for positive controls)
1.	Milk	Water	A lactometer is used to find the reading value.	The reading should not be less than 26
		Starch	A few drops of iodine solution was added to the sample.	Formation of a blue colour indicates the presence of starch.
		Urea	To the sample, soyabean powder was added in the ratio of 2:1 and mixed. After 5 minutes, a red litmus paper was dipped into it.	Red colour turns to blue after 30 sec, indicates presence of urea.
		Vanaspati*	To the sample, 10 drops of HCl and 1 teaspoon sugar was added.	After 5 minutes, a red colouration indicates the presence of vanaspati.
		Detergent	The sample was mixed with an equal amount of water and shaken vigorously.	Formation of a soapy lather indicates the presence of detergent.
		Formalin	To the sample, 5 ml conc. sulphuric acid was added carefully, by the sides of test tube without shaking,	Formation of a violet or blue ring at the junction of the two liquids, indicates the presence of formalin.
2.	Ghee*	Coal tar dyes	5 ml of sulphuric acid was added to about 1gm of the sample and shaken.	Appearance of a pink colour with sulphuric acid and crimson with HCl indicates the presence of coal tar dyes.
		Vanaspati	1 gm of sample was melted and mixed with an equal quantity of conc. HCl and a pinch of sugar. This was shaken for a minute and observed after 5 minutes.	Appearance of a crimson colour indicates the presence of vanaspati.
		Mashed potato/sweet potato/other starch	Few drops of iodine were added to the sample.	Formation of a blue colour indicates the presence of starch.
3.	Sugar	Chalk powder	10 mg of sample was dissolved in distilled water.	Chalk or dust if present, settles at the bottom.
		Urea	The sample was dissolved in water and odor was noted.	Presence of urea is indicated by the smell of ammonia.
4.	Honey	Sugar solution	Cotton was dipped in the sample of honey and burned.	If honey is adulterated with sugar solution, it either does not burn or may burn with a crackling sound.
		Invert sugar or jaggery	5 ml solvent ether was taken in a test tube and 5ml honey was added. This was shaken and the ether layer was decanted into a petridish. The ether layer was then evaporated and a few drops of resorcinol were added.	Appearance of a cherry red colour indicates the presence of Jaggery.
5.	Chilli powder	Brick pieces	The sample was taken in a glass of water.	Grittiness on rubbing sediment shows presence of brick or salt.
		Artificial colour	The sample was taken in a glass of water.	If the water gets coloured instantly, it indicates the addition of artificial colour.
		Oil soluble coal tar dye 0.	The sample was taken in a test tube, and mixed with 2ml of solvent ether. The ether layer was then decanted into another test tube with 2ml dil.HCl (1:1) and shaken.	Appearance of a pink colour indicates the presence of coal tar dye.
		Sudan III	The sample was taken in a test tube with 2ml hexane and shaken. It was then allowed to settle and the clear solution was decanted into another test tube. 2ml of acetonitrile was added and shaken.	Appearance of a red colour indicates the presence of Sudan III.
		Saw dust	The sample was sprinkled onto water.	Saw dust if present floats on water.
6.	Tea leaves	Artificial coal tar dye	The tea leaves were spread on a moistened filter paper.	If the paper gets stained it indicates the addition of artificial colour.
		Leather flakes	Tea leaves were put on a burning paper ball.	The smell of burning leather indicates a positive test.
7.	Asafoetida	Soap stone	The sample was shaken in water and allowed to settle.	Soap stone or other impurities if present, settle at the bottom.

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		Starch	Iodine solution was added to the sample.	Formation of a blue colour indicates the presence of starch.
		Foreign resin	The sample is lighted on fire.	Pure sample burns like camphor whereas the resin if present, does not burn.
8.	Turmeric powder	Metanil yellow	The sample was taken in a test tube and few drops of HCl were added.	Gives a pink colour which disappears on dilution, however, if colour persists it indicates the presence of metanil yellow.
		Chalk or yellow soap stone	Sample was taken in test tube with water and few drops of HCl were added.	If effervescence is observed, it indicates the presence of chalk powder or yellow soap stone.
9.	Pulses	Lead chromate	5gm of the pulse sample was taken in 5ml of water and a few drops of HCl were added.	Appearance of a pink colour indicates the presence of lead chromate.
10.	Jaggery	Metanil yellow	The sample was taken in a test tube and 3ml of alcohol and 10 drops of HCl was added.	Appearance of a pink colour indicate the presence of metanil yellow.
		Washing soda	To the sample in a test tube, water and a few drops of HCl was added.	Effervescence shows the presence of washing soda.
		Chalk powder	The sample was dissolved in water in a test tube.	Chalk powder if present settles at the bottom of the tube.

Results and Discussion/ Findings and Analysis

The observations were as given in the tabular columns below: Abbreviations used: -ve indicates a negative test result and +ve indicates a positive test result (Tables 2-11).

Table 2: Tests on Milk.

↓Sample tests→	Lactometer Reading	Starch	Urea	Vanaspati	Formalin	Detergent
A	34	- ve	- ve	- ve	- ve	- ve
B	34	- ve	- ve	- ve	- ve	- ve
C	32	- ve	- ve	- ve	- ve	- ve
D	32	- ve	- ve	- ve	- ve	- ve
E	33	- ve	- ve	- ve	- ve	- ve
F	31	- ve	- ve	- ve	- ve	- ve
G	32	- ve	- ve	- ve	- ve	¬+ve
H	32	- ve	- ve	- ve	- ve	- ve
I	33	- ve	- ve	- ve	- ve	- ve
J	30	- ve	- ve	- ve	- ve	+ve

Table 3: Tests on Tea Leaves.

↓Sample tests→	Artificial colour	Iron filings	Leather flakes
A	- ve	- ve	- ve
B	- ve	- ve	- ve
C	- ve	- ve	- ve
D	- ve	- ve	- ve
E	- ve	- ve	- ve
F	+ve	- ve	- ve
G	+ve	- ve	- ve
H	- ve	- ve	- ve
I	+ve	- ve	- ve
J	+ve	- ve	- ve

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Table 4: Tests on Ghee.

↓Sample tests→	Coal tar dye	Vanaspati	Any starch
A	- ve	- ve	- ve
B	- ve	- ve	- ve
C	- ve	- ve	- ve
D	- ve	- ve	- ve
E	- ve	- ve	- ve
F	- ve	- ve	- ve
G	- ve	- ve	- ve
H	- ve	- ve	- ve
I	- ve	- ve	- ve
J	- ve	- ve	- ve
K	- ve	+ve	- ve
L	- ve	- ve	- ve
M	- ve	- ve	+ve
N	- ve	- ve	- ve

Table 5: Tests on Sugar

↓Sample tests→	Chalk powder or dust	Urea
A	- ve	- ve
B	+ve	- ve
C	- ve	- ve
D	- ve	- ve
E	- ve	- ve
F	- ve	- ve
G	- ve	- ve
H	- ve	- ve
I	+ve	- ve
J	- ve	- ve
K	- ve	- ve
L	- ve	- ve

Table 6: Tests on Honey

↓Sample tests→	Sugar solution Burning test	Sugar(dispersion)	Invert sugar/ jaggery
A	- ve	- ve	- ve
B	- ve	- ve	+ve
C	- ve	- ve	- ve
D	- ve	- ve	- ve
E	+ve	+ve	- ve
F	- ve	- ve	- ve
G	+ve	+ve	+ve
H	- ve	- ve	- ve
I	- ve	- ve	+ve
J	- ve	- ve	- ve
K	+ve	+ve	- ve
L	+ve	+ve	+ve

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Table 7: Tests on Red Chili Powder

↓Sample tests→	Brick/ salt/talc	Artificial colour	Oil soluble coal tar dye	Sudan III	Saw dust
A	- ve	- ve	- ve	- ve	- ve
B	- ve	- ve	- ve	- ve	- ve
C	- ve	- ve	- ve	- ve	- ve
D	- ve	- ve	- ve	- ve	- ve
E	- ve	- ve	- ve	- ve	- ve
F	- ve	- ve	- ve	- ve	- ve
G	- ve	- ve	- ve	- ve	+ve
H	- ve	- ve	- ve	- ve	+ve
I	- ve	- ve	- ve	+ve	- ve
J	- ve	- ve	- ve	- ve	+ve
K	- ve	- ve	- ve	- ve	+ve
L	- ve	- ve	- ve	- ve	+ve
M	- ve	- ve	- ve	+ve	+ve
N	- ve	- ve	- ve	- ve	+ve

Table 8: Tests on Asafoetida.

↓Sample tests→	Soap stone	starch	Foreign resin
A	+ve	+ve	- ve
B	- ve	+ve	- ve
C	- ve	+ve	- ve
D	+ve	+ve	- ve
E	+ve	+ve	- ve
F	+ve	+ve	- ve
G	- ve	+ve	- ve
H	- ve	+ve	- ve
I	+ve	+ve	- ve
J	- ve	+ve	- ve

Table 9: Tests on Ghee.

↓Sample tests→	Stone /Chalk/ Dust	Washing soda
A	- ve	- ve
B	+ve	- ve
C	- ve	- ve
D	- ve	- ve
E	- ve	- ve
F	- ve	- ve
G	- ve	- ve
H	- ve	- ve
I	+ve	- ve
J	- ve	- ve

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lable 10: Tests on Turmeric Powder.

↓Sample tests→	Metanil yellow	Chalk powder/ yellow soap stone
A	- ve	- ve
B	- ve	- ve
C	- ve	- ve
D	- ve	- ve
E	- ve	- ve
F	- ve	- ve
G	- ve	- ve
H	- ve	- ve
I	- ve	- ve
J	- ve	- ve
K	- ve	- ve
L	- ve	- ve

Table 11: Tests on Turmeric Powder.

↓Sample tests→	Lead chromate
A	-ve
B	- ve
C	- ve
D	- ve
E	- ve
F	- ve
G	- ve
H	- ve
I	- ve
J	- ve
K	- ve
L	- ve

Conclusion

Based on our research, it was found that out of Ten different samples of milk, two milk samples showed presence detergent. Of the Eight samples of tea leaves, four samples indicated the presence of artificial colour. The two samples of chilli powder, out of Fourteen samples gave positive results for presence of Sudan III, and few showed presence of saw dust. Of the total Fourteen ghee samples tested, one showed presence of vanaspati and another showed presence of starch. One sample of pulses in the Ten samples tested showed presence of some unknown colour. Honey was found to be adulterated too, with four samples showed presence of sugar and presence of jaggery out of Twelve samples tested. Two samples of sugar showed presence of dust and chalk powder. The Ten tested samples of jaggery showed the presence of stone and chalk powder in five samples and washing soda was seen in two samples. Out of Ten samples of asafoetida tested, five positively indicated the presence of dirt and other impurities whereas all the ten samples showed presence of starch which may likely to have been due to addition of wheat flour during its processing. Hence on the whole, it was seen that the locally available items were more vulnerable to adulteration and since these items are more frequently purchased as compared to the costlier variants, it is the recommendation of this study that required measures should be enforced to check adulteration in the same.

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