

Food Adulteration: Its Challenges and Impacts

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Abstracts

Food is any substance composed of carbohydrates, water, fats and proteins, which can be eaten or drunk by humans or animals for nutrition or very important aspect for life. Food products are often a target of adulteration while supply chains usually deal with perishable products that could be harmful to consumers if they are not managed properly. There are two types of food adulteration; namely intentional/deliberate adulteration done by dishonest producers, retailers and processors for financial up liftmen and incidental/unintentional which may be done at the time of producing, handling and/or storing, etc. Different food items and drinks prone for adulteration include: dairy products, cereals grains, fats and oils, and others like honey, juice, peppers, etc. Food adulteration has a great impact on producers/farmers, consumers, enterprises and government. The main challenges are public health problem, lack of acceptance in the market due to lack of originality, decrease in consumer confidence. Regulations that penalize such a criminal traders and dishonest producers/processors that adulterate different food products in various places should be applied. Therefore, the objective for this review was to document food adulteration has a great impact on producers and consumers as well as to awareness creation for public.

Keywords: adulteration, food items, incidental, intentional, public health.

1. Introduction

Food is one of the basic needs for every living being and is composed of carbohydrates, water, fats and proteins, which can be eaten or drunk by animals, including humans, for nutrition or pleasure (FAO/WHO, 2007). Many plants or plant parts are eaten as food. There are around 2,000 plant species which are cultivated for food, and many have several distinct cultivars. Almost all foods are of plant or animal origin. Cereal grain is a staple food that provides more food energy worldwide than any other type of crop. Maize, wheat, and rice together account for 87% of all grain production worldwide (Awasthi et al., 2014). Animals are also used as food either directly or indirectly by the products they produce. Meat is an example of a direct product taken from an animal, which comes from either muscle systems or from organs. Food products produced by animals include milk produced by mammary glands, which in many cultures is drunk or processed into dairy products such as cheese or butter. In addition, birds and other animals lay eggs, which are often eaten, and bees produce honey, reduced nectar from flowers, which is a popular sweetener in many cultures (Awasthi et al., 2014).

Food safety and factors affecting it have been major emerging areas within the food supply chain and have attracted a lot of attention from various research, government and regulatory bodies (Ayalew et al., 2013). The vulnerabilities of food supply chains, that define the food safety and security risks imposed on foods are mainly a direct result of supply chains being long, global and highly interconnected. Food and drink products are often a target of adulteration (intentional or unintentional) while supply chains usually deal with perishable products that could be harmful to consumers if they are not managed properly (SGS, 2013).

Adulteration is the act of either by adding extraneous substances (adulterants) into food items or products or reducing essential nutrients partly or wholly for financial gain or due to carelessness and lack of proper hygienic condition during processing, storing, transportation and marketing. This ultimately results that the consumer is either cheated or often become victim of diseases. Because of that it is important for the consumer to know the common adulterants and their effect on health since the increasing number of food producers and the outstanding amount of foodstuffs import enables the producers to mislead and cheat consumers (Anita and Neetu, 2013).

An adulterants are chemical substances which should not be contained within our food or beverage, and may be intentionally added to more expensive substances to increase visible quantities and reduce manufacturing costs, or for some other deceptive or malicious purpose (Anita and Neetu, 2013). The usage of adulterants has been common in societies from very ancient time with few legal controls on food quality due to poor or nonexistent monitoring by authorities; sometimes this usage has even extended to exceedingly dangerous chemicals and poisons. More recently, adulterant use for example, in the People's Republic of China (Chinese milk scandal case with melamine) in which some children killed and thousands were harmed (Lakshmi et al., 2012) has inspired much public attention. So it is indicative that food adulteration is fast growing worldwide as an industry and global market of adulteration and fake goods is more than several hundred billion dollars which constitutes more than 10 percent of total trade (Alauddin, 2012).

2. Types of adulteration and food items

Either because of high demand or seasonality in supply, various food products and/or drinks can be adulterated in diverse situations. According to different authors like El-loly et al.(2013), Asrat and Yilma (2014) and Narayan (2014), there are intentional/deliberately/knowingly and unintentional/unknowingly/incidental adulterations. So it is very important to see them separately.

2.1. Intentional/deliberate Adulteration

This is a kind of adulteration in which dishonest producers and traders deliberately adulterate different food products in order to promote the level of their essential nutrients after reduction of a given amount in order to increase their profit margin by several chemicals like urea, melamine, and increase its volume by adding substances such as starch, flour, cane sugar, vegetable oils, , water, skim milk, sand, chalk powder, molasses, stone, brick powder, ergot, chicory, roasted barley powder, grinded papaya seeds, etc. into various food items as reported by different authors such as El-loly et al.(2013), Asrat and Yilma (2014), Narayan (2014) and Faraz et al.(2013). As compared with that of unknown adulteration, this one is the most dangerous because of amounts of nutrients deducted and extraneous substances added into food items that is done by business oriented people just forgot the humanity in behind of money making mentality as Awasthi et al.(2014).

According to Lakshmi et al.(2012), Olive oil, milk, honey, saffron, orange juice, coffee and apple juice are the seven most likely food ingredients to be targets for intentional or economically motivated adulteration of food, or food fraud, according to analysis of the first U.S. public database created to compile information on risk factors for food fraud published in the Journal of Food Science.

2.2. Incidental/unknown adulteration

This type of adulteration is brought due to lack of proper hygienic conditions of food products and drinks throughout production site to consumption table. Here the producers or traders/retailers are not in position to add different adulterants but the ways the products are produced, handled, passed, processed, stored, transported and marketed may be the places where they were contaminated or adulterated since any substance without its original is extraneous to the product; include: residual pesticides from cans, rodent droppings, preservatives, mercury from effluents, lead from water, etc., (Narayan, 2014) and Asrat and Yilma (2014).

2.3. Food items and adulterants

There are various food items and drinks that are prone for adulteration as revealed in table 1 below according to the reports of different authors in different places. It is difficult to get a food items, may be flour, pulse, oil, fruit, vegetable, milk, sweet, spices, tea, coffee, honey, bakery item, chocolate, fruit juice, etc. which is free from one or the other adulterants. Even animal feed like cake as protein supplement for lactating animals is adulterated accounts about 90 percent of un-branded loose forms as Alauddin(2012). And these are not the only food and drink items prone to adulteration, extraneous substances added into them and reasons or purposes of adulteration but also a lot of others which are highly sophisticated and seeks a sophisticated technology for quantification and identification are there.

Depending on the types of foods and drinks adulterated it is possible to see adulteration in four major categories like milk and milk products, fats and oils, food grains and others (animal and plant originated foods) adulteration respectively.

Table 1: Different food items and extraneous substances added into them

Food & drink items	Adulterant/extraneous substances	Purposes/reasons	Types of adulteration
Ghee	Vanaspati, anatta, & oleomargarine	To make more yellow	Deliberate
Milk	Water, skim milk	To increase volume	Deliberate
Condensed milk	Paneer, khoya	To give rich texture	Deliberate
Ice cream	Starch, rice powder or wheat flour	To thicken cream	Deliberate
Butter	Vegetable oil, anatta, banana, oleomargarine	To increase volume & make yellowish	Deliberate
Tea leaves	Black/Bengal gram dal husk with color	To add color	Deliberate
Wheat	Ergot (poisonous fungus)		Deliberate
Red wine	Juice of bilberries	To attract/produce deep blue precipitate with lead acetate	Deliberate
Sugar	Chalk powder	To increase amount	Deliberate
Turmeric, dals & pulses	Metanil yellow, Kesari dal	To enhance the yellow color	Deliberate
Chillies powder	Stones	To increase weight	Deliberate
Jaggery powder	Chalk powder	To increase amount	Deliberate
Common salt	White powdered stone, chalk	To increase amount	Deliberate
Mustard seeds	Argemone seeds	To add bulk	Deliberate
Honey	Molasses, cane sugar	To increase volume	Deliberate
Cinnamon	Cassia bark	To increase volume	Deliberate
Coffee	Chicory, roasted barley powder, tamarind seeds	To add bulk and color	Deliberate
Black pepper	Papaya seed	To add bulk	Deliberate
Green chillies& peas	Malachite Green	To give bright glowing green color	Deliberate
Mustard oil	Papaya seed	To add bulk and weight	Deliberate
Others like preservatives, etc.	Formalin, etc.	To increase shelf life, etc.	Unintentional

Sources:-Narayan (2014), Asrat and Yilma (2014), Lakshmi et al.(2012), Awasthi et al.(2014).

2.3.1. Milk & milk products adulteration

In developing countries, the industrialization brought a series of problems along with the much appreciated progress, with the mass collection and distribution of milk from various sources playing the role of potential vehicle for disease transmission. In olden days, milk was collected from small groups of animals in farms and it was supplied to a small number of people living nearby (Chanda et al., 2012). But with the advent of industrialization, population growth and urbanization, the demand increased drastically. Milk supply through the small farms no longer met the increasing demand (Dehinet et al., 2013). Hence commercialization of the milk industry ultimately took place (Revathi et al., 2012). Milk adulteration involves adding water to milk and removing the beneficial fats from milk. Often soya milk (ESA, 2012), starch, groundnut milk, and wheat flour are added to milk and gird ghee added into butter. The producers deliberately adulterate milk and its products in order to promote the level of these essential nutrients after reduction of a given amount and/or to mislead the consumers to increase their profit margin by several chemicals like urea, starch, flour, cane sugar, vegetable oils, detergents etc (table 1) (Faraz et al., 2013). Various preservatives like formalin and some antibiotics are also added in milk to increase its shelf life (Awan et al., 2014). This addition decreases the nutritive value of milk (El-loly et al., 2013) and its incidences are at increase over the years according to Alauddin (2012).

Although milk is produced throughout the year yet the supply and demand of milk are related to the seasonal fluctuations (Afzal et al., 2011) due to this milk used by the people for consumption is adulterated to such an extent that there is very less nutritive value in it and may also be toxic for public health their profit margin by three ways dilution, extraction of valuable components like milk fat which is removed as cream, addition of cheap substances like starch to increase the value of total solids up to a level which is acceptable by the consumers (El-loly et al., 2013). And all dairy foods are made from milk, and their components are the same as those of milk, except butter being comprised mainly of milk fat, but in varying amounts (Faraz et al., 2013) are also adulterated in one or another forms (Khan et al., 2008).

Milk and its products can be exposed for adulteration at different points such as at farm and procurement level, while transporting and processing, in view of the fact that fresh milk is pure when it comes out of the udder and free of adulterants and microbes but can be contaminated by bacteria, yeast, fungi and dust, water, different chemicals or adulterants and animal hair due to livestock keepers' unhygienic milking, handling and storage practices, some dishonest producers retailers and manufacturers (Singuluri and Sukumaran, 2014).

2.3.2. Adulteration of Fats and Oils

It is easy to adulterate oils and fats. Majority of fats, oils and butter are paraffin wax, castor oil and hydrocarbons. But it is difficult to detect such adulteration. Ghee is often mixed with hydrogenated oils and animal fats. Synthetic colors and flavors are added to other fats to make them appear like ghee (table 1).

2.3.3. Food Grain Adulteration

Food grain adulteration involves mixing sand or crushed stones to increase the weight of food grains. Cereal grains and pulses are mixed with plastic beads that resemble grains in color and size (table 1). Very often, water is also sprayed on grains to increase the weight.

2.3.4. Other Adulterations

Others (animal and plant originated foods) adulteration is common, for example, red chilli powder is often mixed with brick powder, while tea leaves are often mixed with used tea leaves. Pepper is mixed with dried papaya seeds. These adulterations are very harmful to the consumer and they should be addressed by consumer organizations and consumers seriously. Another harmful adulteration is honey adulteration which appeared on the world market in the 1970s when high-fructose corn syrup was introduced by the industry. As the sugars (60.7 to 77.8%) are the major components of honey and the most dominant are the monosaccharides fructose and glucose (accounting for 85 to 95%), the actual proportion of glucose to fructose in any particular honey depends largely on the source of the nectar. The average ratio of fructose to glucose is 1.2:1. The amount of glucose in honey is usually at a supersaturated level at normal temperatures. With reduction in temperature or water content, the glucose can crystallize out. Saccharose (sucrose) is present in honey at approximately 1% of its dry weight. Normally, honey contains 12.4 to 24.5% moisture. Unless the moisture content is below 17%, no fermentation takes place. Consumption of honey and honey products has grown considerably during the last few decades.

However, at the present time, the traceability of this food is limited to the quality of each processor's documentation. In case of doubt or fraud, there is no standardized analysis available that can discriminate or determine the botanical (floral or vegetable) and geographical (regional or territorial) origin of the honey. Counterfeiting and product adulteration are now commonly practiced in the global food marketplace (Pilizota and Nedic, 2009). Because of its high nutritional value and unique flavor, the price of natural bee honey is relatively much higher than that of other sweeteners. Honey is susceptible to adulteration with cheaper sweeteners; those that have been detected in adulterated honeys include sugar syrups and molasses inverted by acids or enzymes from corn, sugar cane, sugar beet and syrups of natural origin such as maple. Adulteration of pure honey with synthetic honey (based on C4 plant sugars) has become much more prevalent in recent years. In addition, there has been a recent major adulteration problem in honey from the Far East (Pilizota and Nedic, 2009).

3. Reasons of adulterations

As indicated by different authors, reasons for adulteration of food products is to fetch higher cash income and/or to increase shelf life. As El-loly et al.(2013) and Afzal et al.(2011). The main reason that attracts adulteration is for boosting their cash income by increasing its volume. Even though increasing their profit margins initiated adulteration done by some selfish producers, processors and retailers, the main cause for adulteration is dishonesty and lack of accidental quality assessment on products suspected(Asrat and Zelalem, 2014). It is the same fraudulence which is so extremely ingenious in every department of life that has devised an inferior material of the quality one. The issue of counterfeiting which is a growing phenomenon, is one of both domestic and international concern that counterfeiting, diversion, cargo theft and economically motivated adulteration are crimes of opportunity which flourishes because of the dramatic way the world has changed in a relatively short period of time. On the other hand, food products are fake and adulterated when demand for popular and or expensive products are high. Thus, it still follows that there is economic motive for adulteration and counterfeiting of products which enter the supply chain right from the production of raw ingredients through the point of sale (Dogarawa, 2013). Another reason for faking and adulteration of goods and services is outsourcing to offshore producers (Hamburg, 2010). Outsourcing became possible because comparatively labor is cheap in some countries and this is also what makes product faking easy since the cost of producing is far less compared to the super normal profits being made (Sicpa, 2012). That is why Cofie (2012) argues that counterfeiting thrives on the whole process of globalization because spread of capital and know-how to new markets is usually achieved through globalization.

Similarly, any break in steady supply of original product or service could induce the introduction of fake and adulterated ones in order to meet the demand by users. Here, the new sources may not be immediately differentiated or identified and therefore the stringent measures which original producers are subjected to would have been avoided. Ehsan et al.(2010) found that people were stimulated by the high price of fuel to adulterate fuel in Bangladesh in order to gain undue financial benefits. Harsh business environment like stringent price control and inflation in the domestic markets discourages local production at competitive level with imported

substandard, fake and adulterated products and rapid urbanization with the attendant result of depleting natural plants which serve as ingredients for herbal medicines also provides incentives for unscrupulous suppliers and producers to substitute scarce and expensive ingredients with alternatives of lower quality which of course could be harmful since there is no perfect substitute to any natural thing (Dogarawa, 2013).

In general foods and drinks are adulterated for the following six reasons as reported by Narayan(2014). These are:-

1. When the demand is more than the supply in the market,
- 2.To come at par with the market competitors by lowering the cost of production,
3. The greed for increased profit margins,
- 4.The common man cannot afford food items with their original constituents,
5. Lack of trained manpower with outdated food processing techniques and
- 6.No idea about the disease outbreaks caused due to adulterated food products.

4. Impacts of adulteration

The problems of adulteration makes the food items used in our daily life unsafe and unhygienic for use due to poor handling (Asrat et al., 2012). In the past few decades, adulteration of food has become one of the serious problems and consumption of adulterated food causes serious diseases like cancer, diarrhoea, asthma, ulcers. In general, adulteration of food items has a very serious impact on producers/farmers, processors or manufacturers/enterprises, consumers and government.

Impacts on enterprises

Enterprises are impacted by a loss of consumer confidence in their products, recalls and destruction of contaminated products, complaint expenses and increases of insurance premiums and costs related to equipment replacement or cleaning. A supplier's fault is inevitably reported in the mass media, casting doubt on that company's reputation (Pandpal et al., 2012). This affects not only the sales of that particular product, but also the sales of many other products supplied by the company's warehouse or retailers and even the products can be banned/discarded automatically. The effects of such bans on the food production industry are multiple, profound, and far-reaching. A producer that depends on a banned imported foodstuff not only suffers economic loss to the impacted product but also faces lost sales caused by loss of public confidence. The resulting brand damage can be devastating, and recovery can require significant time and expense when consumers have moved on to other suppliers' products (Ibens, 2014). People have lost their trust in the products. For example, about 40 to 60% of consumers either ceased or were unwilling to purchase domestic milk products, whereas those who purchased imported milk powder increased from 34% to 47% in China due to milk adulterating by melamine as Qian et al.(2011).

Impacts on farmers/producers

Adulteration not only has an effect on big enterprises but also farmers or producers (like dairy, honey, coffee, wheat, etc) can be affected by the weakest link in the industry chain. Many farmers suffered massive losses, cost increases due to feed costs, milk cow shortage caused by mass sales or slaughter during the crisis, for example in the case of China dairy Scandal and lack of acceptance of the products (Qian et al.,2011 and Nie, 2008).

Impacts on consumers

Hazardous effects of food adulteration is associate with diarrhea, abdominal pain, nausea, vomiting, eyesight problem, headache, cancer, anemia, insomnia, muscular paralysis and brain damage, stomach disorder giddiness, joint pain, liver disorder, dropsy, gastrointestinal problems, respiratory distress, edema, cardiac arrest, glaucoma carcinogenic effects, kidney failure, digestive system disorders, etc as reported by Anita and Neetu (2013), Faraz et al.(2013) and Lakshmi et al.(2012). It is found that there are various chemicals and colors used in fruits and vegetables which are very poisonous for health. Calcium carbide used in mangoes, bananas, copper sulphate used to ripen fruits faster, oxytocin a hormone used for faster growth of pumpkin, watermelon, brinjal, gourds, cucumber. Wax adds shine on apples and pears. Cheap green colors containing chemicals such as metallic lead applied to bitter gourd and leafy vegetables to give fresh color. Pesticides & herbicides used excessively for growing fruits and vegetables. Consumption of chemical-laden fruits and vegetables can prove disastrous for digestive system, eyes and liver (Lanzhou, 2008). It can also results in vomiting and diarrhea in children, kidney failure. Oxytocin can lead to damage of the brain (Anita and Neetu, 2013).

5. Challenges of adulterations

It is no secret that there have been significant media exposure, public health impact and decrease in consumer confidence in recent years due to some significant food safety incidents. This has increased focus on food safety by consumers, the industry, lawmakers and regulatory agencies (Ades et al., 2012). In both developed and

developing countries, inadequate laws, funding and staffing appear to be common challenges to the control of substandard and counterfeited goods and services. There is also inability to prosecute offenders in developing countries as well as threats to lives of enforcement officers where gratification has not worked. In addition, there is inadequate information and technology to detect fake and adulterated products. Often times, the exact number of foreign sources of the products is not known while in terms of physical site inspection, only a negligible percentage of the facilities are covered (Dogarawa, 2013). The main challenge of food adulteration is lack of acceptance in the market due to distrusting its originality as reported by Asrat and Yilma (2014) or discouraging market (Asrat et al., 2013) for example, dairy products of Wolaita and Kucha area were recognized for its high quality thus fetch high price. Because of this, it was noted that Wolaita butter was adulterated with vegetable oil and marketed with reduced prices in Dilla and Shashemene towns (Yigrem et al., 2008). Such a practice should be avoided as it can affect among others the reputation of the butter of the area for its high quality. Therefore, there should be regulations that penalize such a criminal traders (Li, 2008a) and dishonest producers that infect different food products in various places and a more selective sample preparation and testing technology is needed to enable rapid screening of food adulteration since effective analytical techniques to detect frauds are also other challenges (Ibens, 2014).

Conclusion

Food adulteration has negative impacts on public health. The causes for food adulteration are; profit margin by increasing volume of the products and dishonesty of producers, retailers and processors. This ultimately results that the consumer is either cheated or often become victim of diseases. Consumption of adulterated food causes serious diseases like cancer, diarrhoea, asthma and ulcers. And adulteration of food has become one of the serious problems. The main challenge of food adulteration is lack of acceptance in the market due to distrusting its originality. Therefore, the following recommendations were forwarded;

- i. In developing countries, adequate laws, funding and staffing should be appeared to control above discussed challenges
- ii. Different stakeholders should play great role to develop appropriate sampling programs based on statistical validity and sound sampling methodologies
- iii. Further study should be conducted on quantification of adulterants and
- iv. Effective analytical techniques to detect frauds must be there.

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