Chapter 1

GENERAL INTRODUCTION

1.1 MARKET SURVEY

Recently a detailed survey of the market has been made and it has been painfully observed that large number of food articles in the market are adulterated. Government records show that on an average, 25 to 30 per cent of edibles sold in various parts of the country are adulterated. The incidence of food adulteration in some states is even higher and it is no exaggeration to say that the nation's health is in peril. For the millions of our people who are under nourished, the danger of this menace is likely to be more pronounced than in the case of well fed. In many instances, the health effects of adulteration become apparent only after lapse of days, months or years. To understand the problem fully, it is necessary to know when and how a food article becomes adulterated.

1.2 WHAT IS FOOD ADULTERATION?

The general concept is that only intentional addition of non-permitted foreign matter to food or abstraction of certain ingredients from food, constitutes food adulteration. Actually, food adulteration includes not only the intentional addition or substitution or abstraction of substances which
adversely affect the nature, substance and quality of foods but also their incidental contamination during periods of growth, harvesting, storage, processing, transportation and distribution. The former is a wilful act on the part of the adulterator intended to deprive the buyer of his money's worth and thereby reap a large margin of profit. But incidental food contamination is usually due to ignorance, negligence or lack of proper facilities. Where the adulteration involves contamination of a serious nature, the consequences will be grave. The variety of human ailments caused by such adulteration is broadly termed as "food poisoning" although in a strictly technical sense the term generally is confined to explosive outbreaks of diseases produced by pathogenic organisms. The concept of food adulteration will be more clear from the following FFA definitions.1

Adulterant - Adulterant means any material which is or could be employed for the purpose of food adulteration.

Adulterated - An article of food shall be deemed to be adulterated if

(a) the article sold by a vendor is not of the nature, substance or quality demanded by the purchaser and is to his prejudice, or is not of the nature, substance or quality which it purports to be
(b) the article contains any other substance which affects or if the article is so processed as to affect, injuriously the nature, substance or quality thereof

(e) any inferior or cheaper substance has been substituted wholly or in part for the article, so as to affect injuriously the nature, substance or quality thereof

(d) any constituent of the article has been wholly or in part abstracted so as to affect injuriously the nature, substance or quality thereof

(e) The article had been prepared, packed or kept under insanitary conditions whereby it has become contaminated or injurious to health

(f) the article consists wholly or in part of any filthy, putrid, rotten, decomposed or diseased animal or vegetable substance or is insect infested or is otherwise unfit for human consumption

(g) the article is obtained from a diseased animal

(h) the article contains any poisonous or other ingredient which renders it injurious to health

(i) the container of the article is composed wholly or partly of any poisonous or deleterious substance which renders its contents injurious to health
(j) any colouring matter other than that prescribed in respect thereof is present in the article, or if the amounts of the prescribed colouring matter which is present in the article are not within the prescribed limits of variability

(k) the article contains any prohibited preservative in excess of the prescribed limits

(l) the quality or purity of the article falls below the prescribed standards or its constituents are present in quantities not within the prescribed limits of variability, which renders it injurious to health

(m) the quality or purity of the article falls below the prescribed standard or its constituents are present in quantities not within the prescribed limits of variability but which does not render it injurious to health.

In case of primary food if this happens due to natural causes and without human interference then this article may not be deemed to be adulterated.

1.3 WHAT IS QUALITY?

To understand the quality features of a certain foodstuff, it is essential to know the meaning of the word 'quality'. It is defined as 'that which makes a thing what
it is; nature; character; kind; property; status; grade of goodness; excellence*. The parameters of quality are the grades, standards and specifications laid down by the Government or Expert Bodies constituted for the purpose

1.4 INTERNATIONAL FOOD STANDARDS

ICAC is the principal organ of a world-wide food standards programme under the joint auspices of FAO and WHO, two specialised agencies of the United Nations Organisation. The Commission's main task is to prepare an international Codex Alimentarius based on the principles outlined by the Commission itself. Codex standards contain requirements for food aimed at ensuring for the consumer a sound, wholesome food product free from adulteration, correctly labelled and presented.

1.5 INDIAN FOOD STANDARDS

A number of existing food standards in India are based on the international Codex Alimentarius with relevant modifications and additions wherever necessary. The most important national standards of quality at present are

1. PFA standards: These prescribe the minimum requirements for all types and categories of food. The PFA Rules were first introduced in 1955 superseding original State Food Adulteration Rules and have been subsequently amended in
1968 and 1973. The standards are formulated and revised when required, by an Expert Body, CCFs. Any food that does not conform to the minimum standards laid down by the FFA Rules, is said to be adulterated, irrespective of anything has been added to or removed from the original food.

(2) FPO Standards: The FPO was promulgated by the Govt. of India in 1946, under the Defence of India Rules. In 1955, the order was revised under Section III of Essential Commodities Act. The FPO lays down the minimum standards relating to the quality of various fruit and vegetable products.

Obviously, the objective of the FFA and FPO standards is to obtain a minimum level of quality for foodstuffs, consistent with the minimum quality attainable under Indian conditions by the majority of farmers, processors, sales, and distribution agencies. To express degrees of excellence above these floor levels, there are in India today, two main sets of standards. These are:

(a) Agmark Standards: This was set up by Govt. of India to cover the various quality levels of agricultural commodities. The Grading and Marketing of Agriculture Produce Act 1937, defines quality of cereals, oilseeds, oils, butter, ghee, legumes, eggs etc. and provides for the categorisation of commodities into various grades depending on the degree of purity in each case.
The benefits of the Agmark standardisation are made available to the public by providing for Agmarking of articles of food such as edible oils, butter, ghee, confectionery etc. The mark gives the consumer an assurance of quality in accordance with the standards laid down.

(b) Indian Standards: These are available for vegetable and food products, spices, condiments, cereals and various processed foods. The standards are formulated and revised from time to time by various Committees set up by the ISI. The ISI mark on any food article is a guarantee of good quality, in accordance with prescribed Indian standards for that commodity.

The above two standards are not mandatory. They are purely voluntary and hence the benefits which accrue from them are limited as far as the consumer in India is concerned. They are however, useful for meeting the requirements of 'export quality goods'. The foodstuff to be sold within India are to possess minimum FPA standards otherwise offenders are liable to legal action.

1.6 COMMON ADULTERANTS IN FOOD

Prohibited substances are either added to food or partly or wholly substituted in food. Valuable components may be removed from the food as for instance, fat from milk. In each case, the quality of the food is deliberately lowered by
the adulterator in order to derive the maximum profit from its sale. The result is, the consumer is cheated of his money's worth and often becomes prey to disease. This type of adulteration is practically non-existent in developed countries but is fairly common in India.

Food commonly adulterated in India are the following:

1. Milk
2. Milk Products
3. Salted Products
4. Cereals and Pulses
5. Sweets and Sweetening agents
6. Spices and Condiments
7. Edible Fats and Oils

Following are some of the injurious common adulterants encountered in them.

1.7 'LATHYRUS SATIVUS' OR KHSARI DAL

Khesari is the staple food of the poorest of the poor. The plant grows with minimum effort and yields abundant crops even under extremely adverse conditions. Compared to other edible pulses, therefore, lathyrus is very cheap. This factor, coupled with its easy availability, has contributed to its large scale use as an adulterant in various other pulses and their flours (Bessen). Neurolathyris, a syndrome
characterized by such profound neurological disturbances as weakness, irritability, spasticity and rigidity of leg muscles and paralysis has been described in humans subsisting for prolonged periods on the seed meal of certain legumes belonging to the genus of Lathyrus. The existing of this crippling disease in an endemic form among the poor people in certain regions of Central India accustomed to consume khesari dal as the major dietary constituent has been reported.

Experiments conducted at the National Institution of Nutrition, Hyderabad from 1962 onwards, indicate that khesari seed contains more than one toxic factor. But it is proved that $\beta$-m-exalyl amino alanine (BOAA), a toxic amino acid not found in other edible pulses is chiefly responsible for causing neuralathyriasis in men when excessive amounts are consumed.

Considering the serious toxic effect of Lathyrus sativus Government of India has put some restrictions on cultivation of the crop. The sale of khesari and khesari products have been prohibited. Government of India has banned the use of khesari for human consumption.

A simple and specific paper chromatographic method for detection of adulteration of other pulses with Lathyrus sativus has been evaluated by Nagarjan et al.
1.8 ADULTERANTS IN EDIBLE OILS AND FATS

Cheap edible and non-edible oils such as cotton seed oil, linseed oil, argemone oil, used motor oil and white oil etc. have been found as adulterants in the more expensive common edible oils such as mustard oil, coconut oil, olive oil, sesame oil and groundnut oil etc. Orthotriresyl phosphate (TCP), an oily liquid used in plastic industry, has been found at times in mustard and other edible oils. The most important dangerous adulterants are the following:

Argemone Oil

From the very wide distribution of the plant Argemone mexicana Linn. it is likely that some of the argemone seeds get mixed up with mustard seeds and are occasionally responsible for the commonly used mustard oil in some parts of India. Circumstantial evidence, however, strongly indicates that in a number of cases at least this adulteration is intentional. The plant is very common throughout India and the oil obtained from the seeds is cheap.

The oil contains two alkaloids, sanguinarine and dihydrosanguinarine, the former being more toxic than the latter, and contains about 40 per cent free glycerides of fatty acids. Regular consumption for one to three months of any edible oil contaminated with as low a concentration as 0.1 per cent argemone oil, can give rise to epidemic dropsy in
human beings. As the disease progresses glaucoma (an eye
symptom which may cause blindness), erythematous - nodules,
enlargement of the liver, respiratory distress and cancer, are
possible. It may even be fatal due to cardiac arrest.17,18

Argemone poisoning has been repeatedly reported from
several parts of the country due to adulteration of mustard
and groundnut oils with argemone oil. Gujarat, Bihar and West
Bengal, have topped the list in the number of cases reported.
The latest report of argemone oil poisoning in Calcutta was in

Number of methods have been evaluated for detection
of argemone oil in other edible oil.19-24 Considering
seriousness of the toxic effect, Government of India, has
given direction in regard to compulsory test for argemone oil
in edible oils particularly mustard oil and suggested some
quick methods.25

Ortho-triacetyl phosphate (TCP)

In 1938 an epidemic occurred in Mauritius which was
believed to be due to the contamination of imported edible
oil by triacetyl phosphate derived from second hand drums.
Unfortunately, none of the oil in question was ever available
for analysis, but a routine examination of oil imported in
drums (mainly arachis, soya and mustard) was begun by the
Medical and Health Department.26 As recently as 1972, several
villagers of West Bengal, had been crippled due to consumption
of mustard oil containing TCP.

TCP can cause permanent damage to the fatty nerve axon sheaths and other parts of the central nervous system. Like some other organic phosphorus compounds (pesticides etc.), it can inhibit the action of the nerve protecting enzyme cholinesterase, thereby seriously impairing the neuro-muscular control of the body which ultimately can lead to death.27,28

Detections of TCP in oil are done by the method suggested by Collins.29,30

Animal Body Fat

This may find a place in Ghee or Vanaspati. Vanaspati is defined as pure hydrogenated vegetable oil and if animal body fats are added, the product must be considered as adulterated. Animal fats like, tallow (beef fat) and lard (pork fat) etc., may be found in Vanaspati and it is most likely that the fat added may be unhygienic. This type of adulteration is to be looked with great concern not only from the point of view of health but also the prejudices of the orthodox religious people may surely be harmed. So Government of India, has taken up the matter very seriously. Various methods had been utilised to detect this type of adulteration.31-34
Mineral Oil

These have their origin in petroleum and are very much cheaper than any edible oil. This is the reason why petroleum fractions especially the used oils like used motor oils have been used as adulterants in edible oils. In the year 1973 and 1974 a fairly large number of suspected vanaspati samples had been received from different parts of the North East Region. Out of which many samples after examination were proved to contain mineral oil as an adulterant. Credit went to the Public Analyst to the Government of Assam, for taking the leading role for detection of this type of dangerous adulteration taking place not only in this region but also throughout India. Valuable suggestions in regard to stopping of this mischievous admixture of Vanaspati with mineral oil had been put forward to the Ministry of Health, Government of India. The Government subsequently took strong measures and alerted other States to bring this menacing practice to an end. Recently it has also come to notice that there is a tendency among the spice traders for polishing black pepper, chillies etc. with mineral oil or white oil.

If taken in sufficient quantity, even pure mineral oil causes gastro intestinal disturbances diarrhoea and vomiting. Smaller amounts interfere with the absorption of fat soluble vitamins such as Vitamin-A, as well as carotene. In addition, the mineral oil may contain polycyclic aromatic hydrocarbons which have been proved to be carcinogenic. For
detection of mineral oils there are many existing methods which have been discussed in Chapter 6.

1.9 ARTIFICIAL SWEETENING AGENTS

Saccharin

Saccharin (2-sulpho-benzoic imide), C$_7$H$_5$O$_3$NS Mol. wt. 183.2, is sparingly soluble in water. Saccharin tablets are prepared as sodium and calcium salts which are easily soluble. It is 550 times sweeter than sugar. Due to its very strong sweetening effects non-alcoholic beverages like soft-drinks, squashes etc., are sweetened artificially by it. The sweetened "Pan-masala"; "Superi" (a flavoured powder taken with betel leaf; superi in English is betel nut) are found to contain saccharin invariably. While ordinarily saccharin is slightly toxic, hyper sensitive persons may react even to small amounts with gastro-intestinal disturbances such as vomiting and diarrhoea.

The ingestion of large amounts results in nausea and vomiting with epigastric pain and subsequently haemorrhagic nephritis may develop.$^{36}$

Saccharin shall not be added to any article of food, except where the addition of such artificial sweetener is permitted in accordance with the standards laid down in FFA and the addition should be declared on the container.$^{37}$ Various detection methods are available in literature.$^{38-40}$
Cyclamate

Previously "The Artificial Sweeteners in Food Regulations 1967" of U.K. permitted both saccharin and cyclamates to be present in foods. Requirements were laid down as to the of artificial sweetening tablets containing both or either of these sweeteners. Following reports of experiments carried out in the USA in which rats developed cancer after being fed with large amounts of cyclamates over long periods (Gwynne)\(^1\) and the MAFF decided to ban the use of cyclamates in food and beverages.\(^{41a,41b}\)

Many methods of detection and determination of this injurious contaminant in the food had been suggested by many workers.\(^{42-45}\)

1.10 TOXIC COLOURINGS

Soon after the discovery of the coal tar dyes about 1850, these dyes rapidly gained favour for colouring food in place of mineral pigments and natural colours which had hitherto been only ones available. The main advantage to the food manufacturer of using coal tar dyes are that they give him a much wider range of colours with a higher and more uniform tinctorial power and brilliance. Though the colouring of food by coal tar dyes was a legitimate practice it was recommended by FSC that only a few of them should be allowed to be used in food colouring.\(^{46}\) According to FFA no coal tar dyes or a mixture thereof except those shown in the following
Table 1 shall not be used in food.\textsuperscript{47,48}

Table 1
PERMISSIBLE DYSES USED AS FOOD COLOURANT

<table>
<thead>
<tr>
<th>Colour</th>
<th>Common name</th>
<th>Chemical class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Red</td>
<td>Ponceau 4R</td>
<td>Azo</td>
</tr>
<tr>
<td></td>
<td>Carmoisine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast Red R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amaranth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Erythrosine</td>
<td>Xanthene</td>
</tr>
<tr>
<td>2. Yellow</td>
<td>Tartrazine</td>
<td>Pyrazolone</td>
</tr>
<tr>
<td></td>
<td>Sunset Yellow FCF</td>
<td>Azo</td>
</tr>
<tr>
<td>3. Blue</td>
<td>Indigo Carmine</td>
<td>Indigoid</td>
</tr>
<tr>
<td></td>
<td>Brilliant Blue FCF</td>
<td>Triaryl methane</td>
</tr>
<tr>
<td>4. Green</td>
<td>Green S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Green FCF</td>
<td></td>
</tr>
</tbody>
</table>

The common non-permitted colouring matters used were found to be mineral pigments like lead chromate, red or yellow earth, iron oxide, coal tar dyes such as Metanil Yellow, Orange I, Orange II, Auremine, Rhodamine B, Blue VRS, Malachite green and oil soluble colours like Sudan Red, Butter Yellow etc. The most popular dye seems to be water-soluble Metanil yellow, which is widely used to colour a variety of commodities such as pulses, spices (turmeric and mixed spices), sweetmeats
such as 'ladoo', 'Jalebi' etc., beverages and drinks etc. Non-permitted oil soluble colours are frequently used in chilli powder, oil, fat and ghee etc.

Colour adulteration involve not only the use of prohibited colourants but also the following:

1. Addition of any colour to food such as pulses, spices, tea, coffee etc. where the FPA prohibits the use of artificial colour (Rule 29, Part VI).

2. Addition of permitted colourants to food where artificial colouring is allowed by FPA, but the added amount should not exceed the permitted maximum of 0.2 g of the dye per kg of the final food (Rule 30 under Part VI).

3. Use of colour preparations not certified by ISI. Impure colour preparations can contaminate food with poisonous ingredients such as arsenic, lead, copper, chromium and subsidiary dyes etc. (Rule 31 under Part VI).

On the basis of experiments on animals the possible health hazards of the above non-permissible colourants can be summarised in Table 2.49,50
### Table 2

**NON-PERMITTED COLOURS USED IN FOOD AND THE POSSIBLE HEALTH HAZARDS**

<table>
<thead>
<tr>
<th>Name of the dye</th>
<th>Responsible for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange II</td>
<td>Pathological lesions in vital organs like kidney, spleen and/or liver.</td>
</tr>
<tr>
<td>Auramine</td>
<td></td>
</tr>
<tr>
<td>Rhodamine B</td>
<td></td>
</tr>
<tr>
<td>Blue VRS</td>
<td></td>
</tr>
<tr>
<td>Malachite Green</td>
<td>Increase in the incidence of tumours of lung, breast, ovary and liver and</td>
</tr>
<tr>
<td>Sudan Red</td>
<td>Teratogenic abnormalities of eyes, bone, skin and lungs</td>
</tr>
<tr>
<td>Malachite Green</td>
<td></td>
</tr>
<tr>
<td>Citrus Red 2</td>
<td>Malignant growths</td>
</tr>
<tr>
<td>Orange I</td>
<td>Catharsis (purgative)</td>
</tr>
<tr>
<td>Congo Red</td>
<td>Ocular defects</td>
</tr>
<tr>
<td>Metanil Yellow</td>
<td>Testicular degeneration in males.</td>
</tr>
<tr>
<td>Lead Chromate</td>
<td>Anaemia, abortion, paralysis, mental retardation, accumulation of lead in the</td>
</tr>
<tr>
<td></td>
<td>body and blood and finally may be brain damage.</td>
</tr>
<tr>
<td>Oil soluble</td>
<td>Carcinogenic</td>
</tr>
<tr>
<td>Coal tar dyes</td>
<td></td>
</tr>
</tbody>
</table>
Prevention of Colour Adulteration

To catch the fancy of many housewives, items like turmeric, chilli and pulses (dals) are now very often coloured and polished with toxic colourants discussed above. Even vegetables like carrots and leafy greens are coloured bright to attract the consumers. The following steps should be taken to check this menace.

(1) The consumers should be encouraged to avoid highly coloured foodstuffs. They should be reminded "all that glitters is not gold".

(2) The people should be socially educated regarding the problem of food adulteration. Mass media can play a very important role in this regard.

(3) Suitable legislative and administrative action to be taken against the offender.

Detection and determination of the food colours are possible colorimetrically and chromatographically.\textsuperscript{51-56}

1.11 METAL CONTAMINANTS

Feed can become tainted with toxic metals such as lead, mercury, cadmium, tin, arsenic, copper, zinc, antimony, chromium, cobalt etc. due to the following reasons.

(1) Accidental mixing of feed with metallic compounds such as arsenic oxides, barium carbonate, lead arsenate and
(2) The material of the food container being dissolved by the food, which may be cooked or stored in the vessel (tinned foods).

(3) Treatment of the food with metallic pesticides or excess food additives to prevent infestation and spoilage (lead arsenate, organo mercury compounds etc).

(4) Food adulteration or accidental contamination by metal machinery and containers, extensively used in the food processing industry.

Metals when present beyond small concentrations are more or less toxic. Initially they may combine with proteins and neutralise any poisoning effect. But when the concentration exceeds the tolerance limit, generally they produce a quick onset of symptoms such as vomiting, nausea and pain in the stomach.\textsuperscript{57} Calvery broadly classified trace elements according to their effects in life and their toxic doses.\textsuperscript{58}

The incidence of mercury in food has been surveyed by APF\textsuperscript{59} and the levels of mercury, lead and cadmium have been evaluated by the "Working Party in the Monitoring of Foodstuffs and Heavy Metals."\textsuperscript{60-62}

Chemicals described in monographs of the Indian Pharmacopoeia, when used in foods, shall not contain poisonous
metals beyond the limits specified in the appropriate monographs of the Indian Pharmacopoeia for the time being in force. No article of food specified in column shall contain any metal specified in excess of the quantity specified in separate column shown in Tabular form (Rule 57(2) under Part XI of FFA).

The detection and determination of these trace elements had been discussed by Menier-Williams.

1.12 TOXICANTS NATURALLY PRESENT IN FOOD

Some foodstuffs which are normally considered wholesome, may naturally contain toxic principles in small amounts. Before consumption the toxic components have to be removed from the food article. If removal is not possible, such food should not be consumed. Some important toxicants are the following:

Solanine

This is a glucoside alkaloid found in potatoes. Solanine poisoning as a result of consuming baked potatoes containing 400 to 500 ppm of the toxicants has been reported. The symptoms of solanine poisoning are nothing specific — vomiting, abdominal pain and diarrhoea. Various methods of detection of solanine are known.
Gossypol

A phenolic toxic pigment has been identified in cottonseed flour. The pigment is not harmful to ruminants (cows, buffaloes) but is toxic to man. ISI specification has prescribed a maximum limit of 1.10 per cent total gossypol (free plus bound) and 0.065 per cent free gossypol in edible cottonseed flour. Solvent extraction removes more of the gossypol. Cottonseed oil prepared from the seeds fortunately contains very little amount of the toxicant, which is completely removed after refining. Determination of gossypol can be made spectrophotometrically. 65

Ricinoleic acid

Caster oil obtained from the seeds Ricinus communis is sometimes used as an adulterant in other edible oils. Caster oil contains a characteristic fatty acid, ricinoleic acid, 80 to 85 per cent. The purgative action of the oil has been definitely traced to the presence of the glycerides of this hydroxy acid. Furthermore, the castor seeds contain besides oil a poisonous blood coagulating toxin, ricin.

Adulteration of other edible oils by caster oil can be detected by several methods. 66-68

Phalleolins

Poisonous mushrooms mistaken for the edible variety cause mushroom poisoning. There are about 70 to 80 toxic
species of poisonous mushrooms, of which most toxic is *Amanita phalloidee*, usually called 'White Amanita' or 'Deadly Amanita'. The poisoning is believed to be due to "Phalloidine" and alpha and beta amatoxins. The symptoms start appearing within few hours - convulsions, severe abdominal pain, intense thirst, nausea, vomiting and profuse watery evacuations sometimes containing blood and mucus.

Detection of muscarine, a characteristic alkaloid of the mushroom, *Amanita muscaria* can be detected gravimetrically.  

**Anti-Vitamins**

Some types of fresh water fish contain thiaminase. This compound destroys thiamine, a water soluble vitamin, deficiency of which produces beri-beri in man. Thiaminase, fortunately, is destroyed by cooking.

Anti-Vitamin K or anti-blood coagulants are present in some green leafy vegetables.

Anti-Vitamin D factor is present in raw soyabean. This causes rickets in poultry. This factor is also destroyed by heat.

**Goitrogenic Principles**

Fresh cabbage and the red scales of groundnut, if eaten in quantity, can produce goitre.
Toxin in Fish

Although a number of non-toxic fish are available, there are some varieties which can cause poisoning. Three hundred species of tropical fish are known, which become toxic to man when their liver, roe, head or intestines are eaten. Fish from foul waters may develop toxicity due to the poisonous matter they feed on. Shell-fish poisoning is a common happening since they have a special affinity for poison accumulating from the plankton.

Fish poisoning due to consumption of fish contaminated with pathogenic bacteria is one of the important factors responsible for epidemic diseases like cholera, amebiasis etc.

1.13 BACTERIAL AND FUNGAL CONTAMINANTS

This type of contamination of food has a direct, extensive and immediate impact on public health, which is more pronounced in the poor and under nourished populations. The foods commonly found to cause bacterial and fungal disease in man are milk and milk products, meat and meat products, raw vegetables, fruits, cereals etc. The food may serve simply as a vehicle for the transmission or transportation of the microbes to man.

Bacterial contaminants of food are (1) Clostridium Botulinum, (2) Staphylococcus, (3) Salmonella, (4) Shigella etc. The bacterial contamination is mainly due to unhygienic
condition and faulty process of food processing which may result in severe food poisoning.

Fungal Contaminants (Mycotoxins)

A number of toxic compounds produced by fungi are known today. The first mycotoxin recognised as a causative agent of human disease was that produced by the ergot fungus, *Claviceps purpurea*. Rye flour is occasionally contaminated with ergot, a parasite which is the sclerotium of *Claviceps purpurea* and originates in the eary of *Secale cereale*. Ergot is slightly curved, hard and dark purple in colour. Ergot alkaloids are ergotine, ergotamine, cornutine, pirole-selerotine etc. Symptoms of poisoning are dryness and irritation of the throat, intense thirst, suppression of the urine, convulsions and delirium etc.\(^70\)

For detection of this toxicants a method has been recommended by the AACC.\(^71\)

Aflatoxins

The search for more mycotoxins have been intensified since 1960, when more than 100,000 turkey poults died in the U.K., due to consumption of mouldy groundnut meal, which had been imported from Africa and South America. This led to the discovery of aflatoxin, a toxic metabolite of certain strains of the mould *Aspergillus flavus* and other species of *Aspergillus* which develop in many food stuffs, particularly
groundnuts, cottonseed and their cake and flour. It has been found that even food grains such as maize, rice and wheat are attacked by the fungus producing the toxin. The presence of compounds related to aflatoxins has been demonstrated in the milk of animals (cows, buffaloes etc.) fed on feeds containing aflatoxin.72

Among the discovered aflatoxins, aflatoxin B₁ and G₁ are the most highly hepatotoxic (toxic to liver) to animals. The toxins were found to be capable of inducing malignant tumours in liver and other organs, the toxicity being higher for young animals and males than the older animals and females. Human liver cells exposed to aflatoxins 'in vitro' have shown alterations in normal tissue architecture. Studies at the CFTRI, Mysore, India, have shown that the toxin, even in low doses can alter the red blood corpuscles. Attempts to relate the incidence of human liver cancer in one district of Kenya to the aflatoxin levels in food samples, have been successful. Similar investigations are being conducted in Mozambique, where the incidence of liver cancer is reported to be the highest (International Agency for Research on Cancer, 1971).

Prevention and Control of Aflatoxin Poisoning

Obviously, prevention of poisoning consists in taking steps to see the aflatoxins do not form in food materials favouring mould growth such as groundnuts, cottonseeds, rice, wheat, corn, cassava (tapioca), sweet potatoes, beans and
others.73 If the harvesting and storage have been defective, the food must be tested for the presence of the toxins.

There are many existing analytical techniques for the detection of this mycotoxin and many more improved sensitive methods have been developed recently.74-79

1.14 FOOD ADDITIVES

A variety of chemicals, called collectively food additives, are now being used in food processing.

Preservative

Preservative means a substance which when added to food, is capable for inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food. Preservatives are divided into two classes. There is some restriction on use of class II preservatives in food (Rule 52-55A under Part X of FPA).

There are various analytical methods for detection and estimation of class II preservatives.80

Antioxidants

Anti-oxidant means a substance which when added to food retards or prevents oxidative deterioration of food and this does not include sugar, cereal oils, flours, herbs and spices. No antioxidant other than lecithin, ascorbic acid
and tocopherol shall be added to any food (Rule 59 under Part XII of PFA).

A useful scheme of routine analytical methods for antioxidants has been published by APA. 81

Emulsifying and Stabilising Agents

"Emulsifying agents" and "Stabilising agents" mean substance which when added to food are capable of facilitating a uniform dispersion of oils and fats in aqueous media or vice versa, e.g., agar, alginic acid and gelatine etc. No emulsifying or stabilising agents shall be used in any food, except where the use of them is specifically permitted (Rule 60-62 under Part XII of PFA).

Schemes for the identification of gums and various thickening agents have been published. 82, 83

Flavouring Agents

Coumarin and dihydrocoumarin as flavouring agents shall not be used in any article of food. 84

Separation and identification of coumarins by thin layer chromatography have been suggested by Datta et al. 85

PFA and Food Additives

Any food that contains food additives that are not permitted by PFA is adulterated. In addition, even when a
permitted additive is present, if its proportion in the food exceeds prescribed limits or if the quality of the additive used is sub-standard, the food becomes adulterated.

1.15 PEST AND PESTICIDE CONTAMINANTS

Heavy contamination of food can occur if infestation by pests such as rodents and insects is high. Apart from consuming large proportion of the stored foods, and thereby reducing the nutritional value to some extent, they introduce into the feed a high dose of filth in the form of excreta, bodily secretions, insect fragments and rodent hairs as well as disease-bearing and spoilage micro-organisms. Food grains like rice, pulse etc. are generally considered adulterated as per FPA if the insect infestation is more than 10 per cent (by count). The protein content (mainly gluten) of cereal products mainly 'atta' (whole-meal flour), 'maida' (fleur), decreases and sometimes even go below the minimum limit prescribed by FPA due to insect infestation and as a result should be considered adulterated.

Considering the above aspects it is highly necessary to treat the food articles in a carefully controlled way to prevent rodent and insect infestation which is a burning problem related with storage of food grains.
Rodenticide

Rodents mainly include different types of rats and mice. Recently many comparatively safe and powerful rodenticides have been developed. The chemicals cause internal haemorrhage in rats and finally death. The most modern and safest rat control device seems to be an ultrasonic machine which can emit high frequency sound waves and cause permanent sterilisation in rats without any effect on man or other animals.

Insects

Insects such as beetles, weevils and borers make short work of stored food, especially cereals, pulses and their flours if stored under warm humid conditions. Insects preferentially consume the starchy endosperm and nutritive parts, leaving the food depleted of much of its vitamins and other essential nutrients. A complication which makes insect infestation serious is that it paves the way for the quick development of fungi. This is because it creates favourable conditions for the quick fungal growth. Heavily infested food showing live and dead insects and their larvae should be rejected as unsafe for human consumption.

Control of Insect Pests

Infestation of foodstuffs with insects may be prevented as follows:
(1) Storehouses should be kept clean and tidy. Garbage and sewage must be properly disposed so that any nuisance and as a result breeding of flies and insects will be minimum.

(2) Foodstuffs should be properly dried, cleaned and stored in clean sheets before storage.

(3) Slightly infested foodgrains may be fumigated in an airtight container kept outside the storehouse by using ethylene dibromide and later thoroughly aerated, dried before taking the stock back in the storehouse.

(4) Controlled use of pesticide: To protect the stocks, use of pesticide is a common practice in agriculture. Some of the prevailing practices at present is far from healthy. Either too much amount of a recommended pesticide is used or highly toxic ones which should never be employed are used.

Pesticides

Residues of various pesticides ranging in amount from ppm to several ppm may be found on food after harvesting. Some insecticides leave residues of metals (e.g., As, Cu, Pb, Hg, etc.). In recent years, organic pesticides (both organo-chlorine and organo-phosphorus) have almost completely replaced the earlier inorganic poisons. The most important organo-chlorine insecticides are such as aldrin, BHC, DDT, dieldrin and heptachlor. The organo-chlorine pesticides are both
persistent and toxic. The organo-phosphorus insecticides like malathion, parathion etc., are most toxic but are usually quickly metabolised to less toxic residues. Pesticides, in general, leave behind on the food with which they come in contact, the unchanged chemicals and their derivatives and adjuvants. These are called 'pesticide residues' which are expressed as ppm based on fresh weight of the sample. The residues are more or less toxic, depending on the nature of the pesticide used.

No foodstuff at the time of consumption must contain any pesticide or pesticide residue exceeding the permissible levels prescribed. Food articles having a pesticide content higher than the permitted limit are considered unfit for human consumption. In countries like ours where the staple food is wheat or rice, the grains containing even low residues can spell danger, since large quantities of the cereal are consumed at a time. The chlorinated pesticides, due to their stability are responsible more for public health hazards and chronic poisoning. Furthermore, the storage of halogenated hydrocarbon pesticides such as DDT in the body of the man is well established. The entry of these chemicals into the body is derived from many sources. Feeds of animal origin such as milk, eggs and seafood represent one source. The acute DDT poisoning can occur from the sudden release of the toxic principles from the storage sites. However, the organo-phosphorus pesticides, due to their easy breakdown into harmless end products are becoming popular now-a-days.
To save the consumers from the hazards of these potential killers, maximum limits have been prescribed at various International and National levels. A maximum limit is the maximum concentration of pesticide residue that is permitted on food. FACC recommended the statutory limits for aldrin and dieldrin. Recommended tolerance levels in food for various pesticides have been published by Codex Alimentarius and FAO/WHO. PFA has also restricted the use of pesticides and insecticides in food and has prescribed the tolerance limit (Rule 65 under Part XIV of PFA).

Methods of examining food for pesticide residues have been reviewed by Thomson and Abbott. A general scheme for the extraction and cleanup has been described by Law and Webley. Organochlorine pesticides can be detected and determined using PC, TLC and GLC. Bio-assay methods compare the response (knock down) of insects such as flies to the sample with standard pesticides. Although far from specific the method is fairly sensitive and provided facilities are available for storing the insects it is useful as a routine test. A biological method using Drosophila flies has been described by Hall.

The method of detection and determination of organophosphorus pesticides and pesticide residues in food have been discussed in details by many workers.
1.16 SOME EXAMPLES OF VERY COMMON ADULTERATION IN ASSAM (BY COURTESY OF PUBLIC ANALYST'S LABORATORY, GOVERNMENT OF ASSAM)

(1) Abstraction of Fat from Milk (both Cow and Buffalo) and/or Addition of Water: Nearly 80 per cent of the market milk samples are found to be adulterated. The problem becomes more dangerous in case the added water is not wholesome and contaminated with pathogenic organisms.

(2) Mixture of Two Oils: This is very common type of adulteration. According to FFA any oil containing a second oil whether edible or non-edible is deemed to be adulterated.

(3) Foreign Starch in Spices: Spices like turmeric, cumin and chilli powder are commonly adulterated with rice, pulse and maize powder etc. The problem becomes more menacing when harmful pigments like lead chromate and non-permitted oil soluble coal tar dyes are traced in the spices.

(4) Sweets and Confectioneries: Sweets, e.g., 'ladoo', 'jalebi', 'bundia' and 'lozenges' etc, are unusually found to be brightly coloured with non-permitted colours. Fungal growth, which is a common occurrence on sweets particularly on 'sandesh', is responsible for food-poisoning.

(5) Vanaspati in Ghee: Almost all the adulterated samples of Ghee are found to contain Vanaspati (hydrogenated oils and fats). Some of the samples also contain non-permitted oil soluble coal tar dyes and natural colour anmatto.
(6) Maize Starch in lieu of Shoti: Actually 'shoti' a brood name of starch of commerce is a product extracted from Curcuma zedoaria and maize powder is a product obtained from Zea mays Linn. Shoti starch is highly valued as an article of diet especially for infants and convalescents. Shoti starch often sold in the market is nothing but maize powder. Maize starch cannot serve the same dietary purpose as shoti starch does. Furthermore, the amino acid imbalance in maize endosperm protein is mainly responsible for its low nutritional value. Its amino acid imbalance is also responsible for the prevalence of pellagra, in certain areas, among people consuming maize as the main cereal in their daily diet. Maize starch is comparatively cheaper, so substitution of shoti by maize serves for pecuniary gain of the unscrupulous traders.

Many cases of adulteration of this type have been detected by the Public Analyst's Laboratory, Government of Assam, and many pioneer efforts like publicity in this regard and institution of prosecution against the offenders have been made in order to get rid of this serious problem which may threaten the health of children and patients consuming this adulterated stuff.

(7) Tea and Coffee: In the past, Tea (consists of the prepared leaves of various species of Thea, the commonest being, Thea sinensis, Thea bohea and Thea assamica) was admixed with the foreign leaves, spent tea and iron filings
etc. But recently the adulteration of tea is mainly due to presence of excessive stalk and exhausted tea leaves. Very recently some problems due to the presence of iron dust in excess have been reported. 103

Adulteration of coffee, *Coffee arabica* and *Coffee robusta* with chicory, *Cichorium intybus* is not uncommon.

(8) Adulteration of Cinnamon : Cassia bark (*Cinnamonum cassia*) closely resembles cinnamon and has been used as an adulterant or substitute for the latter. Chemically, however, the volatile oil of cassia contains no eugenol, which is the most valuable ingredient of cinnamon (4-10 per cent phenols, mainly eugenol) Betts 104 however has shown that the two barks can be differentiated by TLC separations based mainly on the detection of eugenol in the volatile oils.

(9) Adulteration of Asafoetida (Hing) : Asafoetida means the oleo gum resin obtained from the rhizome and roots of *Ferula alliance*, *Ferula rubricaulis* and other spices of *Ferula*. It is generally adulterated with cheaper resins like colophony resin, galbenum resin, asmanicum resin or any other foreign resin. Colophony resin in 'hing' can be detected colorimetrically. 105

(10) Adulteration of Honey : Honey means the juicy food derived entirely from the work of bees operating upon the nectar of flowers and other sweet exudation of plants. Honey is generally adulterated by addition of technical invert
sugar, i.e., invert sugar produced by acid hydrolysis. In some cases moisture, sucrose etc. are also found in excess of the prescribed FFA limit. Various methods have been reviewed by Pearson in detection of adulteration of honey. 106

(11) Fruit Squash and Fruit Drinks: Adulterated by non-permitted coal tar dyes and artificial sweetening agents like saccharin.

(12) Ice Candy and Ice Cream: The adulteration in this particular food stuff is very common. In adulterated ice candy, non-permitted colours and artificial sweeteners are present invariably. Ice-cream containing milk fat less than the prescribed FFA minimum is commonly found in the market. The adulteration of ice-candy and ice-cream should be looked with great concern as the victims are mainly children.

(13) Khesari in Besan (Powdered Pulse): This type of adulteration is very common. Also 'papad' made of 'besan' usually contains khesari powder.

1.17 STATISTICS

A statistics has been prepared on the basis of number of samples itemwise received and detected to be adulterated, for the last five years in the Public Analyst's Laboratory, Government of Assam. The overall percentages of adulteration yearwise were also calculated on the basis of number of samples detected to be adulterated out of the total number of samples received from different parts of the State. 107 The incidence
of adulteration in the State of Assam can be well understood from Table 3. From the scrutiny of the Table the following conclusions can be arrived at.

(1) Milk, 'Dahi' (Curd) etc. samples were uniformly adulterated every day.

(2) Depending on scarcity or some other processing defects (which might impair the quality of the product) adulteration was conspicuously maximum for different items in different year, e.g.

(a) In 1974, a fairly good proportion of the samples of Vanaspati were found to be contaminated with mineral oil. Adulteration of mustard oil by linseed oil was also not uncommon.

(b) In 1975, although few samples of fruit products were collected, all were found to be below the specifications or adulterated by non-permitted colours, sweetening agents etc.

(c) In 1977, adulteration of spices and butter, Ghee were detected to be maximum. The tea samples (a good proportion) were found to contain iron dust due to processing defects. The adulteration of pulses were maximum. Due to scarcity, price of pulses rose exorbitantly which resulted in hoarding of the commodity. Due to storage for long period in order to extract more profit, the food grains became insect infested and damaged. Almost all the adulterated samples were
found to contain a fairly considerable proportion of insect damaged grains.

(d) In 1978, the adulteration of non-alcoholic beverages were maximum. Almost all the adulterated samples of mustard oil were found to contain rapeseed oil in appreciable quantity.
Table 3

STATISTICS FOR ITEMWISE ADULTERATION (1974-1978)

(Figures in per cent)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Non-alcoholic Beverages</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>14.2</td>
<td>38.9</td>
</tr>
<tr>
<td>Spices and Condiments</td>
<td>2.6</td>
<td>14.2</td>
<td>11.4</td>
<td>29.0</td>
<td>14.2</td>
</tr>
<tr>
<td>Sweetening Agents</td>
<td>38.9</td>
<td>11.4</td>
<td>14.3</td>
<td>4.0</td>
<td>8.7</td>
</tr>
<tr>
<td>Tea, Coffee and Chicory etc.</td>
<td>-</td>
<td>15.1</td>
<td>11.4</td>
<td>43.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Milk and Milk Products etc.</td>
<td>71.8</td>
<td>90.1</td>
<td>84.1</td>
<td>73.4</td>
<td>84.4</td>
</tr>
<tr>
<td>Butter, Ghee etc.</td>
<td>51.2</td>
<td>45.6</td>
<td>32.4</td>
<td>77.4</td>
<td>55.8</td>
</tr>
<tr>
<td>Edible Oil, Fat, Vanaspati etc.</td>
<td>32.7</td>
<td>1.4</td>
<td>1.5</td>
<td>15.6</td>
<td>32.6</td>
</tr>
<tr>
<td>Cereal Products, Pulses etc.</td>
<td>7.6</td>
<td>6.7</td>
<td>8.6</td>
<td>45.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Fruit Products (Orange Squash, Jam etc.)</td>
<td>66.6</td>
<td>100.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Misc. (Beans, Common Salt, Timmed Food, etc.)</td>
<td>29.8</td>
<td>23.2</td>
<td>23.0</td>
<td>27.4</td>
<td>18.7</td>
</tr>
<tr>
<td>Total</td>
<td>16.3</td>
<td>13.8</td>
<td>16.8</td>
<td>17.4</td>
<td>24.6</td>
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