The Pharmaceutical and Chemical Journal, **2021, 8(1):151-171**

Available online www.tpcj.org

Research Article

ISSN: 2349-7092
CODEN(USA): PCJHBA

HACCP in Fresh Frozen Beef Burger: Safety and Quality

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Abstract Food is defined as a substance whether processed, semi-processed, or raw that is intended for human consumption and is essential for nourishment and subsistence of life. HACCP and Food safety with quality are therefore of paramount importance and have drawn attention of all stakeholders. With the increasing liberalization of the agro-industrial market and consumer awareness, the food supply chain is becoming integrated. Food safety and quality therefore have become major concerns. It is not enough to just produce food; the food must first be safe to consume and, second, be wholesome and nutritious throughout the supply chain, from production to consumption. This paper deals with definitions of frozen beef burger processing and food safety with quality; types of physical, chemical, and microbiological adulterants, contaminants, residues, and toxins; as well as Hazard Analysis and Critical Control Points (HACCP), with an example of producing and supplying safe food.

Keywords HACCP; Adulterant; Contaminant; Food safety; Residues; Toxin

1. Fresh Frozen Beef Burger

1.1. Introduction

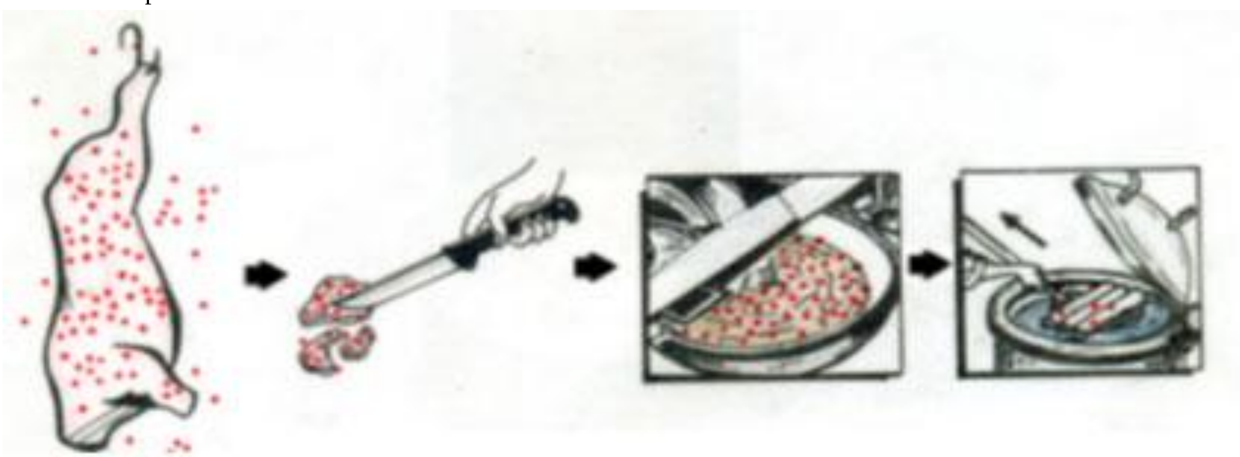
Meat processing hygiene is part of Quality Management (QM) of meat plants and refers to the hygienic measures to be taken during the various processing steps in the manufacture of meat products. Regulatory authorities usually provide the compulsory national framework for food/meat hygiene programmers through laws and regulations and monitor the implementation of such laws. At the meat industry level, it is the primary responsibility of individual enterprises to develop and apply efficient meat hygiene programmers specifically adapted to their relevant range of production. Operations in **meat processing plants** comprise the **manufacture of value-added meat products** from primary products of meat origin and non-meat origin. There are three principles of meat hygiene, which are crucial for meat processing operations.

- **Prevent microbial contamination** of *raw materials*, intermediate (*semi-manufactured*) *goods* and *final products* during meat product manufacture through absolute cleanliness of tools, working tables, machines as well as hands and outfits of personnel.
- **Minimize microbial growth** in *raw materials*, *semimanufactured*1 *goods* and *final products*2 by storing them at allow temperature.

- **Reduce** or **eliminate**3 **microbial contamination** by applying heat treatment at the final processing stage for extension of shelf life of *products* (except dried and fermented final products, which are shelf-stable

The above three principles guide meat hygiene programmers in the further processing of meat However, meat processing hygiene is more complex. In particular, the hygienic treatment of meat before reaching the processing stage is of utmost importance for the processing quality of the meat. Failures in slaughter hygiene, meat cutting and meat handling/transportation and in the hygiene of by-products and additives will all contribute to quality losses and deterioration of the final processed meat products.

Highly contaminated raw meat is unsuitable for further processing. Final products made from hygienically deficient raw meat materials are unattractive in color, tasteless or untypical in taste with reduced shelf life due to heavy microbial loads. Moreover, there is also the risk of presence of food poisoning microorganisms, which can pose a considerable public health hazard.



Carcass contamination during slaughtering (red dots) Unavoidable – keep as low as possible.

Meat cutting No reduction of contamination possible, but further contamination should be prevented.

Further processing No reduction of contamination possible, but prevent further contamination and create challenges / hurdles for microbial growth and survival (aw, preservatives)

Heat treatment of final product Pasteurization (approx. 80°C): Substantial reduction of contamination, but products need refrigeration. Sterilization (above 100°C): Total elimination of contamination, products can be stored without refrigeration (in sealed food containers).

Figure 1: Microbiological contamination in the meat processing chain

In the light of growing consumer consciousness as well as regionalization and globalization in trade, quality conscious meat plants need *internal quality control/quality management schemes* not only for the final products but also for the raw materials and the various processing steps.

Such Quality Management Schemes (QM) have technical and hygienic components. *Technical* aspects encompass *product composition, processing technologies, packaging, storage* and *distribution*. Details on the manufacturing practice for each individual group of meat products are included in the chapters on processing technology. For the *sanitary quality and safety* related to meat processing, two useful schemes1 can be applied known as

- Good Hygienic Practices (GHP) and
- Hazard Analysis and Critical Control Point (HACCP) Scheme

Both schemes are not verbally laid down in codes ready to be used for the various purposes in the meat sector although some generic examples can be accessed in handbooks or via internet as recommended codes of practice. Factory and production specific versions need to be established and compiled by taking into account official laws and regulations as well. Both schemes are not verbally laid down in codes ready to be used for the various purposes in the meat sector although some generic examples can be accessed in handbooks or via internet. Factory and production specific versions need to be established and compiled by taking into account official laws and regulations as well as recommended codes of practice.

1.2. Good Hygienic Practices (GHP)

Good Hygienic Practices/GHP follows general hygienic rules and applies recognized hygienic principles2 as well as laws and regulations issued by the competent authorities, referring to *meat and meat products*, *equipment*, *premises* and *personnel*. GHP schemes are *not factory specific*, they apply to all types of meat plants. They are intended to establish and maintain acceptable hygienic standards in relevant meat operations. There is more emphasis on slaughter hygiene in GHP schemes for slaughterhouses and more emphasis on meat processing hygiene in GHP schemes for meat products manufacturing enterprises. However, in principle, GHP schemes remain interchangeable for similar types of meat plants.

GHP for meat processing plants refers principally to:

- Appropriate functional plant layout and sanitary design of equipment
- Raw materials that meet hygiene quality standards
- Processing methods that allow safe handling of food
- Appropriate waste and pest control measures disinfection)
- Compliance with potable water criteria
- Functional cold chain
- Regular examination of health and personal hygiene of staff
- Regular training of staff on hygiene requirements

1.3. Hazard Analysis and Critical Control Point Scheme (HACCP)

HACCP are *factory* and *product specific* strictly sanitary control schemes that shall prevent, detect, control and/or reduce to save levels *accidentally occurring hazards* to consumers' health. Despite GHP in place, accidental hazards cannot be ruled out and may occur at any processing step of the individual meat product. Specifically, for *meat processing plants*, such hazards may be provoked by failures such as:

- batches of incoming raw meat materials with abnormal tissues or heavy contamination,
- breakdowns in refrigeration,
- failure in cooking/sterilization operations,
- abnormal pH or aw in raw or finished products,
- errors in levels of application of curing salts and other additives,
- technical problems in sealing of vacuum packages or cans with the risk of recontamination

HACCP schemes serve as additional alarm systems in the interest of consumer protection to prevent such problems occurring.

The revolutionary idea of HACCP is to implement control measures that focus on prevention rather than relying on end-product-testing. All relevant possible hazards in the entire production chain, from primary production to consumption of each individual product, must be identified and measures taken for their prevention. In case potential hazards should occur, they can be detected, contained or eliminated at any stage.

Plant personnel have a key role to play and must be trained in hazard detection and elimination. For practical purposes, those possible hazards may be listed on specific templates for confirmation of presence or absence during routine controls. Specific control mechanisms, in the first place of *physical*, *chemical and visual nature* (temperature, pH, visual check etc.), are installed at selected control points to detect such potential hazards. These control mechanisms are designed to deliver most results almost instantly and allow immediate intervention during the processing phase of food/meat products.

The need for immediate action within HACCP systems excludes *microbiological control* (of raw materials, semi-fabricated products, tools, equipment, and premises) as a directly applicable control measure. Microbiological control takes hours or days to obtain the results, which does not allow corrective interventions during the usually short manufacturing period. However, this does not mean that microbiological control is worthless for HACCP. Routine microbiological control carried out within the framework of GHP is an extreme helpful tool also for HACCP as its results will demonstrate the efficiency of the HACCP system. Hygienically acceptable microbiological test results are an indicator of the proper functioning of the meat plant's HACCP scheme.

HACCP1 is *not* a scheme for the assessment and improvement of the general hygienic status of a meat plant. HACCP is not designed to further raise hygienic standards. Excellent conditions as applicable for GHP conform plants must already be in place. GHP is a prerequisite requirement for the introduction of HACCP.

The misconception still exists that HACCP is intended to raise levels of general hygiene in meat plants with low hygienic standard.

HACCP is not workable where plant layout/structure, equipment and/or processing methods do not comply with good hygienic standards. One important point to distinguish HACCP from GHP is that GHP describes *process requirements and practices* incl. personal hygiene of staff to ensure safety of food. The individual product is not specifically targeted. Unlike GHP, HACCP always focuses *on the individual product*. As technologies vary from product to product, it is obvious that separate HACCP approaches are required for each category of products.

1.4. HACCP in small meat processing plants

The rather complex HACCP approach including identification of critical control points and measurement and interpretation of test results, demonstrates the difficulties in introducing HACCP schemes in small food or meat processing enterprises. Comprehensive test systems would require a multidisciplinary approach, as well as knowledge of microbiological, chemical and physical hazards, technical processes and operation of equipment. This is available in large industries but generally not in small- to medium-scale enterprises. Flexibility should be given in these situations for simplified approaches, if HACCP schemes are to be introduced in small food businesses. Competent authorities tend to accept these views. In plants dealing with limited numbers of products or technologies, these simplified approaches can even go so far as to use GHP schemes instead of HACCP. It is obvious that in such cases GHP approaches may be more practical and less cost-intensive than HACCP.

1.5. Examples for preparation of HACCP plans

These are summary plans, which need to be expanded in more detail if adapted for relevant meat plants, depending on the plant layout, equipment and processing technology. Potential hazards, which are indicated as physical, chemical and biological, would have to be specified in detail according to the listings given. The majority of the potential hazards are "biological", which mostly refer to microbiological risks. This corresponds with the aim of HACCP, which is prevention of health hazards to consumers. Health hazards through food are mostly caused by microbiological activity, which can be prevented if properly controlled.

Example

Refers to a meat product, which does not undergo heat treatment during processing (fresh frozen beef burger) and therefore remains particularly sensitive from the hygienic point of view.

Due to the nature of the two products, periodic microbiological tests are recommended in the framework of GHP. Periodic microbiological testing is particularly important for the product "Fresh Frozen Beef Burgers" to be marketed raw. Microbiological test results can be incorporated in HACCP. They are not a means for immediate intervention in ongoing productions (microbiological tests take too long to use their results for immediate action), but rather in the verification procedure, which serves to prove whether the HACCP system is working. Microbiological results are a means to confirm the efficiency of the meat plant internal HACCP system, when it can be proved that the established limits were not exceeded. The Critical Control Points (CCPs) indicated are examples for the establishment of CCPs. It is up to the processing plant to increase or decrease their number according to the plant specific risk assessment.

Table 1: HACCP plan for Fresh Frozen Beef Burgers (extended, with salt and spices, vacuum packed)

Process steps	**Hazard**	**Target level/ Critical limit**	**Monitoring Procedure**	**Corrective action if standards are not met**	**Records**
Reception of raw meat materials (beef, boneless) CCP	Physical, chemical, biological	Internal meat temperature≤+4°C, red meat colour, fresh slightly acidic odor, no visible contamination, no discoloration, not slimy, no other defects	Check purchase specification. Inspection of meat surfaces by random sampling. Check internal meat temperature	Reject delivery if target levels not met	Physical characteristics of meat received, certificate of sanitary status and origin of meat. Meat temperature recordings
Storage in reception chiller	Biological	Room temperature ≤+4°C. Meat internal temperature ≤+4°C	Temperature control of chilling room and meat(internal)	Minor temperature deviation: Adjust chiller temperature Major temperature deviation: Rejectmeat1	Temperature/ time recordings of chiller. Temperature recordings of meat
Weighing and composition of non-meat ingredients	Physical, chemical	Visibly clean non-meat ingredients (common salt, no curing salt to be used)	Check salt, spices and extenders for impurities	Reject suspected batches of non-meat ingredients	Record of status and expiration dates for non-meat ingredients
Prepare meat for grinding, effect grinding	Biological	Room temperature ≤+10°C. Period from delivery of meat from chiller to pass through grinder maximum 20 minutes. Meat free of grossly abnormal tissues and post-dressing contamination	Check period of product flow. Check for abnormal tissues and post-dressing contamination	Improvement in product flow. Discard meat parts with abnormal tissues, post dressing contamination	Product flow/ temperature recording
Mixing of meat with ingredients CCP	Biological	No further increase of contamination. Room temperature ≤+10°C. Period from grinding to completion of mixing/blending maximum 30minutes. Temperature of meat/meat ingredients mix≤+10°C	Check period of product flow. Check mix temperature	Minor deviations: Adjust time/temperature regime. Major deviations: Reject batch	Product flow/ temperature recording
Patty moulding	Biological	Carry out immediately after	Temperature/time control	Increase process speed. Return mix to	Product flow/ temperature

		mixing. No significant product temperature increase		chiller if no immediate moulding process	recording
Freezing CCP	Biological	Blast freezer at -35°C	Temperature control	Adjust freezer temperature	Record blast freezer temperatures
Packaging	Biological	Clean packaging materials	Check packaging failures	Adjust packaging machine in case of insufficient vacuum packaging	Results of packaging
Freezer storage	Biological	Temperature of storage freezer -18°C to -30°C	Continuous temperature check	Rise of temperature: immediate identification and correction of temperature problems, transfer to alternative storage freezer if long-term problem	Continuous freezer temperature records

CCP = Proposed Critical Control Point

1) Alternatively: Check meat and decide on further utilization for processing into hygienically less sensitive products.

Remarks**:** In the processing of this product there is no heat treatment included to reduce microbial contamination. The necessary heat treatment immediately prior to consumption, which is not part of the manufacturing process, is the only relevant measure to control potential contamination with pathogenic microorganisms. In order to minimize the risk of pathogenic microorganisms, special advice on the handling of the products before heat treatment and on the intensity of heat treatment must be available on the package. During processing, the nature of the product requires periodic microbiological testing as part of GHP and HACCP verification. Microbial testing of ground meat should take place once a week or more frequently in cases of suspected hygiene failures. Microbiological testing of finished mixes containing meat/non-meat ingredients mixes can be done on case-to-case basis.

1.6. The impact of microbial contamination on meat and products

Meat hygiene serves to minimize the impact of undesirable microorganisms and chemical residues on meat. While residue control is primarily the task of the competent authorities, control of microbial contamination is the responsibility of meat plants in the first place. Meat plant management and staff should therefore possess sufficient knowledge about impact of microorganisms on food and of basic rules on how to prevent or minimize microbial contamination.

Microorganisms of relevance with regard to meat hygiene include parasites, moulds, bacteria and viruses. Within these groups' bacteria play the most important role. Therefore, the focus of meat plant internal hygiene measures is mainly on bacteria, while moulds and viruses play a minor role but disinfection measures must also target them. The incidence of parasites should normally pose no major problems in meat which has passed meat inspection, or if efficient internal pest control programs or measure are in place.

Table 2: Recommended microbiological criteria for fresh meat

	Good microbiological standard	Critical microbiological condition	Not acceptable
Total plate count per cm^2	**10000<104**	**10000 and 100000>104 - <105**	**100000>105**
Enterobacteriaceae per cm^2	**<100**	**>100 - <1000**	**>1000**

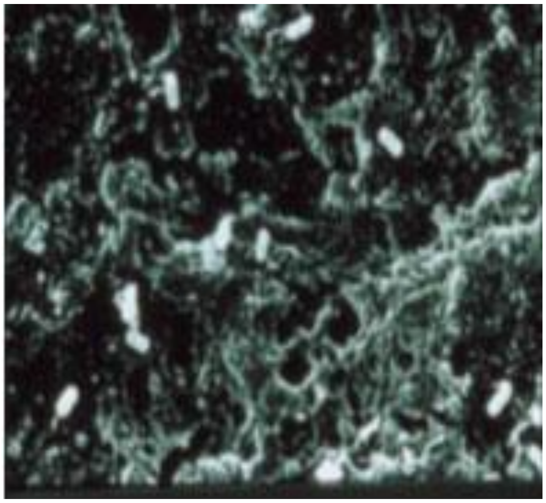


Figure 2: Bacteria (white rod shaped) in comminuted meat mix (3,000-fold enlarged)

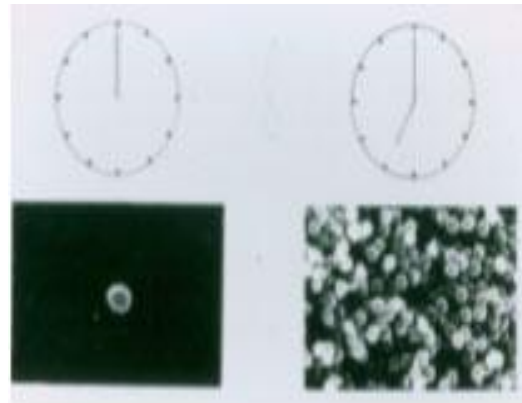


Figure 3:Bacterial growth in 7 hours (from one bacterial cell to more than 2 million). Multiplication through periodic partition of bacterial cells

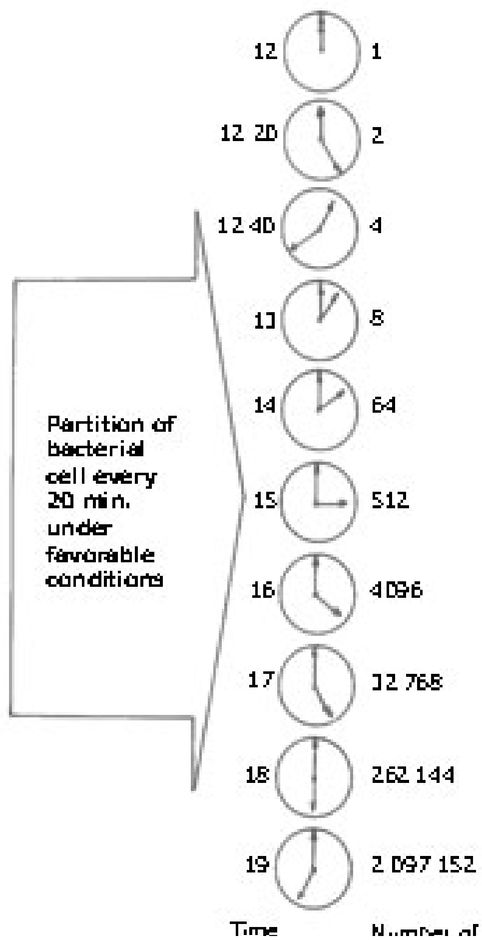


Figure 4: Microbial growth starting

Meat spoilage bacteria will grow if temperatures are not kept in the cooling (-1°C to +4°C) or freezing (below -1°C) range. Not all bacteria which contaminate meat will behave in the same way. Some may multiply already at temperatures at around 10°C, others at higher temperatures, for example 30°C. Most bacteria can optimally grow in the range between 30°C and 37°C. Some may attack the protein portion of the meat resulting in the production of very unpleasant putrefactive odours, others may break down carbohydrate components in particular in processed meats causing intensive sour taste or acidity. Others may attack the fats, producing rancidity. These various bacterial impacts result in meat spoilage or decomposition. Spoilage of meat and meat products causes serious financial losses for the meat industries as such products, due to their sensory changes exposed through unpleasant smell and taste are unfit for human consumption. But spoiled meat, if accidentally ingested, is usually not the cause for illness in consumers.

1.7. Meat spoilage through micro-organisms

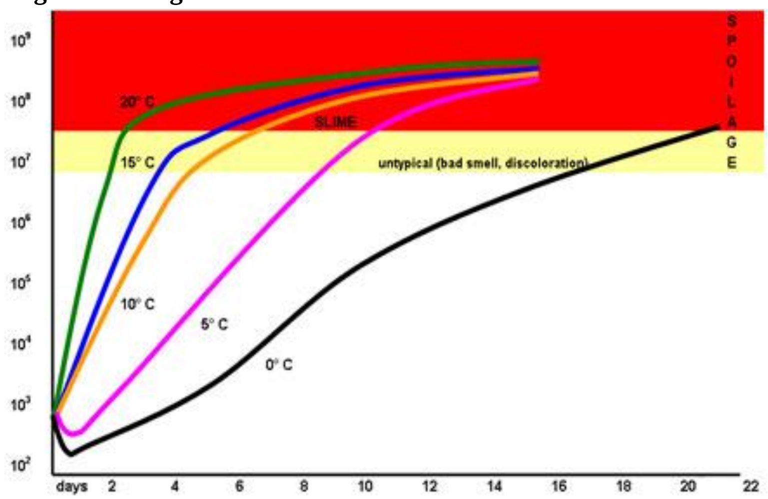


Figure 5: Growth of microorganisms on meat (starting from same initial bacterial loads/approx. 1000 per gram meat, but different storage temperatures, 0 °C, 5°C, 10°C, 15°C). At 20°C spoilage on the second day at 0°C spoilage after more than 20 days

1.8. Proper Hygienic Practices in meat processing

Microbial meat spoilage or food poisoning through meat can be prevented if the microbial load/bacterial contamination, which occurs during slaughtering and meat handling, is kept as low as possible. The key for achieving this is strict meat hygiene including an uninterrupted cold chain throughout the entire meat production and handling chain. Meat hygiene is a complex field, based on regulations by competent authorities and meat plant internal hygiene programs, to be supervised by the plant management.

Those programs will only be successful if meat plant staff are familiar with and active in observing basic hygiene requirements. In order to facilitate the application of hygiene requirements, it has proven useful to differentiate between:

a. Personal hygiene.

b. Slaughter and meat processing hygiene.

c. Hygiene of slaughter and meat processing premises.

d. Hygiene of slaughter and meat processing equipment.

In summary it can be stated that Good Hygienic Practices in meat processing requires efforts by both management and staff.

- It is the duty of the plant management to procure investments in good quality premises and equipment and in continuous plant and equipment maintenance.
- For the meat plant staff it is an obligation to observe during all meat processing operations relevant hygienic rules.
- Such efforts will result in good storage life of attractive meat products with desirable appearance, flavour and taste.

2. Food Safety

2.1. Introduction

Food safety and quality have become major concerns. It is not enough to just produce food; the food must first be safe to consume and, second, be wholesome and nutritious throughout the supply chain, from production to consumption.

This part discuss about food safety wit quality; types of physical, chemical, and microbiological adulterants, contaminants, residues, and toxins; as well as Hazard Analysis and Critical Control Points (HACCP), with an example of producing and supplying safe food.

Food safety is a scientific discipline describing handling, preparing, and storing food in ways that prevent food-borne illness. Food safety is, therefore, an increasingly important public health issue. Food can transmit disease from person to person, as well as serve as a growth medium for bacteria that can cause food poisoning. As the common saying goes, "Prevention is better than cure"; this assumes the utmost significance in the case of food products consumed by humans. In theory, food poisoning is 100% preventable. There are five key principles of food hygiene, according to the World Health Organization [1]:

1. Prevent contaminating food with pathogens spreading from people, pets, and pests.
2. Separate raw and cooked foods to prevent contaminating the cooked foods.
3. Cook foods for the appropriate amount of time and at the appropriate temperature to kill pathogens.
4. Store food at the proper temperature.
5. Do use safe water and cooked materials.

A food safety hazard is an agent or condition that could potentially cause an adverse human health effect. Furthermore, the condition of the food itself can also be hazardous. Most of the time, food-borne hazards cannot be seen, which may be the result of adulteration and contamination by physical, chemical, or biological objects in food or drink that can cause injury or illness [2]. Food adulteration is the act of intentionally debasing the quality of food offered for sale either by the admixture or substitution of inferior substances or by the removal of some valuable ingredient. Food is declared adulterated if a substance is added that depreciates or injuriously affects it. An adulterant is distinct from permitted food additives. There is little difference between an adulterant and an additive. Chicory, for example, may be added to coffee to reduce the cost. This would be considered adulteration if it is not declared, but it may be stated on the label. The term *contamination* is usually used for the inclusion of unwanted substances by accident or as a result of negligence rather than intent. Adulterants added to reduce the amount of expensive product in illicit drugs are called "cutting agents," whereas the deliberate addition of toxic adulterants to food or other products for human consumption is "poisoning." Microbiological pathogens and toxins, introduced either by contamination or by the condition of the food itself, often become threats to life. These adulterants and contaminants are described in the following sections.

2.2. Physical Adulterants and Contaminants

2.2.1. Chemical Adulterants and Residues

Physical adulterants are normally cheaper substances added in larger amounts to food products to get more profit or gain. Physical adulterants usually do not react with the original food. They increase the mass or volume, or improve the food's color and appearance. Types of adulterants are broadly grouped into three categories (Table 3). A few common physical adulterants and their health effects are listed in (Table 4). Physical contamination of food refers to an event where a foreign object falls into prepared food. This may happen as a result of external exposure to poisonous or polluting substances and the environments where food is being prepared. Common physical contaminants in food include hair, dirt, insects, and even glass. Food can be contaminated by a variety of different methods. If you are in a fast food chain or a restaurant, the most common method of physical contamination of food is through dirty hands. If hands remain unwashed, it is possible that workers could contaminate a food supply. Food can also be contaminated in factories. Poor sanitary conditions can taint food easily and cause food poisoning. Some possible common physical contaminants in food are listed in chemical adulterants are chemicals and residues present where the food is grown, harvested, processed, packaged, stored, transported, marketed, and consumed. Food gets adulterated or contaminated by these harmful chemicals beyond the permissible limits fixed by regulators. Chemicals sometimes are also added intensely to increase foods' shelf life, taste, and appearance.

Table 3: Type of adulterants and contaminants

S. No.	Type	Substances Added
1	Intentional adulterants	Sand, marble, chips, stone, mud, other filth, talc, chalk powder, water, mineral oil, and harmful color
2	Incidental adulterants	Pesticide residues, droppings of rodents, larvae in foods, or similar unwanted materials
3	Metallic contaminants	Arsenic from pesticides, lead from water, effluent from chemical industries, tin from cans, or any similar materials

Table 4: Physical adulterants and their effects on health

S. No	Physical Adulterants	Foods Commonly Involved	Health Effects
1	Argemone seeds Argemone oil	Mustard seeds Edible oils and fats	Epidemic dropsy, glaucoma, cardiac arrest
2	Artificially colored foreign seeds	As a substitute for cumin seed, poppy seed, black pepper	Injurious to health
3	Foreign leaves or exhausted tea leaves, artificially colored sawdust	Tea	Injurious to health, cancer
4	Tricresyl phosphate	Oils	Paralysis
5	Rancid oil	Oils	Destroys vitamins A and E
6	Sand, marble chips, stones, filth	Food grains, pulses, etc.	Damages digestive tract
7	*Lathyrus sativus*	*Khesari dal* alone or mixed in other pulses	Lathyrism (crippling spastic paraplegia)
8	Nonfood grade or contaminated packing materials	A food	Blood clot, angiosarcoma, cancer, etc.

Table 5: Common physical adulterants/contaminants in different foods

S. No.	Food Articles	Adulterants
1	Milk	Water, starch, urea, detergent Vegetable oil, synthetic milk, formalin
2	Ghee, cottage cheese, condensed milk, *Khoa*, milk powder, etc.	Coal tar, dyes
3	Sweet curd	Vanaspati
4	Rabdi	Blotting paper
5	Khoa and its product	Starch
6	*Chhana* or paneer	Starch
7	Ghee	Vanaspati or margarine
8	Butter	Vanaspati or margarine
9	Edible oil	Prohibited color
10	Coconut oil	Any other oil
11	Sugar	Chalk powder, urea, color
12	Honey	Sugar solution
13	Jaggery	Washing soda, chalk powder, sugar solution, metanil (yellow color)
14	Sweetmeats, ice cream, and beverages	Metanil yellow (a nonpermitted coal tar color), saccharin
15	Wheat, rice, maize, jawar, bajra, chana, barley, etc.	Dust, pebble, stone, straw, weed seeds, damaged grain, “weevilled” grain, insects, rodent hair and excreta
16	Maida	Resultant atta or cheap flour

17	Maida/rice	Boric acid
18	Wheat, bajra, and other grains	Ergot (a fungus containing a poisonous substance), dhatura kanel bunt
19	Parboiled rice	Metanil yellow (a nonpermitted coal tar color), turmeric (for golden appearance)
20	Parched rice	Urea
21	Wheat flour	Chalk powder
22	Dal, whole and split	Khesari dal, clay, stone, gravels, webs, insects, rodent hair and excreta, metanil yellow (a nonpermitted coal tar color)
23	Atta, maida, suji (rawa)	Sand, soil, insect, webs, lumps, rodent hair and excreta, iron filings

They also sometimes come into food in smaller amounts from the air, water, and soil. Some examples are arsenic, mercury, and nitrates. Chemical residues in foods are common today because of the rampant use of agrochemicals in agricultural practices and animal husbandry with the intent to increase crops and reduce costs. Such agents include pesticides (e.g., insecticides, herbicides, rodenticides); plant growth regulators; veterinary drugs (e.g., nitrofuran, fluoroquinolones, malachite green, chloramphenicol); and bovine somatotropin. There is a separate issue of genetically modified food, or the presence in foods of ingredients from genetically modified organisms. The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of prolonged exposure at low levels (e.g., cancer). Chemical contaminants can be classified (Table 5, Table 6) according to the source of contamination and the mechanism by which they enter the food product.

Table 6: Chemical contaminants in foods and their ill effects on health

S. No.	Natural Contaminants	Foods Commonly Involved	Health Effects
1	Mineral oil (white oil, petroleum fractions)	Edible oils and fats, black pepper	Cancer
2	Lead chromate	Turmeric (whole and powdered), mixed spices	Anemia, abortion, paralysis, brain damage
3	Methanol	Alcoholic liquors	Blurred vision, blindness, death
4	Diethylstilbestrol (additive in animal feed)	Meat	Impotence, fibroid tumors, etc.
5	3,4-Benzopyrene	Smoked food	Cancer
6	Excessive solvent residue	Solvent extracted oil, oil cake, etc.	Possibility of numbness in feet and hand
7	Nonpermitted color or permitted food color beyond safe limit	Colored food	Mental retardation, cancer, other toxic effects
8	Butylated hydroxyanisol and butylated hydroxytoluene beyond safe limit	Oils and fats	Allergy, liver damage, increase in serum cholesterol, etc.
9	Monosodium glutamate (flour) (beyond safe limit)	Chinese food, meat and meat products	Brain damage, mental retardation in infants
10	Coumarin and dihydrocoumarin	Flavored food	Blood anticoagulation
11	Food flavors beyond safe limit	Flavored food	Chances of liver cancer
12	Brominated vegetable oils	Cold drinks	Anemia, enlargement of heart
13	Sulfur dioxide and sulfite beyond safe limit	In a variety of foods as preservatives	Acute irritation of the gastrointestinal tract, etc.
14	Artificial sweeteners beyond safe limit	Sweet foods	Chance of cancer
15	Arsenic	Fruits such as apples sprayed with	Dizziness, chills, cramps,

		lead arsenate	paralysis, death
16	Barium	Foods contaminated by rat poisons (barium carbonate)	Violent peristalsis, arterial hypertension, muscular twitching, convulsions, cardiac disturbances
17	Cadmium	Fruit juices, soft drinks, etc., in contact with cadmium-plated vessels or equipment; cadmium-contaminated water and shellfish	Increased salivation, acute gastritis, liver and kidney damage, prostate cancer
18	Cobalt	Water, liquors	Cardiac insufficiency and myocardial failure
19	Lead	Water, natural and processed foods	Lead poisoning (foot-drop, insomnia, anemia, constipation, mental retardation, brain damage)
20	Copper	Any Food	Vomiting, diarrhea
21	Tin	Any Food	Colic, vomiting
22	Zinc	Any Food	Colic, vomiting
23	Mercury	Mercury fungicide-treated seed grains or mercury-contaminated fish	Brain damage, paralysis, death

Table 7: Natural chemical contaminants and their ill effects on health

S. No.	Natural Contaminants	Foods Commonly Involved	Health Effects
1	Fluoride	Drinking water, seafoods, tea, etc.	Excess fluoride causes fluorosis (mottling of teeth, skeletal and neurological disorders)
2	Oxalic acid	Spinach, amaranth, etc.	Renal calculi, cramps, failure of blood to clot
3	Gossypol	Cottonseed flour and cake	Cancer
4	Cyanogenetic compounds	Bitter almonds, apple seeds, cassava, some beans, etc.	Gastrointestinal disturbances
5	Polycyclic aromatic hydrocarbons	Smoked fish, meat, mineral oil-contaminated water, oils, fats, and fish, especially shellfish	Cancer
6	Phalloidin (alkaloid)	Toxic mushrooms	Mushroom poisoning (hypoglycemia, convulsions, profuse watery stools, severe necrosis of liver leading to hepatic failure and death)
7	Solanine	Potatoes	Solanine poisoning (vomiting, abdominal pain, diarrhea)
8	Nitrates and nitrites	Drinking water, spinach rhubarb, asparagus, etc., and meat products.	Methemoglobinemia, especially in infants; cancer and tumors in the liver, kidney, trachea, esophagus, and lungs. The liver is the initial site but afterward tumors appear in other organs.
9	Asbestos (may be present in talc, kaolin, etc., and in processed foods)	Polished rice, pulses, processed foods containing anticaking agents, etc.	Absorption in particulate form by the body may produce cancer
10	Pesticide residues (beyond safe limit)	All types of food	Acute or chronic poisoning with damage to nerves and vital organs such as the liver and kidney
11	Antibiotics (beyond safe limit)	Meats from antibiotic-fed animals	Multiple-drug resistance, hardening of arteries, heart disease

2.2.2. Microbiological and Pathogenic Contaminants

Food-borne illness caused by microorganisms is a large and growing public health problem. Most countries with systems for reporting cases of food-borne illness have documented significant increase since the 1970s in the incidence of diseases caused by microorganisms in food, including pathogens such as Salmonella, *Campylobacter jejuni*, and enterohemorrhagic *Escherichia coli*, and parasites such as Cryptosporidium, *Cryptospora*, and trematodes. Some important bacterial and fungal contaminants, and pathogens, in commonly available foods and their ill effects on health are listed in (Table 7, Table 8, Table 9) respectively.

Table 8: Common bacterial contaminants and their ill effects on health

S. No.	Bacterial Contaminants	Foods Involved	Health Effects
1	*Bacillus cereus*	Cereal products, custards, puddings, sauces	Food infection (nausea, vomiting, abdominal pain, diarrhea
2	*Salmonella* spp.	Meat and meat products, raw vegetables, salads, shellfish, eggs and egg products, warmed-up leftovers	Salmonellosis (food infection usually with fever and chills)
3	*Shigella sonnei*	Milk, potatoes, beans, poultry, tuna, shrimp, moist mixed foods	Shigellosis (bacillary dysentery)
4	*Staphylococcus aureus* entero-toxins A, B, C, D, or E	Dairy products, baked foods (especially custard or cream-filled foods), meat and meat products, low-acid frozen foods, salads, cream sauces, etc.	Increased salivation, vomiting, abdominal cramp, diarrhea, severe thirst, cold sweats, prostration
5	*Clostridium botulinus* toxins A, B, E, or F	Defectively canned low- or medium-acid foods; meats, sausages, smoked vacuum-packed fish, fermented foods, etc.	Botulism (double vision, muscular paralysis, death due to respiratory failure)
6	*Clostridium perfringens* (Welchii) type A	Milk improperly processed or canned meats, fish, and gravy stocks	Nausea, abdominal pains, diarrhea, gas formation

Table 9: Common fungal contaminants and their ill effects on health

S. No.	**Fungal Contaminants**	**Foods Involved**	**Health Effects**
1	Aflatoxins	*Aspergillus flavu* Contaminated foods such as groundnuts, cottonseeds, etc.	Liver damage and cancer
2	Ergot alkaloids from *Claviceps purpurea*, toxic alkaloids, ergotamine, ergotoxin, and ergometrine groups	Ergot-infested bajra, rye meal or bread	Ergotism (St. Anthony's fire-burning sensation in extremities, itching of skin, peripheral gangrene)
3	Toxins from *Fusarium sporotrichioides*	Grains (millet, wheat, oats, rye, etc.)	Alimentary toxic aleukia (epidemic panmyelotoxicosis)
4	Toxins from *Fusarium sporotrichiella*	Moist grains	Urov disease (Kaschin-Beck disease)
5	Toxins from *Penicillium inslandicum*, *Penicillium atricum*, *Penicillium citreovirede*,	Yellow rice	Toxic moldy rice disease

6	*Fusarium, Rhizopus, Aspergillus* Sterigmatocystin from *Aspergillus versicolour*, *Aspergillus nidulans*, and *Bipolaris*	Food grains	Hepatitis
7	*Ascaris lumbricoides*	Any raw food or water contaminated by human feces containing eggs of the parasite	Ascariasis
8	*Entamoeba histolytica* (viral)	Raw vegetables and fruits	Amebic dysentery
9	Virus of infectious hepatitis (virus A)	Shellfish, milk, unheated foods contaminated with feces, urine, and/or blood of infected human	Infectious hepatitis
10	Machupo virus	Foods contaminated with rodent urine, such as cereals	Bolivian hemorrhagic fever

Table 10: Common food-borne pathogens

S. No.	Athogen	Symptoms	Food Items
1	*Bacillus cereus*	Diarrhea, abdominal cramps, nausea, and vomiting (emetic type)	Meats, milk, vegetables, fish, rice, potatoes, pasta, and cheese
2	*Campylobacter jejuni*	Nausea, abdominal cramps, diarrhea, headache (varying in severity)	Raw milk, eggs, poultry, raw beef, cake icing, water
3	*Clostridium botulinum*	Nausea, vomiting, diarrhea, fatigue, headache, dry mouth, double vision, muscle paralysis, respiratory failure	Low-acid canned foods, meats, sausage, fish
4	*Clostridium perfringens*	Abdominal cramps and diarrhea; some include dehydration	Meats and gravies
5	*Cryptosporidium parvum*	Watery diarrhea accompanied by mild stomach cramping, nausea, loss of appetite; symptoms may last 10–15 days	Contaminated water or milk
6	*Escherichia coli* 0157:H7	Hemorrhagic colitis, possibly hemolytic uremic syndrome	Ground beef, raw milk
7	*Giardia lamblia*	Infection of the small intestine, diarrhea, lose or watery stool, stomach cramps, and lactose intolerance	Food and water
8	Hepatitis A	Fever, malaise, nausea, abdominal discomfort	Water, fruits, vegetables, iced drinks, shellfish, and salads
9	*Listeria monocytogenes*	Meningitis, septicemia, miscarriage	Vegetables, milk, cheese, meat, seafood
10	*Salmonella*	Nausea, diarrhea, abdominal pain, fever, headache, chills, prostration.	Meat, poultry, egg or milk products
11	*Staphylococcus*	Severe vomiting, diarrhea, abdominal cramping.	Custard- or cream-filled baked goods, ham, tongue, poultry, dressing, gravy, eggs, potato salad, cream sauces, sandwich fillings
12	*Shigella*	Abdominal pain, cramps, diarrhea, fever, vomiting, blood, and pus	Salads, raw vegetables, dairy products, and poultry
13	*Vibrio*	Diarrhea, abdominal cramps, nausea, vomiting, headache, fever.	Fish and shellfish
14	*Yersiniosis*	Enterocolitis (may mimic acute appendicitis)	Raw milk, chocolate milk, water, pork, other raw meats

2.2.3. Toxins

- Keep raw meat, poultry, and seafood, vegetables, and so on separate from other foods.
- Use separate equipment and utensils, such as knives and cutting boards, for handling raw foods.
- Store food in containers to avoid contact between raw and prepared foods.

2.2.3.1. Prevention of Adulteration and Contamination

"Prevention is better than cure" is a well-established idiom. One should always ensure that food should not, knowingly or unknowingly, be adulterated or contaminated. To prevent food adulteration and contamination, one should adhere to the following five key elements.

2.2.3.2. Separate Raw and Cooked Materials

2.2.3.2.1. Cook Thoroughly

- Be sure that meat and poultry juices are clear and not discolored.
- Cook food thoroughly, especially meat, poultry, eggs, and seafood.
- Bring foods like soups and stews to boiling to make sure that they have reached 70 °C.
- Reheat cooked food properly before eating.

2.2.3.2.2. Use Safe Water and Raw Materials

- Use safe water or treat it to make it safe.
- Select fresh and wholesome foods.
- Choose foods processed for safety, such as pasteurized milk.
- Wash fruits and vegetables, especially if eaten raw.
- Do not use food beyond its expiration date.

2.2.3.2.3. Keep Food at Safe Temperatures

Keep your food at the right temperature to avoid the temperature danger zone—the temperature in which bacteria can widely spread. To avoid such danger, use aseptic techniques, if possible, and follow the following precautions:

- Do not leave cooked food at room temperature for more than 2 h.
- Refrigerate promptly all cooked and perishable foods, preferably below 5 °C.
- Keep cooked food hot (more than 60 °C) before serving.
- Do not store food too long, even in the refrigerator.
- Do not thaw frozen food at room temperature.

3. Hazard Analysis and Critical Control Points

Food safety assurance is an exercise that covers a whole gamut of interactions among raw materials, food ingredients, processing methods, manufacturing environments, and the other critical areas of the manufacturing process that may affect foods' microbiological quality and safety. It is nearly impossible to monitor every aspect of a large manufacturing process/food manufacturing plants and facilities. It is, however, possible to monitor certain key areas—or, the "critical points"—where safety measures can reasonably be monitored and assured. This is the basis for the HACCP system, which is a systematic approach for identifying, assessing, and controlling hazards. The system offers a rational approach to the control of potential hazards in foods, which avoids many weaknesses inherent in the inspection process or approach and circumvents the shortcomings of reliance on end-product testing. Focusing attention on the factors that directly affect the safety of a food eliminates wasteful use of resources on extraneous considerations, while ensuring that the desired levels of safety and quality are maintained.

3.1. HACCP Principles

Seven basic principles summarize the theme of HACCP from an international perspective:

Principle 1: Identify the potential hazard(s) associated with food production at all stages, from growth, processing, manufacture, and distribution to the point of consumption. Assess the likelihood of occurrence of the hazard(s) and identify the preventive measures for control.

Principle 2: Determine the point/procedures/operational steps that can be controlled to eliminate the hazard(s) or minimize its likelihood of occurrence (critical control point (CCP)).

Principle 3: Fix target level(s) and tolerances that must be met to ensure the CCP is under control.

Principle 4: Establish a monitoring system to ensure control of CCPs by scheduled testing or observation.

Principle 5: Establish a mechanism for the corrective action to be taken when monitoring indicates that a particular CCP is not under control.

Principle 6: Document (keep records) concerning all procedures and records appropriate to these principles and their application.

Principle 7: Establish verification procedures, which include appropriate supplementary tests and procedures to confirm that HACCP is working effectively.

3.2. Implementation of HACCP Systems

HACCP implementation usually involves two separate stages: preliminary preparation and application of HACCP principles.

3.2.1. Stage 1: Preliminary Preparation

3.2.1.1. Create the HACCP team

The multidisciplinary HACCP team should comprise a quality assurance specialist who understands the biological, chemical, or physical hazards connected with a particular product group; a production specialist who has the responsibility of looking after the whole process for manufacturing the product; an engineer who has a good knowledge of hygiene, and the design and operation of a plant and equipment; a packaging specialist who has a thorough knowledge of the effect and nature of packaging material for the desired product; a distribution specialist who has expertise in the area of handling, storage, and transportation from production to consumer; a hygiene specialist who has the responsibility of looking at the process from a hygiene and sanitation point of view, with a proactive approach; and a microbiologist who can identify the “gray areas” of microbial contamination, enumerate microorganisms when required, and suggest safety measures [3-4].

3.2.1.2. Describe the food product

The main purpose of this section is to provide as much information as possible to the HACCP team for proper evaluation. The description must include the following items: composition of the product (e.g., list of ingredients, including description or specifications of the raw materials; characteristics of the product (e.g., solid, liquid, emulsion, pH, Brix); processing methods (heating, smoking, cutting/slicing, freezing, thawing); packaging methods/system (vacuum, modified atmosphere, controlled and/or shrink packaging); storage and distribution conditions; expected shelf life; instructions for use.

3. *Identify intended use*: State the intended use of the product by the consumer and the consumer target group, for example, the general public, institutional caterers, infants.

4. *Construct a flow diagram*: The purpose of this step is to provide a clear, simple picture of all steps involved in producing the product. The flow diagram must cover all steps in the process that are under the direct control of the manufacturing unit, from receipt of raw materials through distribution of the finished product. (A process flow chart for manufacturing tomato puree is presented as a guideline in Figure 6).

5. *Verify the flow diagram on site:* It is important for the HACCP team to verify the flow diagram on site during operating hours. Any deviation must result in an amendment of the original flow diagram. If the analyses are applied to a proposed line, preproduction runs must be observed carefully.

An effective HACCP program works only on a specific product and process and must take into account the actual procedure that is in use. For a HACCP program to be useful, data generated from an initial HACCP study need to be constantly updated and implemented to ensure maximum product safety.

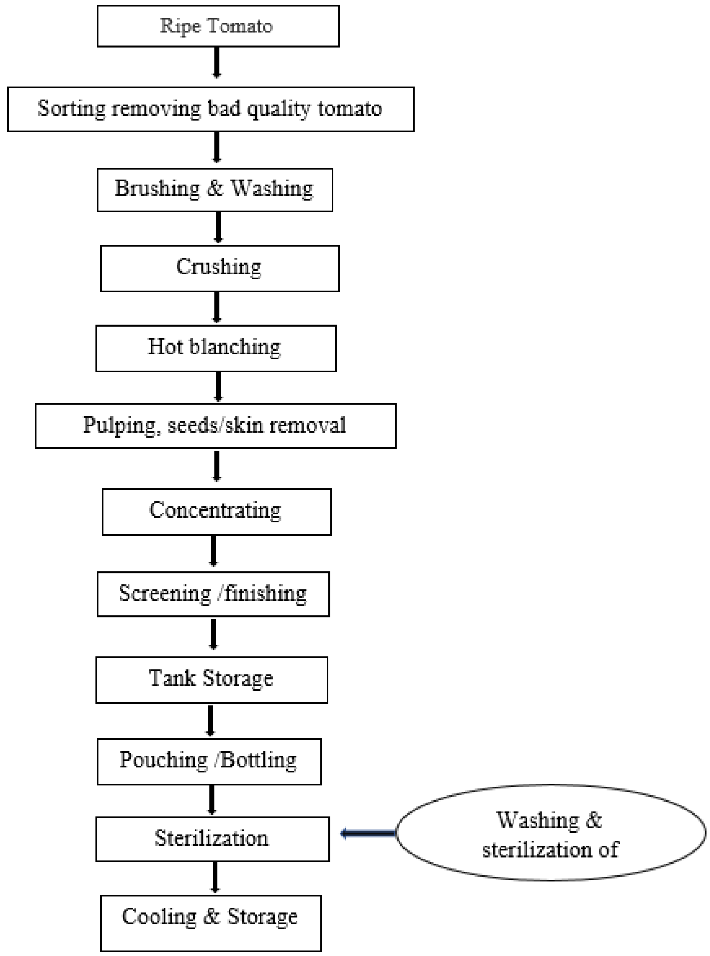


Figure 6: Tomato puree manufacturing process flow chart

3.2.2. Stage 2: Application of HACCP Principles

Principle 1: Identify the potential hazard(s) associated with food production at all stages, from growth, processing, manufacture, and distribution to the point of consumption. Assess the likelihood of occurrence of the hazard(s) and identify the preventive measures for control.

On the basis of the flow diagram generated, the HACCP team should be able to identify all the potential hazards that are expected to occur at each step. The nature of the hazards must be such that their elimination or reduction to acceptable levels is essential to the production of safe food. Once all potential hazards have been identified, the HACCP team may then consider and describe the control measures to be adopted. More than one control measure may be required to control one hazard; similarly, many potential hazards may be controlled by a single control measure.

Principle 2: Determine the point/procedures/operational steps that can be controlled to eliminate the hazard(s) or minimize its likelihood of occurrence (CCP).

The identification of CCPs requires a logical approach such as the CCP decision tree (Figure 6). The sequence given in the flow diagram must be strictly followed. At each step, the decision tree must be applied to each hazard whose occurrence is probable and each control measure identified. The CCP is specific for a specific product; every product, by and large, requires a different manufacturing process and must not have unwanted or unnecessary critical points.

Principle 3: Fix target level(s) and tolerances that must be met to ensure that the CCP is under control. The critical limits for each CCP or control measure should represent some quantitative (measurable) parameters that can be measured relatively quickly and easily, for example, temperature, time, pH, preservative level, firmness, texture, and appearance. Those levels should be commensurate with those required by food standards fixed by the related regulatory authority in marketing areas.

Principle 4: Establish a monitoring system to ensure control of the CCP by scheduled testing or observation. The program should describe the procedure, frequency, and personnel responsible for carrying out the measurements or observations. The monitoring system could be online (flow rate, temperature) or off-line (measurement of total solids, carbon dioxide concentrations, etc.). Online systems give an immediate indication of performance, so it is desirable to have online continuous monitoring systems for each CCP; practically, however, this is not always possible. It is therefore important for the HACCP team to ensure that the results obtained are directly relevant to the CCP and limitations, if any, are fully understood.

Principle 5: Establish a mechanism for the corrective action to be taken when monitoring indicates that a particular CCP is not under control. Since the HACCP team is multidisciplinary, it should be able to specify the action once the monitoring results show a deviation in CCP. Facilities and planning should be available for immediate action when the CCP goes out of the specified limits.

Principle 6: Document (keep records) concerning all procedures and records appropriate to these principles and their application. A comprehensive record-keeping system for ingredients, processes, and product controls should be established to facilitate tracing and recall of the product when necessary. In addition, this also helps to find and correct deviations in CCPs. HACCP records must include the following:

- Product description and intended use
- Complete flow diagram of the process, including the CCPs
- Hazards, control limits, monitoring, and corrective action for each CCP
- Verification procedures and data

Principle 7: Establish verification procedures, which include appropriate supplementary tests and procedures, to confirm that HACCP is working effectively.

In HACCP, verification is necessary to ensure that the system is working correctly. *Verification* is defined as those activities, other than monitoring, that determine the validity of the HACCP plan and that the system is operating according to the plan.

Another important aspect of verification is the initial validation of the HACCP plan to determine that the plan is scientifically and technically sound, that all hazards have been identified, and that these hazards will be effectively controlled when the HACCP plan is properly implemented [5]. Information needed to validate the HACCP plan often includes (1) expert advice and scientific studies, and (2) in-plant observations, measurements, and evaluations. For example, validation of the manufacturing and packaging process for tomato puree should include the scientific justification for the heating times and temperatures needed to appropriately destroy pathogenic microorganisms and studies to confirm that the conditions will deliver the required time and temperature to each pack of juice.

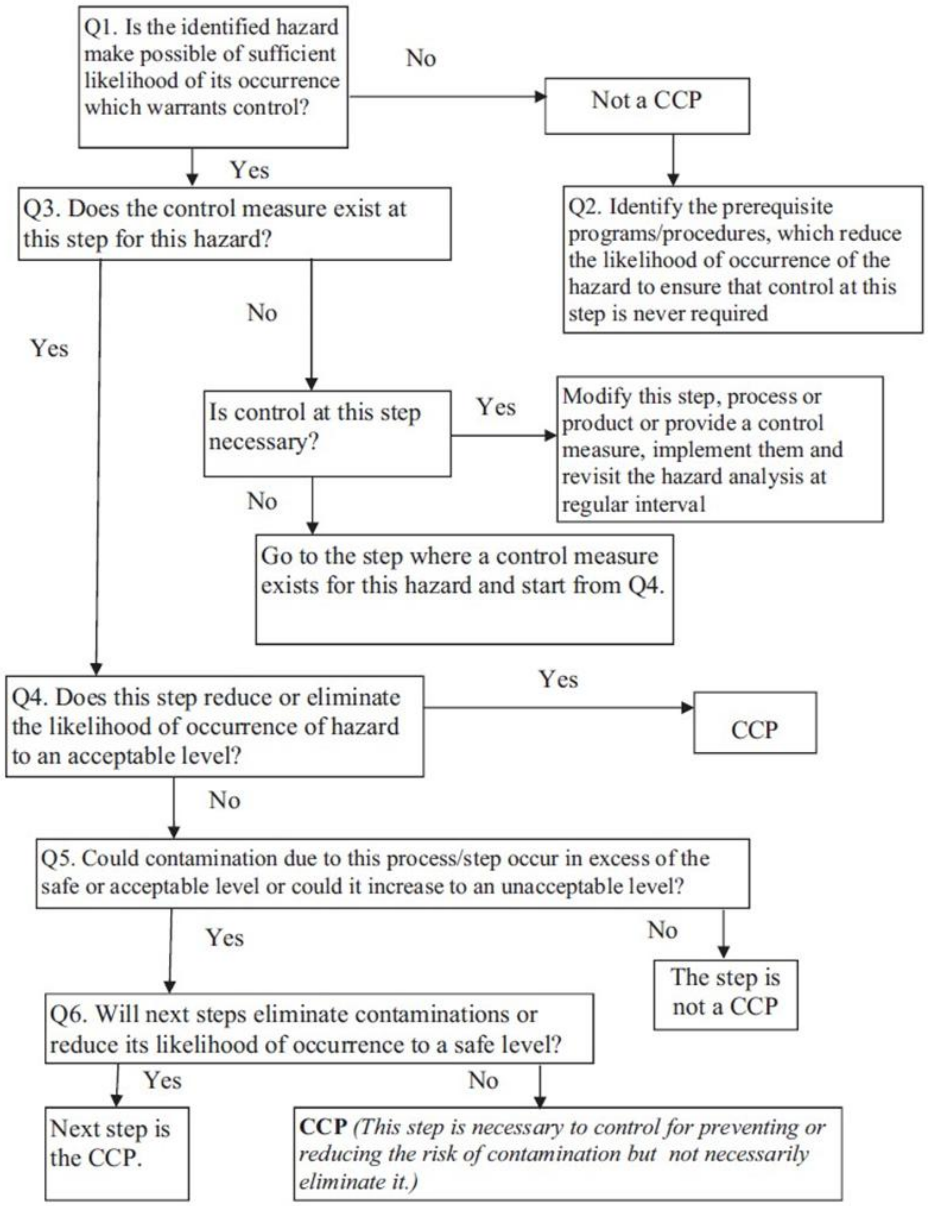


Figure 10: *Typical example of a critical control point (CCP) decision tree for the identification of CCPs in a food processing plant*

Subsequent validations are performed and documented by an HACCP team or an independent expert, as needed. For example, validations are conducted when there is an unexplained system failure; when a significant product, process, or packaging change occurs; or when new hazards are recognized. In addition, an unbiased, independent authority should conduct a periodic comprehensive verification of the HACCP system. Such authorities can be internal or external to the food operation. This independent verification should include a technical evaluation of the hazard analysis and each element of the HACCP plan, as well as an on-site review of all flow diagrams and appropriate records of operation of the plan. A comprehensive verification is independent of other verification procedures and must be performed to ensure that the HACCP plan is controlling the hazards. If the results of the comprehensive verification identify deficiencies, the HACCP team must modify the HACCP plan as necessary. Individuals within a company, third-party experts, and regulatory agencies carry out verification activities. It is important that an individual who is doing verification has appropriate technical expertise to perform this function.

4. Food Quality

4.1. Definition

The term *quality* refers to the rated ability of a product, whether it is a food or fruits and vegetables, to perform its functions. *Quality* implies the degree of excellence of a product or its suitability for a particular use. However, *quality* means different things to different handlers within a distribution chain. According to the International Organization for Standardization, the quality of a food can be defined as the totality of the features and characteristics of a product that bear its ability to satisfy stated or implied needs. Quality produce encompasses sensory properties (appearance, texture, taste, and aroma), nutritive values, chemical constituents, mechanical properties, functional properties, and defects. Quality is not a single, well-defined attribute but comprises many properties and characteristics.

In the ISO 9000 standard (developed by the International Organization for Standardization) quality is defined as "the totality of the features and characteristics of product or service that bear on its ability to satisfy stated or implied needs." Kader [6] defines it, in relation to fruits and vegetables, as "the combination of attributes or properties that give them value in terms of human food." Quality may be equated to meeting the standards required by a selective customer. In this context the customer is the person or organization receiving the product at each point in the production chain. This is important because quality is perceived differently depending on the needs and intentions of the particular customer. If something is not a quality product, this implies that the product does not meet a certain standard that has been adopted by the customer. In this case the market price can be adversely affected. Conversely, if a product is perceived to be a quality product, it can be sold at a better price.

4.2. Product-Oriented Quality

The quality of a food product changes as the product proceeds from processors to handlers after harvest. The relative importance of different quality attributes changes from handling to purchase to consumption. Shewfelt [7] points out that quality is often defined from either a product orientation or a consumer orientation. An understanding of the different perspectives of different participants in postharvest distribution is essential in any attempt to improve the quality of a fresh fruit or vegetable for the consumer.

A product orientation views quality as a bundle of attributes that are inherent in a product and can be readily be quantified throughout handling and distribution. For example, Jha *et al* [8] have tried to determine the maturity of mangoes. A consumer orientation defines quality in terms of consumer satisfaction, a much less tangible and less quantifiable concept. Both orientations have strengths and limitations in the delivery of fresh items from harvest to the consumer. Selection of measurement techniques and development of product standards depend on the orientation. Failure to appreciate the differences in perspective results in barriers to improvements in fresh fruit and vegetable quality.

Most postharvest research (physiological as well as technological) assumes a product orientation to quality. *Quality* is defined as a series of attributes selected on the basis of accuracy and precision of measurement. These attributes are in turn used to evaluate the effect of a breeding line or transgenic product, chemical or quarantine treatment, handling technique or system, set of storage conditions, or other postharvest variables. Product-oriented quality is readily defined and clearly understood. Quality changes can be plotted as a function of time and directly related to changes that occurred, such as an increase in free fatty acid in oil and the rancidity of rice bran during handling and storage. These data can be used to develop a mechanistic understanding of effects on loss of quality. Product-oriented quality is usually measured with analytical instruments, and the data can readily be analyzed and results reproduced. The accuracy and precision of measurement provides "internal validity" to any scientific study. A product orientation provides a clear assessment of which treatment(s) is superior or inferior within the context of study objectives.

Product-oriented quality has its limitations, however. Measurements that are less readily quantified carry less weight than those that are readily quantified. Such biases tend to favor handling and storage treatments that maintain appearance (a readily quantifiable attribute) over texture (less quantifiable) over flavor (very difficult to quantify). Likewise, sugar and acid measurement (readily quantified) are likely to predominate over volatile compound analysis. Instrumental methods are preferred to sensory evaluation, which is preferred over consumer testing. While the generation of large data sets provides a wide range of attributes to separate effects of postharvest treatments, the results lack "external validity," or "the extent to which the test results can be generalized to market behavior." Thus, it is not possible to determine whether the significant differences in appearance after treatment are even detectable by many consumers, much less lead to a change in purchase behavior. Likewise, it is not possible to determine whether large differences in predominant volatile compounds affect flavor perception any more than small differences in compounds present in trace amounts. In addition, the product-oriented approach is unable to keep pace with changes in consumer desires and expectations.

A product orientation to quality is the best for assessing the effectiveness of change in a handling system like cultivar selection, harvest technique, or postharvest treatment. It can be adjusted to become more responsive to the marketplace if the quality attributes important to consumers are known, and if accurate and precise measurements can be obtained.

4.3. Consumer-Oriented Quality

A consumer orientation to quality requires an understanding of consumer behavior and is focused on predicting product performance in the marketplace. When performed well, consumer-oriented studies provide external validity, thus giving a better appreciation of a product's potential performance in the marketplace. Such studies focus more on how to measure human perception and behavior than on how to measure specific quality attributes. Measurement of consumer attitudes can be simplified to determine either acceptability (superior, acceptable, or unacceptable) or willingness to purchase. Qualitative consumer studies can be used to identify quality attributes that drive acceptability at the points of purchase and consumption. Judicious coupling of quantitative consumer panels with sensory descriptive analysis can either verify or refute the accuracy of consumer statements about critical quality attributes.

A consumer orientation to quality is best at identifying consumer needs and expectations. It can be made more useful to physiologists if the consuming population can be segmented into distinct user groups, based on quality preference rather than demographic groupings, and expressed as a percentage distribution of the population. It is an exact tool in assessing a particular experimental treatment within the distribution chain. Consumer satisfaction from both food quality and safety point of views is necessary for human health and sustainable marketing.

References

[1]. World Health Organization, (2010), World Health Organization. Prevention of Food Borne Disease: Five Keys to Safer Food.

[2]. Washington State Department of Health, (2013) Washington State Department of Health Food Safety Is Everybody's Business Washington State Food & Beverage Workers' Manual.

[3]. Codex Alimentarius Commission, 1995a Codex Alimentarius Commission Recommended international code of practice - general principles of food hygiene (CAC/RCP 1-1969, Rev. 2(1985))**,** Codex Alimentarius, General Requirements (Food Hygiene), vol. 1 B, pp. 1-20

[4]. Codex Alimentarius Commission, 1995b Codex Alimentarius Commission Guidelines for the application of the hazard analysis critical control point (HACCP) system (CAC/GL 18-1993) Codex Alimentarius, General Requirements (Food Hygiene), vol. 1 B, pp. 21-30

[5]. Sperber, WH (1991). The modern HACCP system Food Technol., 45, pp. 116-120.

[6]. Kader, AA. (1997). Kader A summary of CA recommendations for fruits other than apples and pears 7th Intl. Contr. Atmos. Res. Conf, Univ. of California, Davis , pp. 1-34.

[7]. Shewfelt, RL. (1999) What is quality? Postharvest Biol. Technol., 15, pp. 197-200.

[8]. Jha, S.N., Kingsly, A.R.P., & Chopra, S. (2006). Physical and mechanical properties of mango during growth and storage for determination of maturity. J. Food Eng., 72 (1), pp. 73-76.